通过练习学习

有机反应机理

福山 透

有机合成化学协会编

三氢剑魔　翻译

演習で学ぶ有機反応機構

化学同人

序　　言

作为学会的事业之一，有机合成化学协会从以前就开始工作于手册和书本出版的事情了。不过,近年来由于出版界的情况变了很多。于是,本协会决定从新时代出发，开始一次新的出版活动。在2004年时组成出版委员会后,一部分委员商讨了今后的出版企划。

虽然当代在学术和研究这方面上，世界上已经充斥了大量的研究有关信息,并且它们整理的各种著作物出版了很多，但是，这相比很久以前，世人对于出版事情上心思状况有很大的变化,于是这就导致了信息泛滥。同时由于计算机技术蓬勃发展，信息处理这方面开始变得简单化,特别是网络搜索这方面，与以前相比,个人获取新的信息和必要的数据也变得十分便捷。在这样的大环境下,不得不承认，今天的出版物的利用价值开始逐渐缩水。

在这种风潮中,有机合成化学协会必须为了推进出版业的发展，做出一本书作为参照。本协会的会员需要在书中引入了各种令人生趣的内容，并且尽可能选择出有益的信息，用于制作题目,最后与类似的出版物达成一致,才能提出许多崭新的内容和企划的建议。从这样的思路出发,出版委员会为之进行了努力。

这次出版的是第一册是东京大学研究生院药学研究系科的福山透教授的研究室企划编写的《通过练习学习有机反应机理》，并即将被出版。它是福山研究室在长期收集了很多资料后,用于理解有机合成反应和反应机理思考能力的练习用书。这本书,它通过完整的总结编辑,新颖的练习和相当风致的豁达的独特内容，使有机有机合成化学专业的学生在阅读过程中妙趣横生。另外鸣谢有关的有机合成的研究人员，尽自己的所能为本协会的书目出版出一份力。

2005 年 7 月

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辻 二郎

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三氢剑魔　翻译

前　　言

自从医学、农学的开发后,科技产生了很大的发展，各种创新应有尽有,有机合成化学的重要性也逐渐增大,这也成为了新反应和新化合物相关的论文在学术杂志上泛滥的主要原因。19世纪以来，各种方面的信息积累产生了名为“有机化学”的宽阔的大海,而我们为了达到目标目的地，掌握出色的航海术,很有必要。当然,把繁综错杂的有机反应,一个一个背过的需要天价的时间,很没有效率。

近年来,由于计算化学的发展, 我们轻视了基于有机电子论形式上的反应机理分析的重要性。但是,掌握了电子论的话,可以将各种各样的反应统一理解成为可能。反应途径的预测和反应方式,反应的设计，可以使我们对于反应的方式有更好的理解。如果只是一味的死记硬背的庞大的已知反应，那么就不会有什么新的发现。而掌握反应时电子的流动方向，就是掌握了有机反应的活力源泉。有机电子论,即所谓的“arrow-pushing mechanism”,就是考虑反应中化学键的稳定性以及他们的生成与开裂，通过能量结合，引导其产生出一个有利的生成物的途径的学问。对于初学者来说尤其重要的是,从整个分子来观察,绝对不可以省略的反应中的每一步。然后仔细、深入的观察接下来会发生什么反应。大多数有机化学教科书中,取录的概念和领域太多,导致了实际上个别的反应的解说很不充分。另外,对于基本反应们的高级的反应机理的详细解说的练习书，也少。

在美国很多大学的有机化学专业研究生每月都要参加一个名为“Cumulative Examination”的测试,到达一定的合格分数后可以提早获得博士学位资格。

测试中有机反应机理的问题题目很多,所以他们都在自己进行有机电子论学习。另一方面,在我国,学院和研究生院的专门教育相比没有美国的大学要求严格，是其所属研究室对于学生教育的大部分责任。而这样的现状的基础上，为了发挥有机化学的力量,为了更好的进行讲座,笔记，教科书以及学习参考书的学习, 相信你在通过这本书的捷径，自学并练习了书写各种各样的重要反应，从而更加彻底的理解自己学习的东西。

这本书是由初级问题(a),中级问题(b), 高级问题(c)和解答篇组成的。A是基础重要的反应问题,B是研究生院的考试题,这比A组题难度要高。而C则是从研究生院的研究人员收集的各种世界上的研究问题。

A组题对于初学者来说，完全可以很轻松地自主挑战的。初级篇是参考于反应的简单的步骤省略。另外,倘若一个问题20分钟也考虑不明白的话，还是乖乖自己翻答案比较好，不懂的题目还可以等到以后再挑战。为此我们特地将问题分类，各种问题分为三个阶段，为能力提高做准备。答案栏写的反应机理同时也著名了引用文献的作者,不仅是福山研究室所考虑到的东西,也有与出版社双方考虑的因素。

一般来说,有机反应中不稳定的中间体很难确认,从而导致反应途径中有许多盲区。因此,考虑真正的反应机构到底是什么是什么叫我们很是头疼。不过从逻辑上考虑，还是反应机理更为重要。这本书的问题如果可以全部变成自己的东西。拥有相当有机化学的实力不是问题。另外。答案栏的评语是用英语书写的，这种程度的英语对于初学者来说不算什么问题,而对于英语简写，后文也有说明。

本考试中刊载的大部分问题,是当时研究室的团队会议出题。工作人员选择的问题,是文部科学省的特定领域的研究“生物功能分子的创制”计划班的班成员承蒙提供的问题，在这里对其表示感谢了。另外,这本书之前的显示的那几页是当时实验室的工作人员和研究生百忙之余中执笔的,特别要感谢横岛聪助手的忘我的努力。

最后,这本书的企划、制作帮助您的化学同人编辑部平佑幸深深地对您表示感谢。

2005年7月东京大学研究生院药学研究科

天然物合成化学研究室福山透

目　录

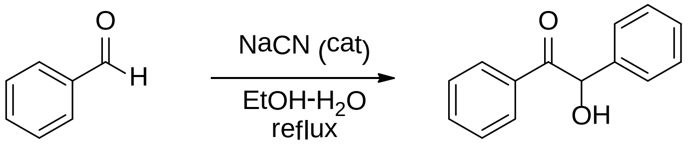
缩 写 表

△	加热
Ac	乙酰基
acac	乙酰丙酮基
AIBN	偶氮二异丁腈
aq	水溶液
Ar	芳基
Bn	苯甲基
Boc	叔丁氧羰基
Bu	正丁基
cat	催化
Cbz	苯甲氧羰基
CSA	樟脑磺酸
CSI	磺酰氯异氰酸酯
Cy	环己基
DABCO	1,4-二氮杂双环[2.2.2]辛烷
dba	已二酸二丁酯
DBU	二环[4.3.0]-1,5-二氮-5-十一烯
DCC	N,N'-二环已基碳二亚胺
DDQ	2,3-二氯-5,6-二氰-1,4-苯醌
DEAD	偶氮二甲酸二乙酯
DMAP	4-二甲氨基吡啶
DME	二甲醚
DMF	二甲基甲酰胺
DMSO	二甲亚砜
dppb	1,4-双(二苯基膦)丁烷
DPPE	双(二苯基膦基)乙烷
EDCI	1-乙基-(3-二甲基氨基丙基)碳酰二亚胺
eq	等量物质
Et	乙基
HMPA	六甲基磷酸胺
hv	光照
i	异-（某基）
KHMDS	六甲基二硅基胺基钾
LDA	二异丙基氨基锂
liq	液体
m	间位
mCPBA	间氯过氧苯甲酸
Me	甲基
MEM	2-甲氧基乙氧基甲基氯
MOM	甲氧甲基
Ms	甲磺酰基
MS	分子筛
n	正-（某基）
NBS	N-溴代丁二酰亚胺
NCS	N-氯代丁二酰亚胺
NMM	N-甲基吗啡啉
NMO	N-甲基-N-氧化吗啉
Ns	邻（对）硝基苯磺酰基
o	邻位
p	对位
Ph	苯基
Pr	丙基
rt	室温
s	仲-（某基）
SET	单电子转移
t	叔-（某基）
TBAF	四丁基氟化铵
TBS	叔丁基二甲基硅烷基
Tf	三氟甲磺酸基
TFA	三氟乙酸
TFAA	三氟乙酸酐
TfOH	三氟甲磺酸
THF	四氢呋喃
TIPS	三异丙基甲硅烷基
TMS	三甲基硅烷基
tol	苯甲基
TosMIC	对甲基苯磺酰甲基异腈
Tr	三苯基
Ts	对甲苯磺酰基
TsOH	对甲苯磺酸

问题 初级编

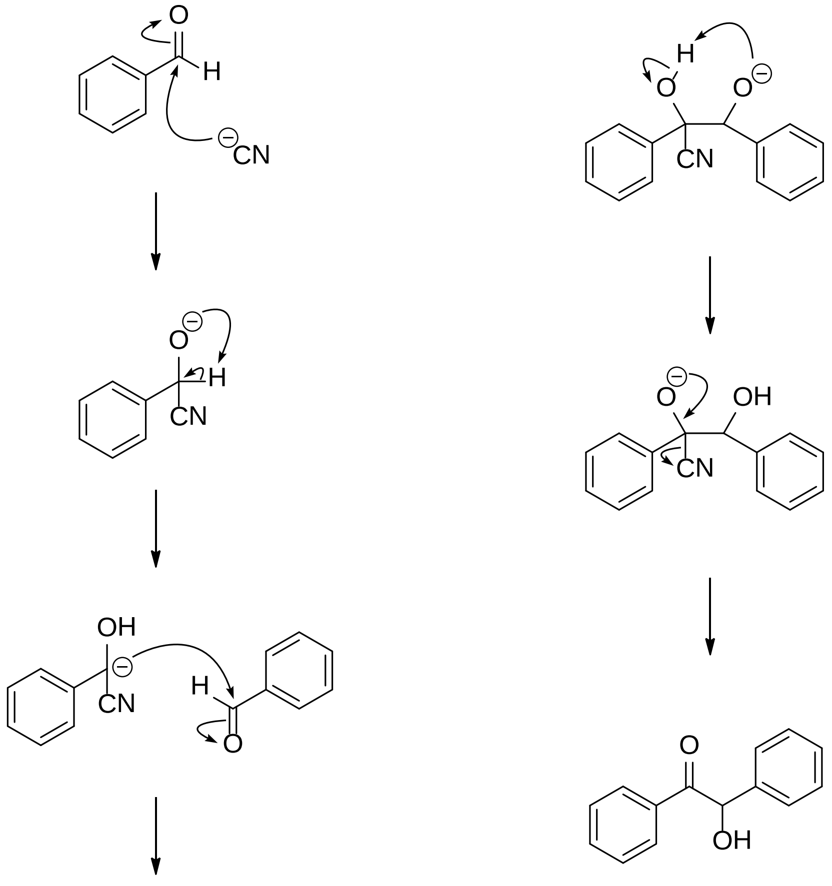
初级篇是以初学者的有机化学教科书中所提到的基础反应为主要成分。初学者需要根据教科书，每个人用手画出反应的箭头的同时，学习有机反应的想法的基础。即使是秒杀C组题的高手,乍看这样简单的东西也会有很多问题。请用心地将氢原子、电子这种细节统统画上,这是你能够充分理解并解开更难解决的问题的准备运动。

例 题 写出合理的反应机理



解 答

芳香醛偶联缩合



Adams, R; Marvel, C. S. *Org. Synth., Coll*. Vol. Ⅰ **1941**, 94

问 题 写出合理的反应机理

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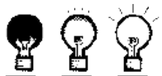

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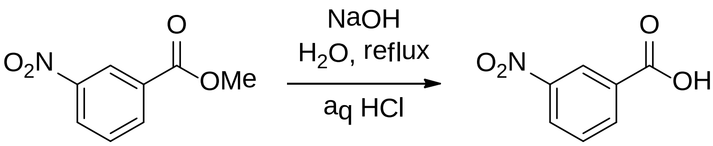

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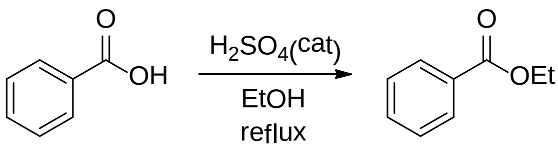

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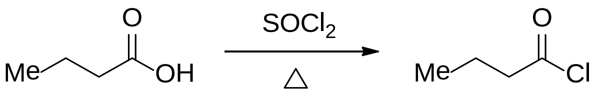

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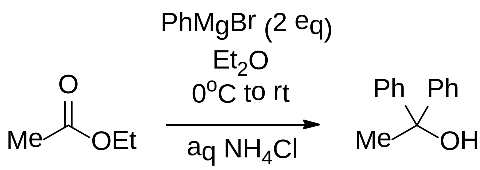

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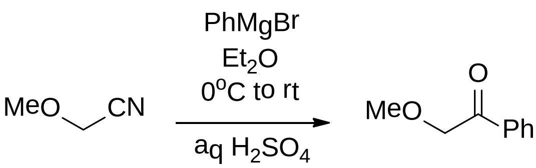

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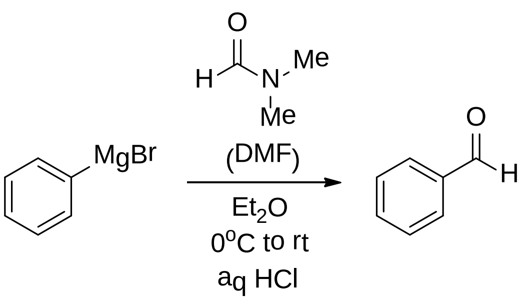

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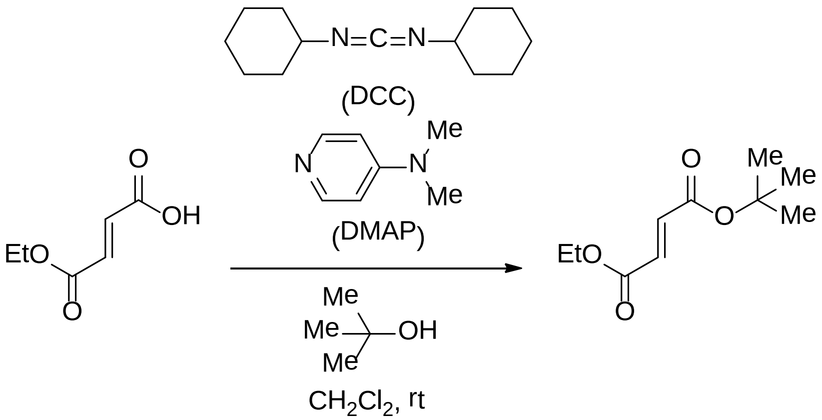

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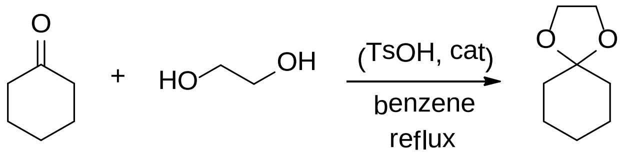

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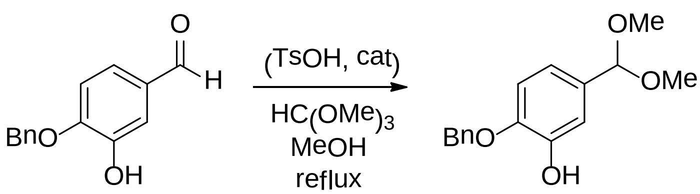

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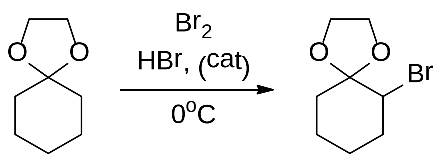

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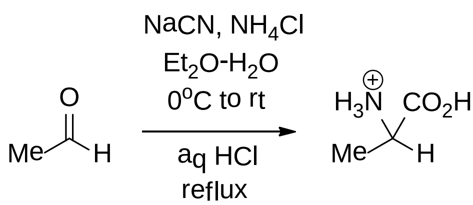

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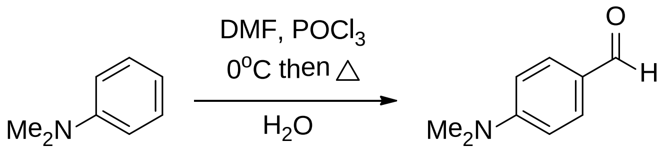

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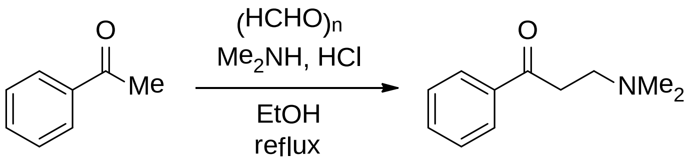

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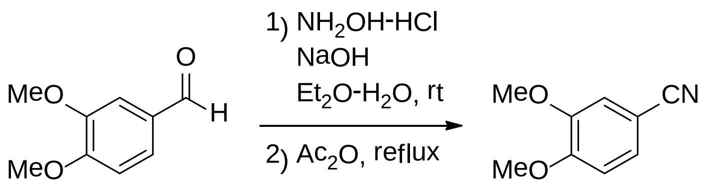

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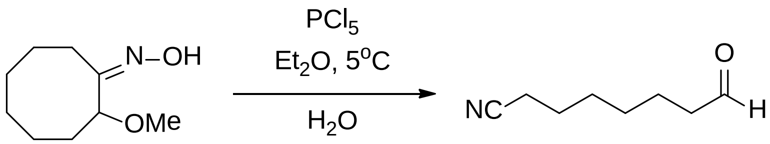

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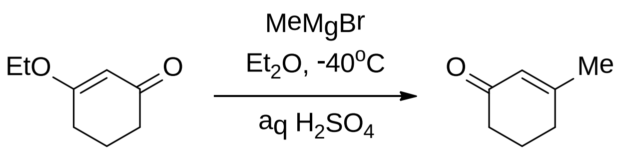

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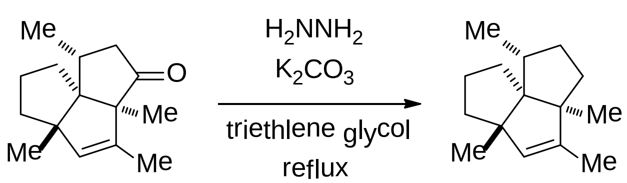

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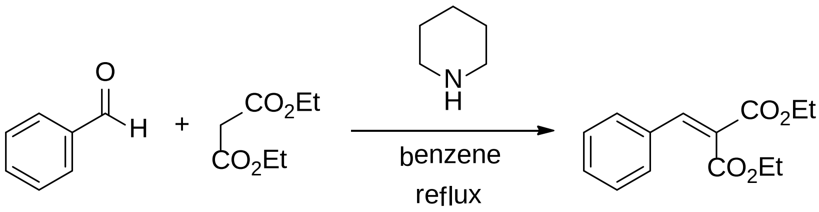

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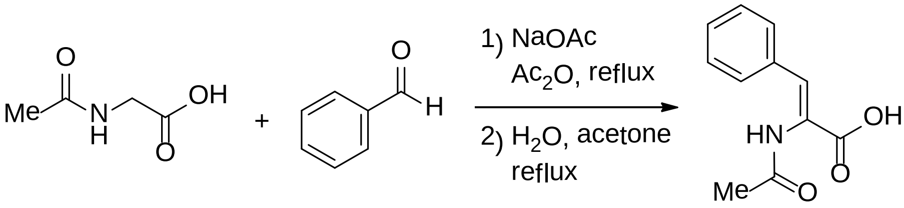

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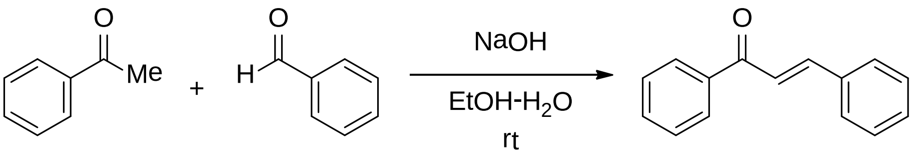

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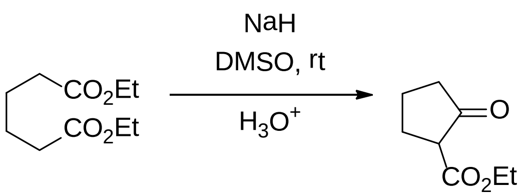

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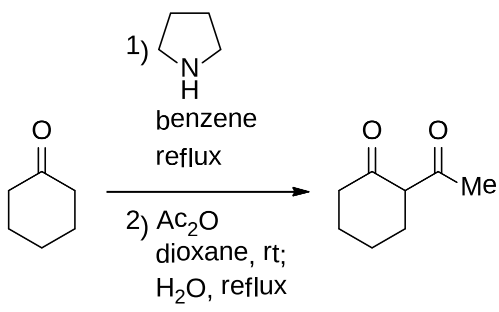

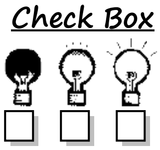

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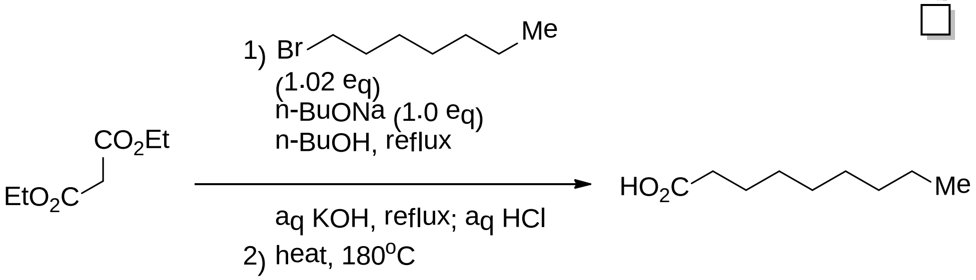

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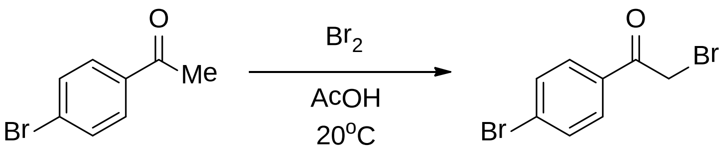

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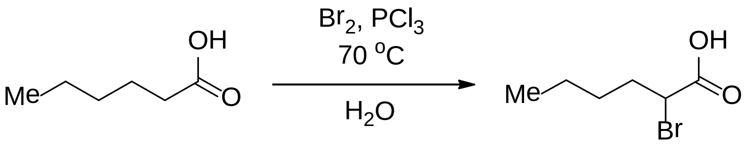

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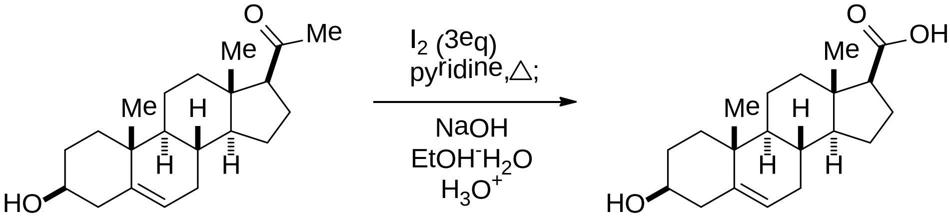

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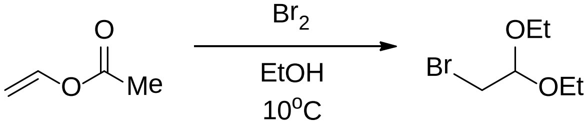

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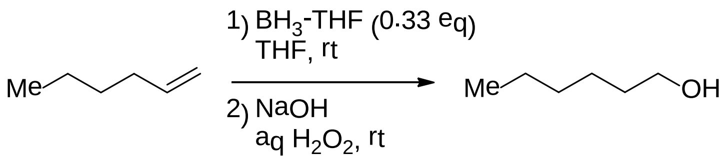

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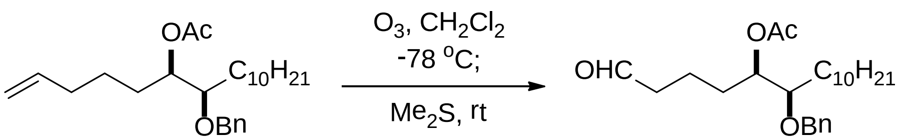

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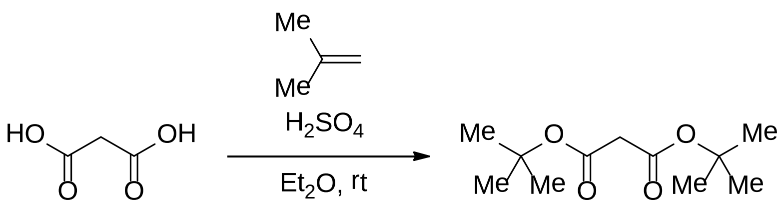

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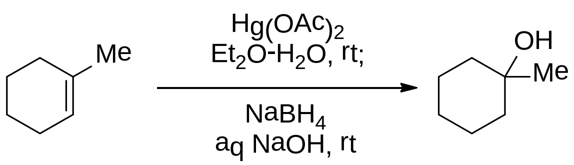

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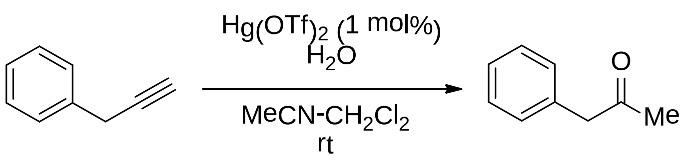

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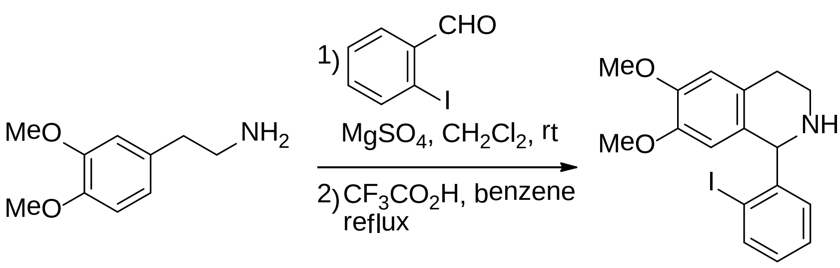

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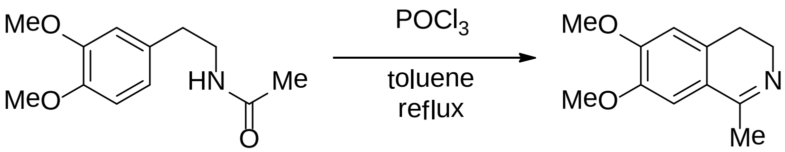

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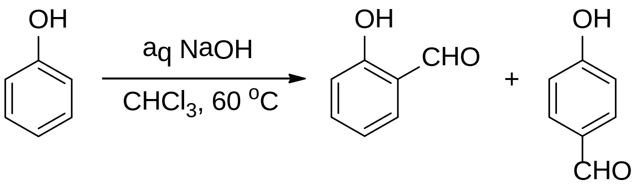

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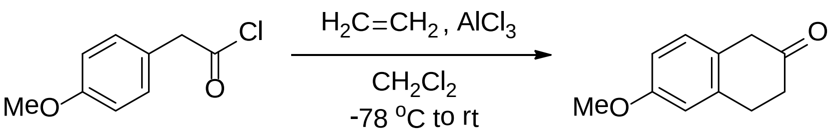

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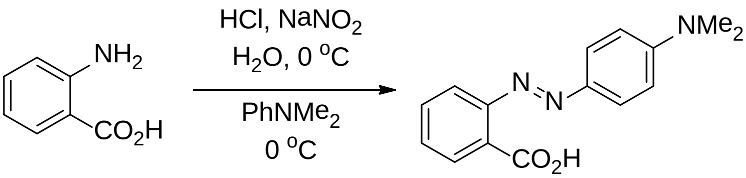

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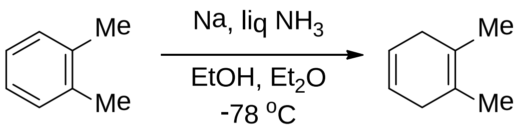

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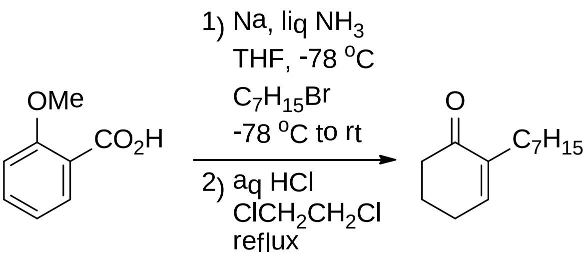

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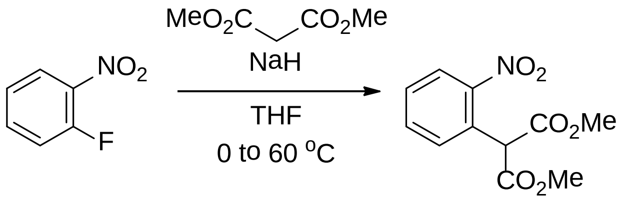

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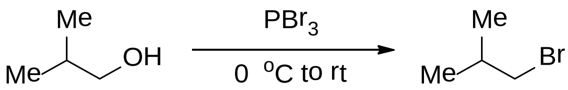

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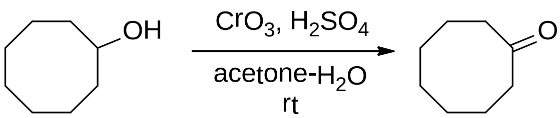

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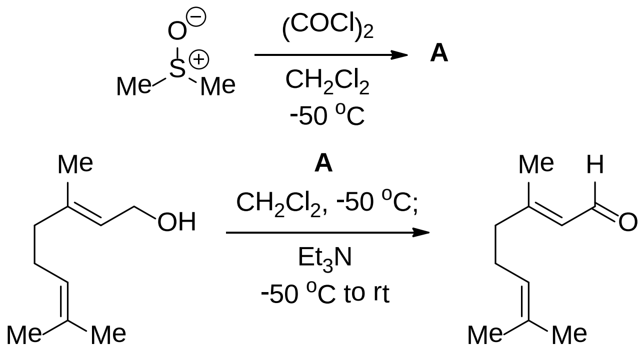

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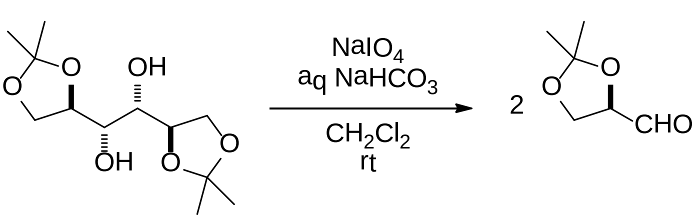

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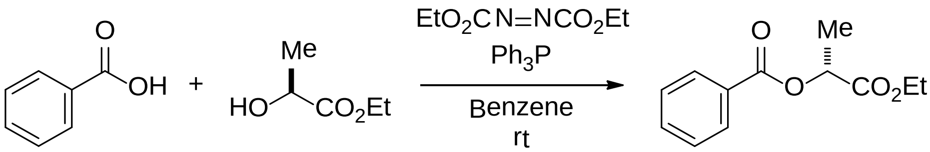

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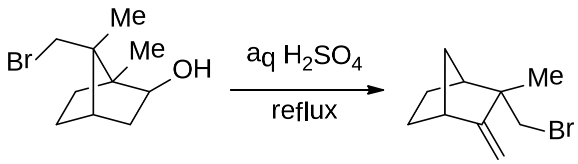

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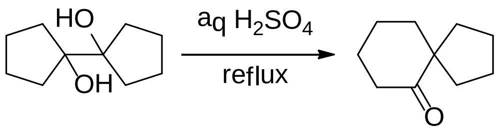

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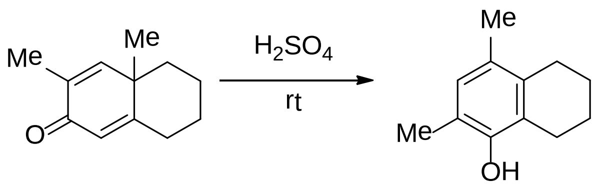

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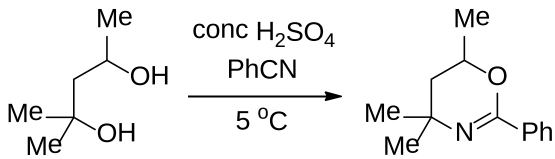

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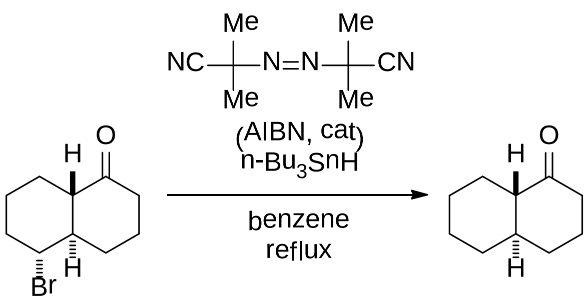

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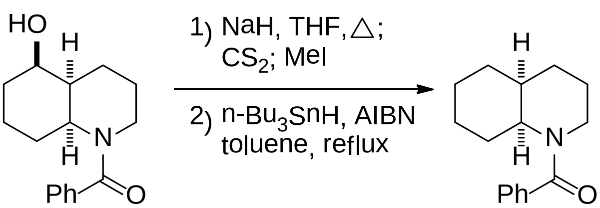

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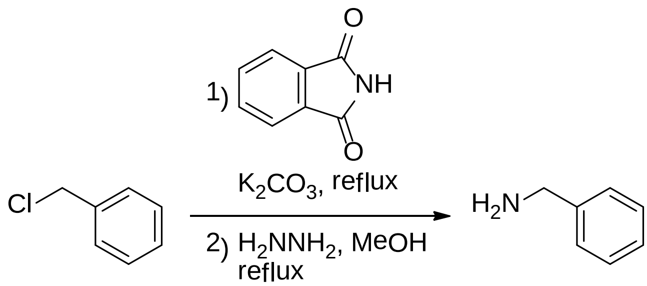

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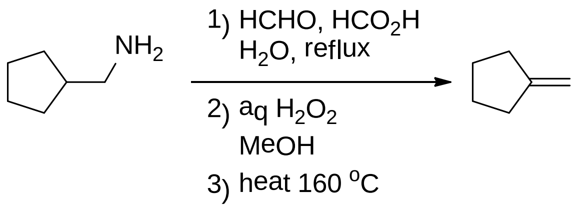

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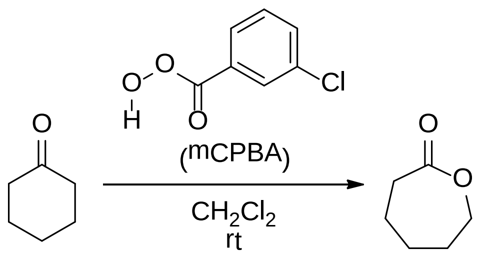

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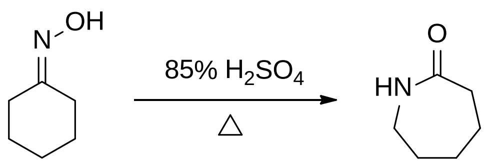

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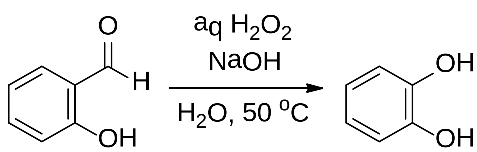

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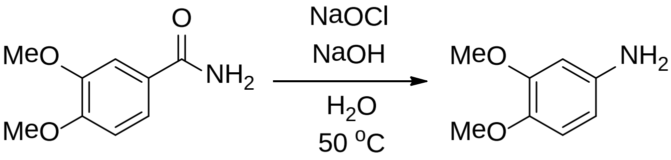

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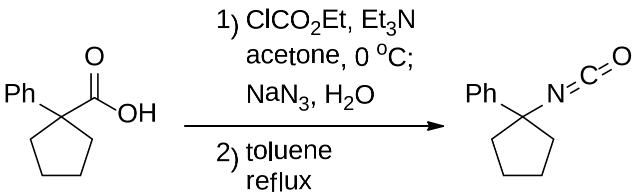

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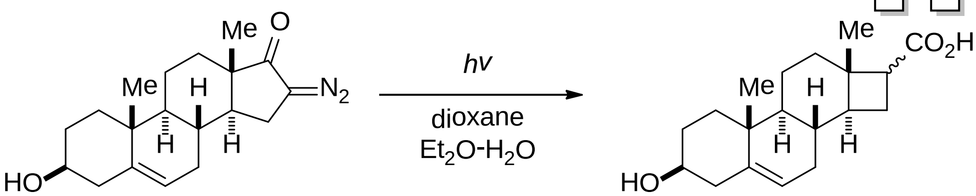

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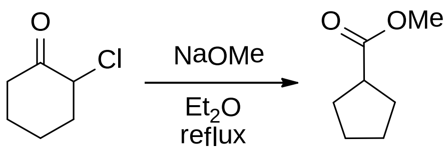

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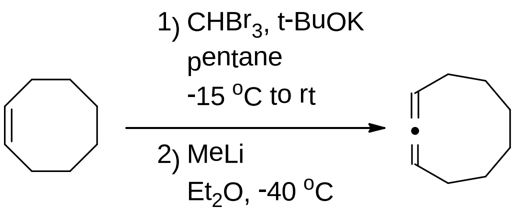

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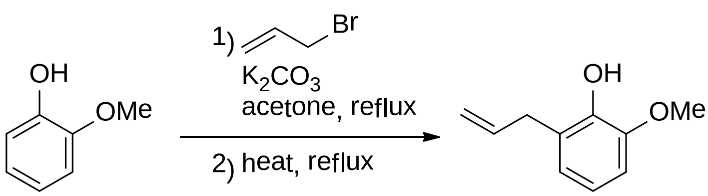

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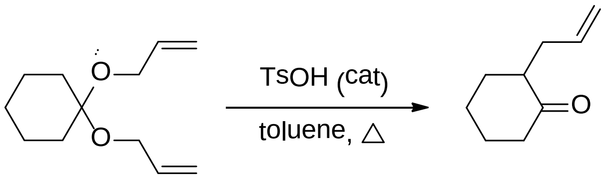

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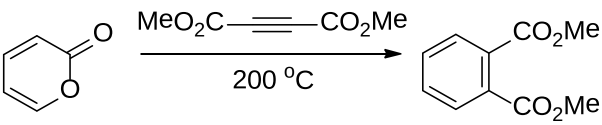

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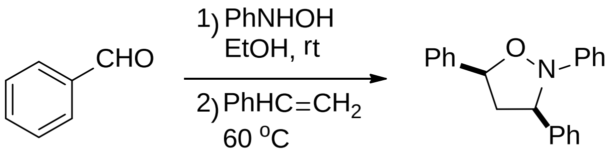

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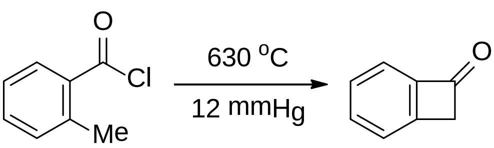

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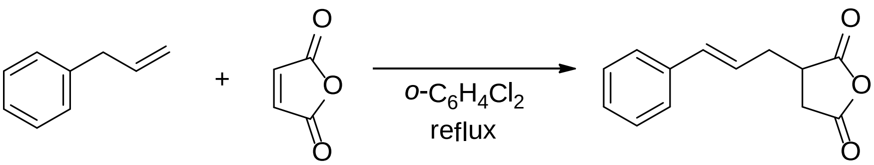

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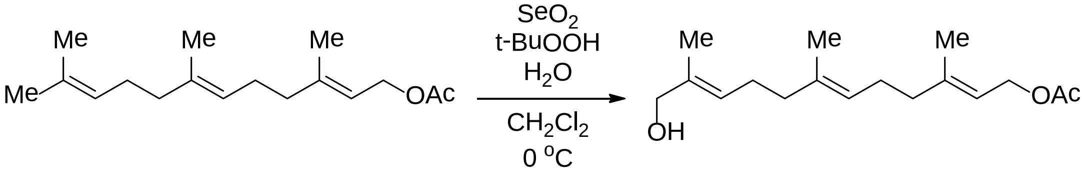

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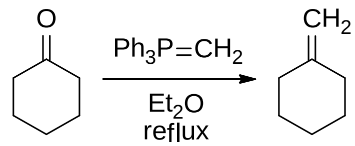

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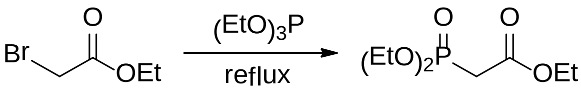

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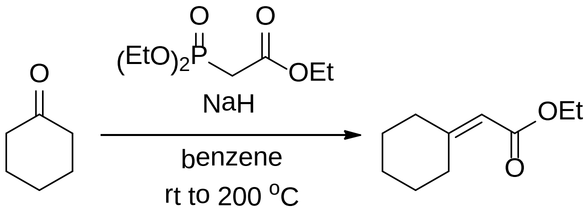

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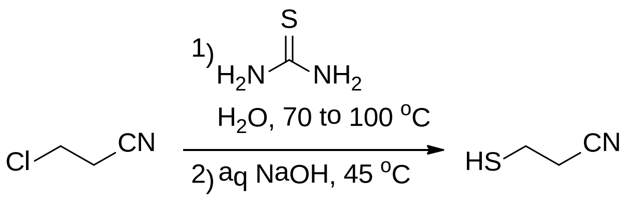

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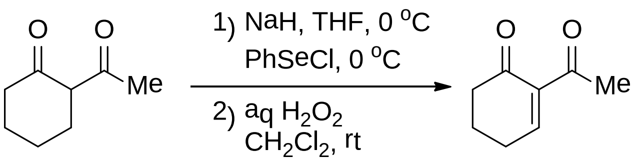

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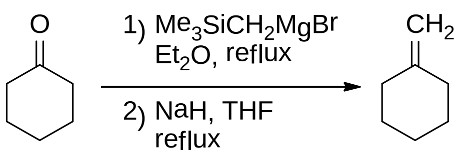

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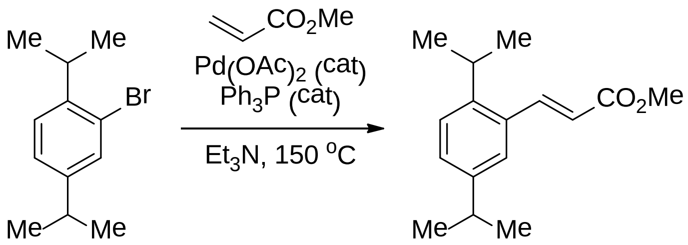

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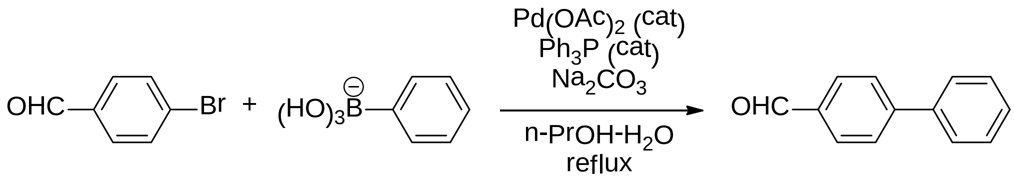

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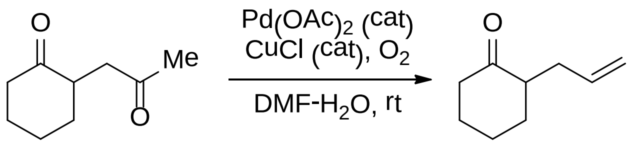

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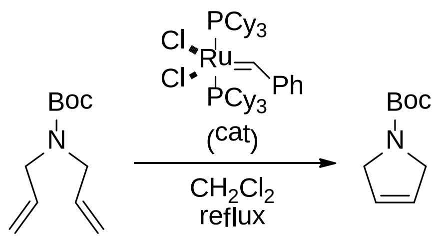


◆专栏①◆

福山研究组

会议景象

福山研究室用每周一次小组会议的时间，对反应机理的问题进行练习，练习时，手脑并用。所以学生的书写的训练十分有效。国内外有些有机化学实验室，也有不少东西是参考本研究室的练习，想通过本研究室将练习方法介绍过去。

首先，问题是在前一周被事先分发，靠自己将这一周题解答。当然，如果不明白反应剂之类的东西可以通过参考书查询——但是这是在不允许学生之间交流，自己出题的前提下。这样可以让大家快速的解决结构式与简式在题目中不同的问题。这样做是为了提升效率，不浪费时间。如果谁出现一次出题失误，就征收谁一次100日元的罚金，聚集的钱就算是忘年会的时候的酒钱了。

当时研讨会上出问题，会有四个人走上黑板前，能够得意洋洋的书写答案。这不错，不过即使没有解开问题，在黑板前尴尬地站着，也是一种修行——在那里，你的尴尬能够鼓励你下次要奋发图强，如果又经历了这样的问题，就有了经验。强烈留在记忆中的答案会超越你的想象。

在出题方提示“已经15 ~ 20分钟了，时间有限”后，出题人就会进行以参考论文为基础的解说。

于是反应机理被详细讨论。如果和论文记载反应机构不同的问题也可以考虑。那个时候将有可能。包括老师在内的全部讨论不一定是正确回答，所以一定要考虑各种可能性，才能更好的学习。

这些问题主要是让学生按顺序出题的。倘若不熟悉这样的套路的学生出不了几个问题来。所以出题的几周前他们就开始骚动——与图书馆山一般的论文搏斗。好不容易发现一个挺好的问题，拿给前辈看，得到的却是“这个问题已经说了”“这还算个什么问题”等严厉的语言。不过与此同时，他们自身的能力也在提高。为了找到更多的问题他们不得不读更多的论文，并且适应这种简单而枯燥的工作。平时仔细阅读论文，却怎么也出不了问题，只留下一双双悲伤的眼神。

问题的答案交流放在在小组讨论后。负责的学生要清理研究室并把文件保存成各种文件和PDF。由于主页的各种原因，不予更新，但也有一定参考作用。

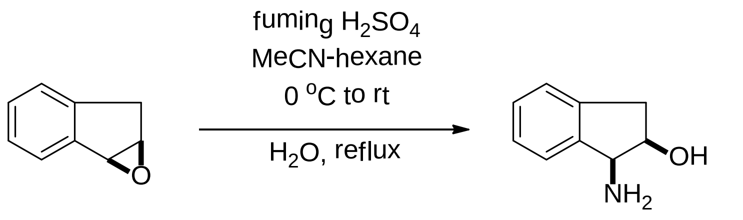
福山研究室地址

http://www.f.u-tokyc.ac.jp/-fukuyama/index-l.htm

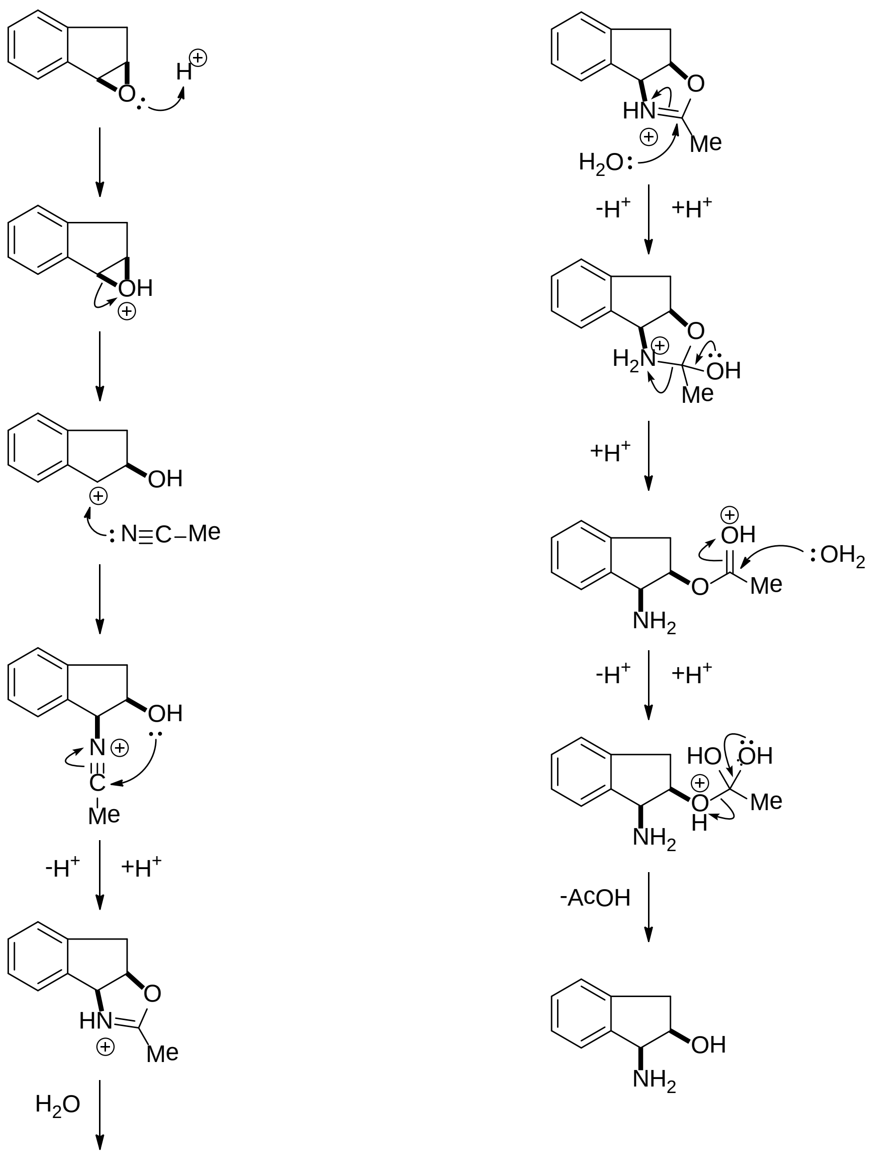
问题 中级编

中级编是研究生院入学考试与研究生院硕士课程的水平的问题，还有大量有趣的人名反应的反应机理，如果分段来说中，前半部分的问题比较基础，后半部分是以发展性的问题为作为中心，可能后半部分问题做起来很没手感，因为有些包含了有机合成化学的公式，希望你能把这些反应机理都写出来。

例 题　写出合理的反应机理



解 答



Jacobsen, E.N. *Org. Synth, Coll*. vol Ⅹ **2004**. 29

问 题 写出合理的反应机理

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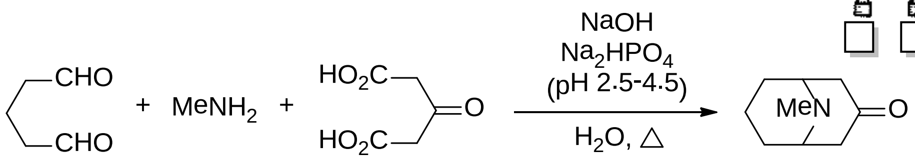

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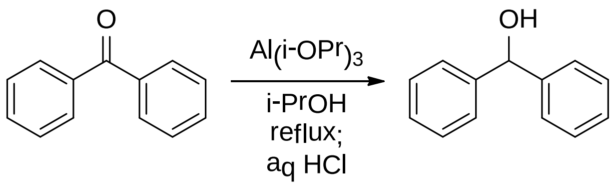

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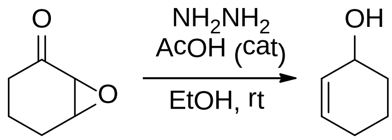

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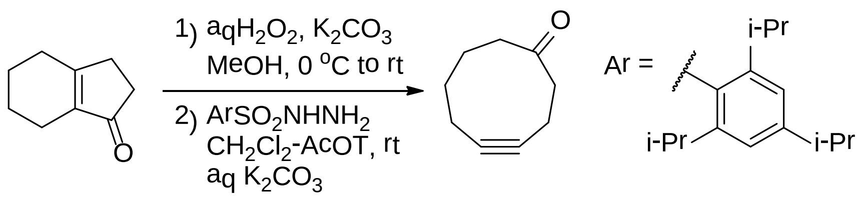

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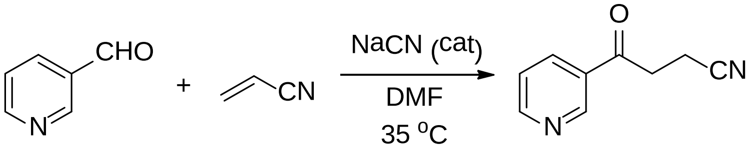

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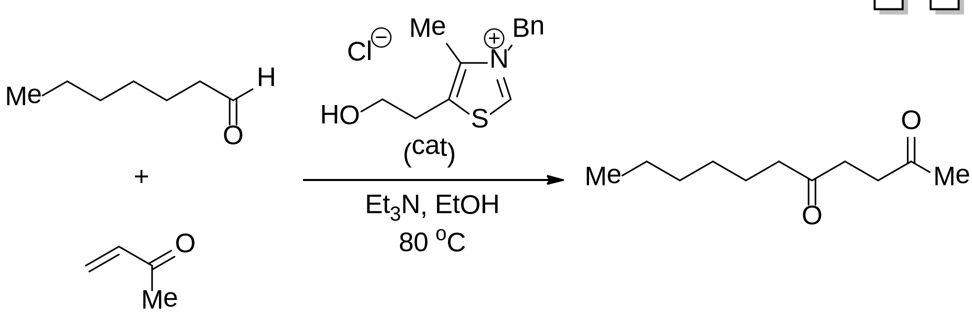

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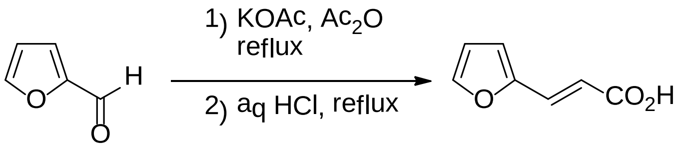

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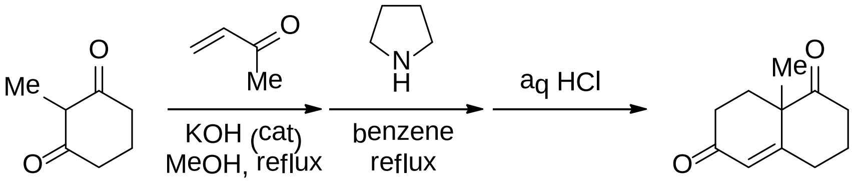

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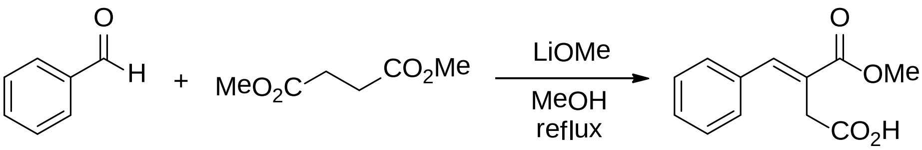

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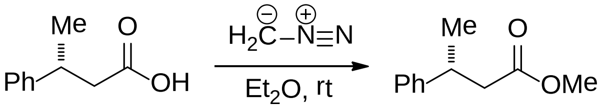

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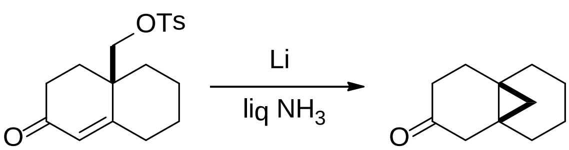

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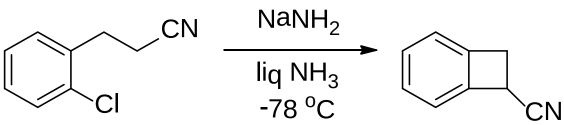

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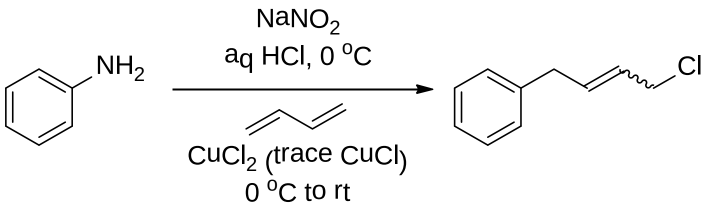

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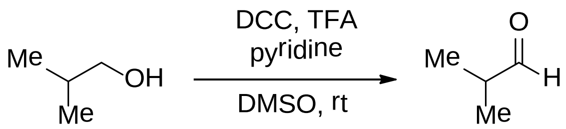

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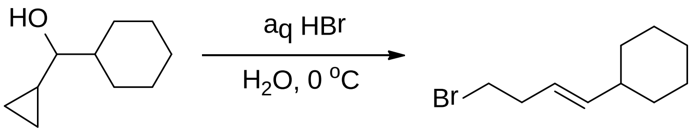

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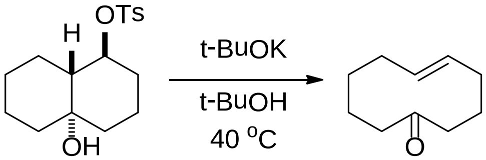

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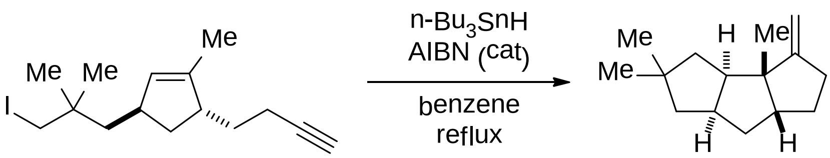

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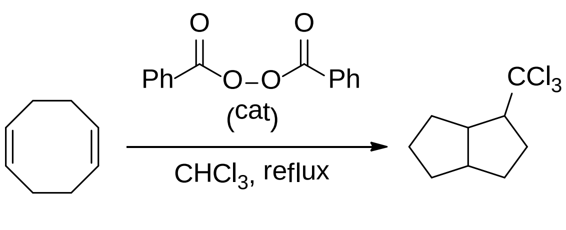

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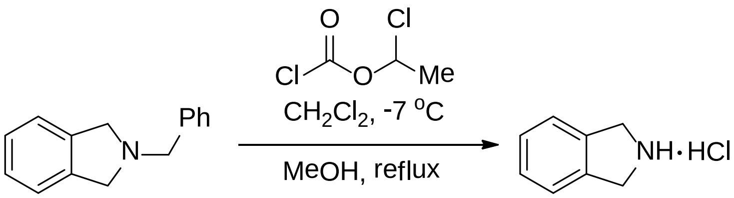

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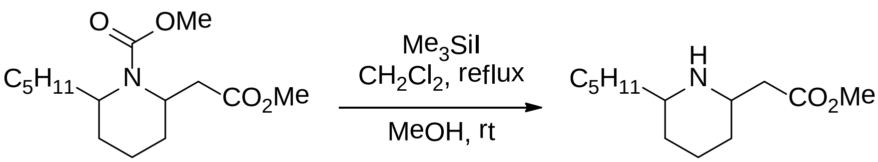

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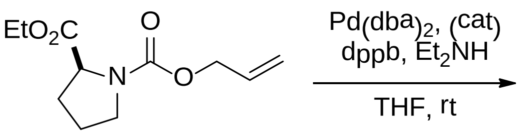

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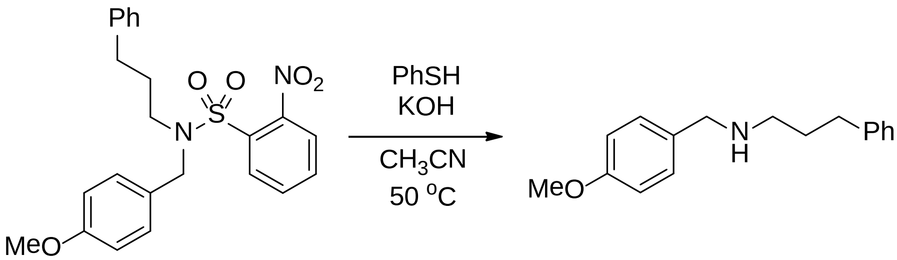

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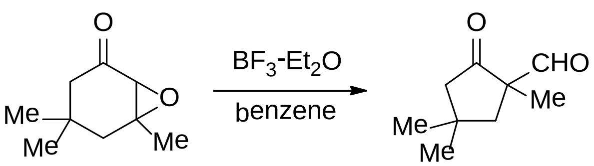

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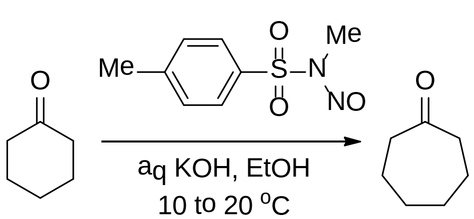

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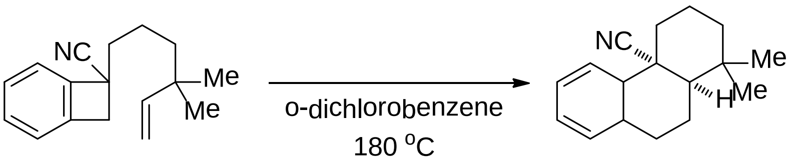

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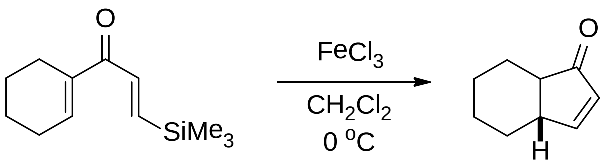

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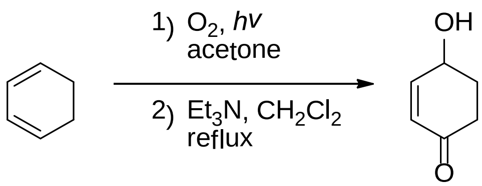

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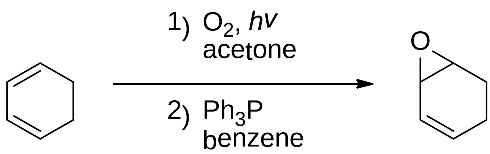

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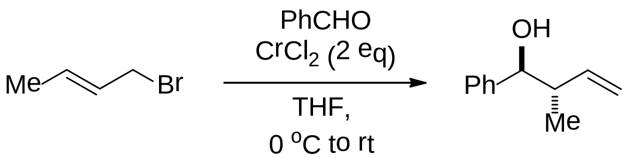

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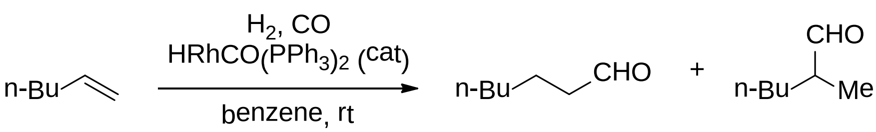

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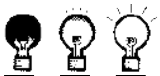

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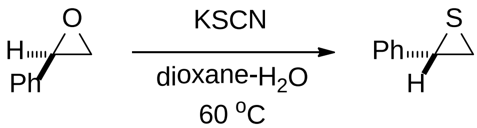

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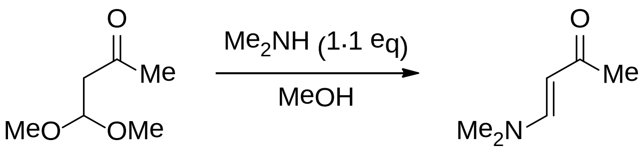

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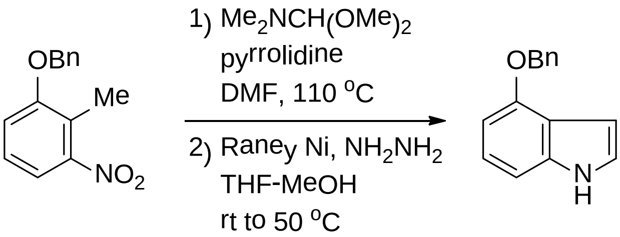

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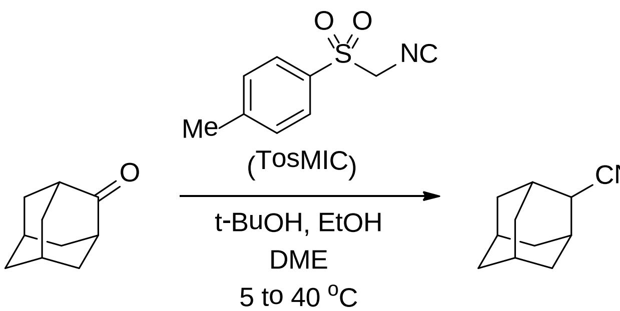

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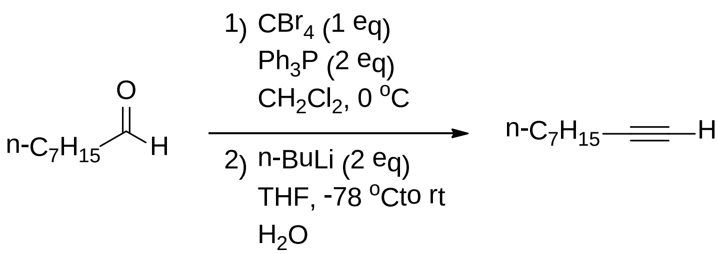

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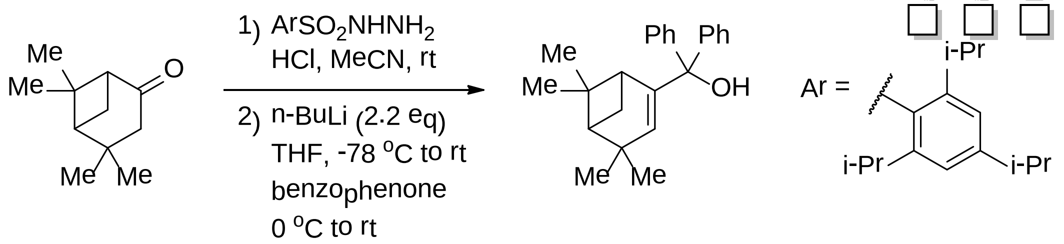

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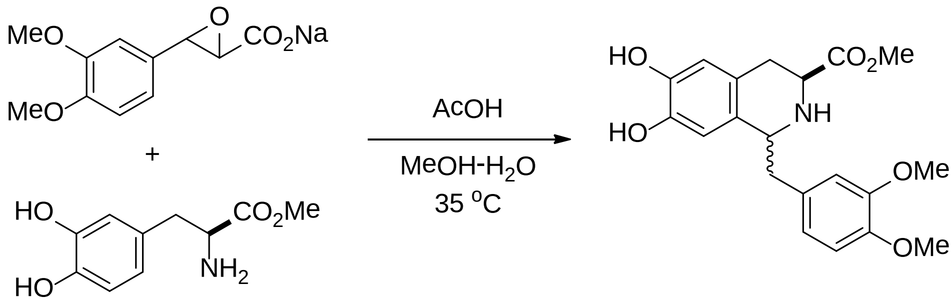

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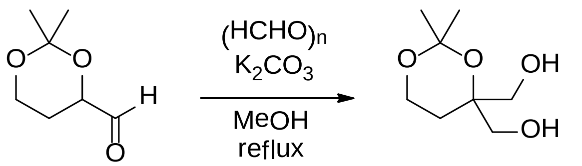

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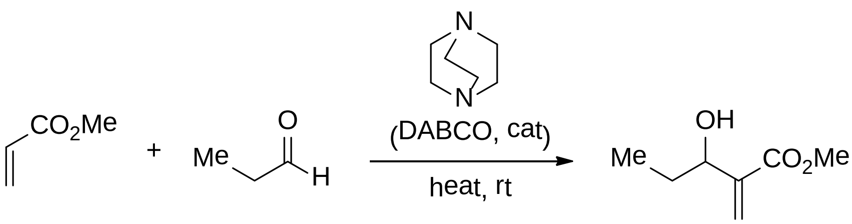

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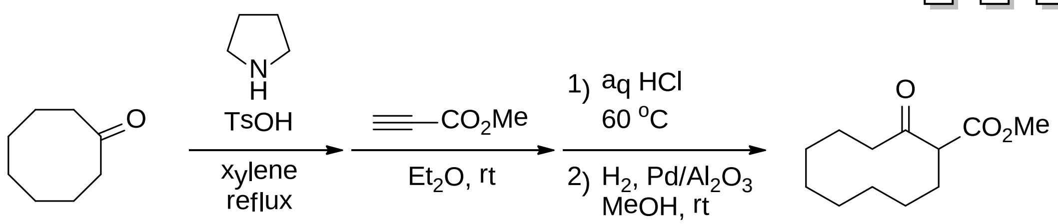

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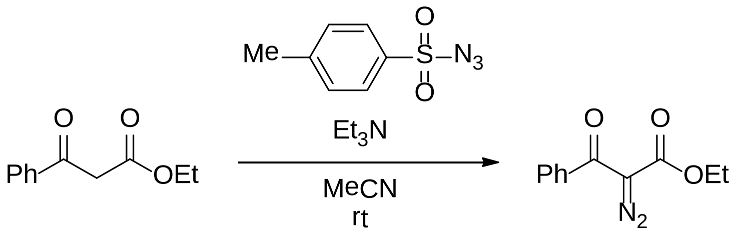

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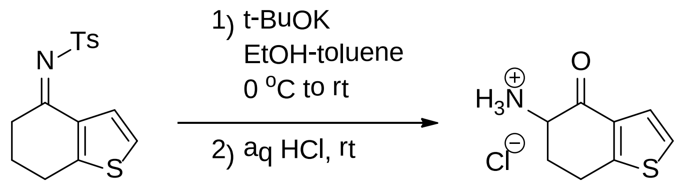

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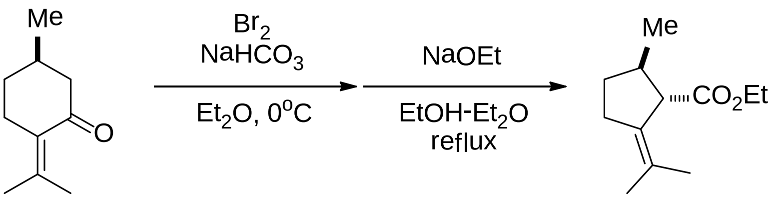

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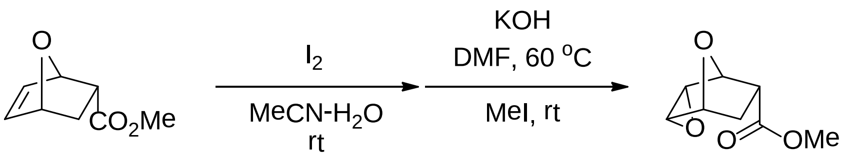

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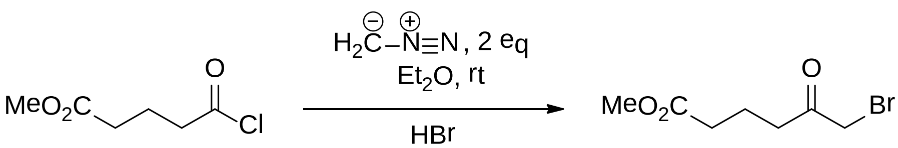

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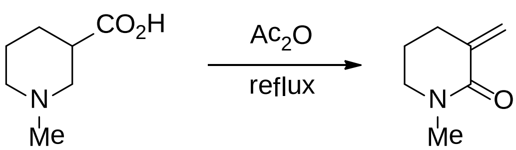

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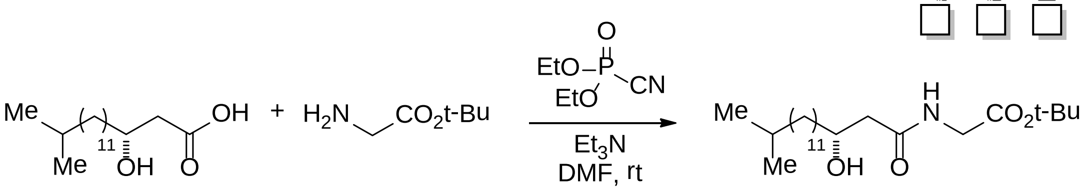

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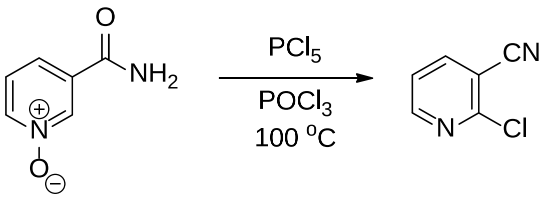

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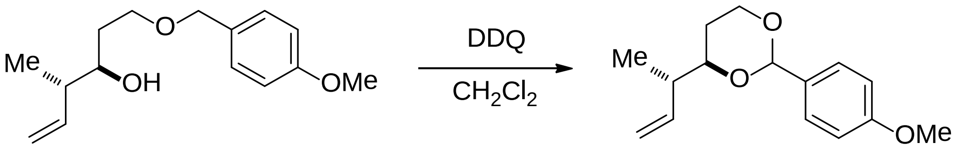

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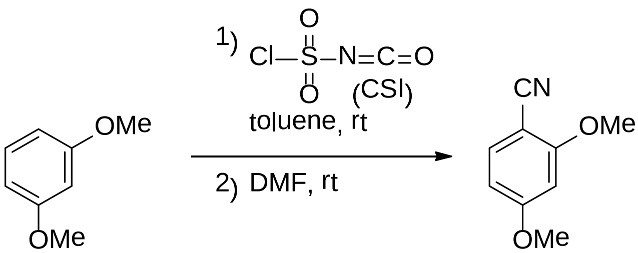

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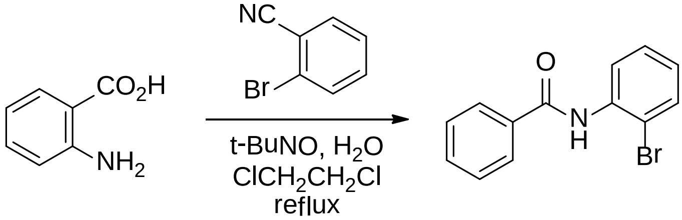

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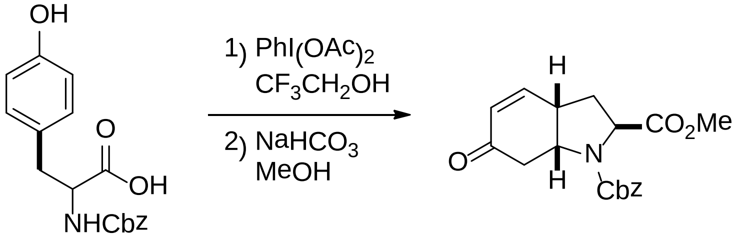

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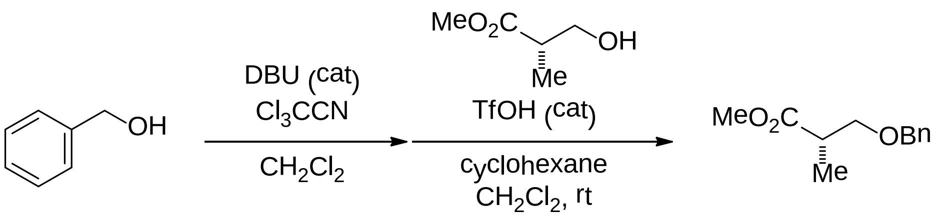

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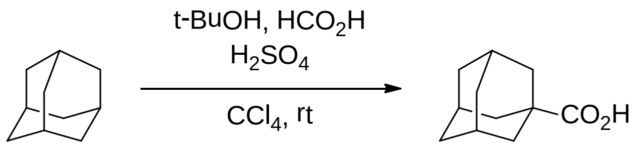

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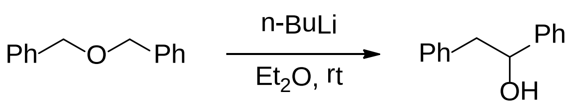

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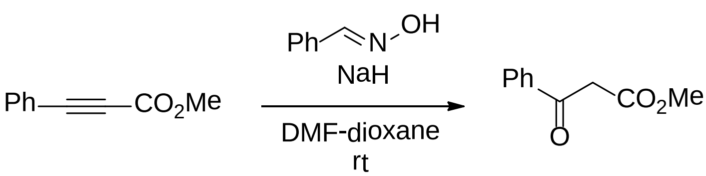

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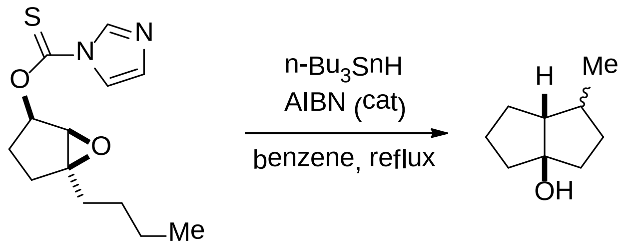

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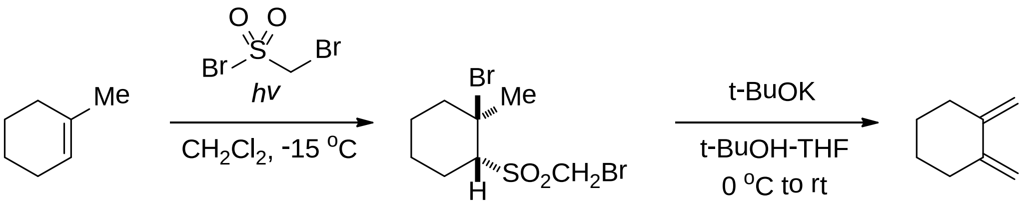

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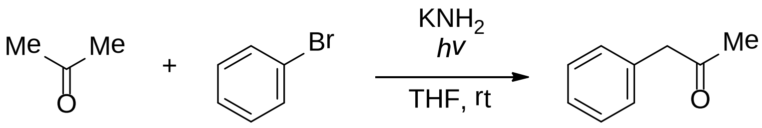

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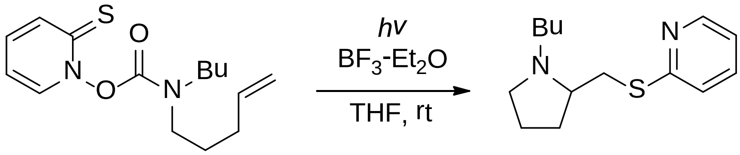

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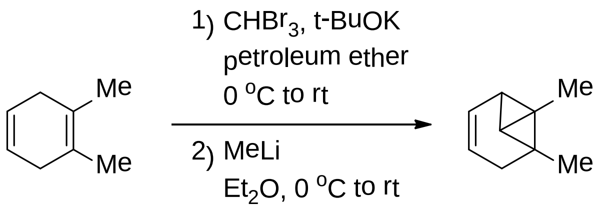

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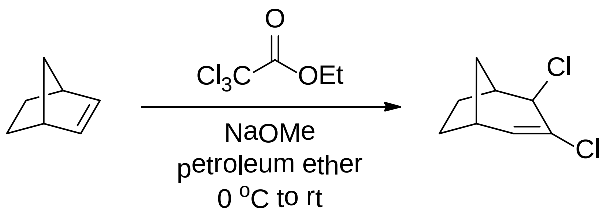

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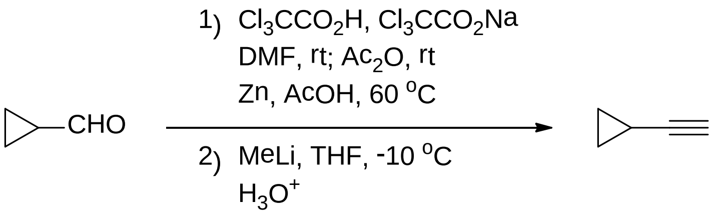

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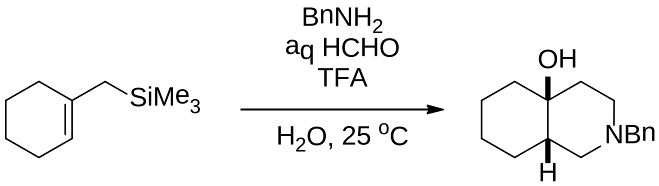

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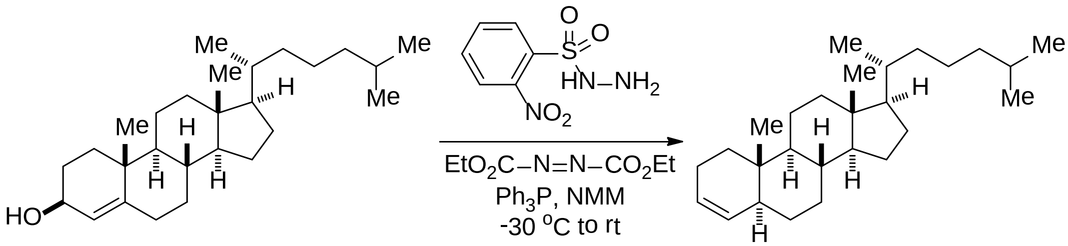

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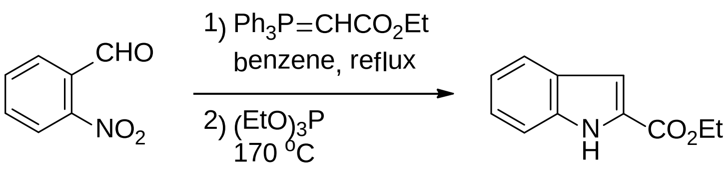

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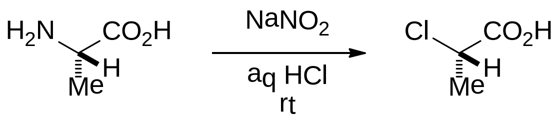

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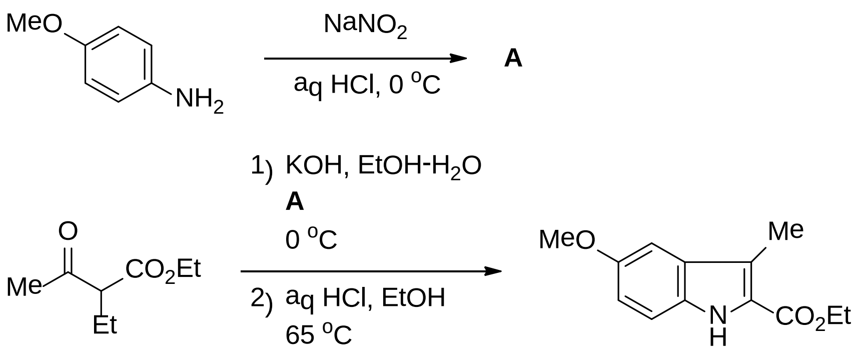

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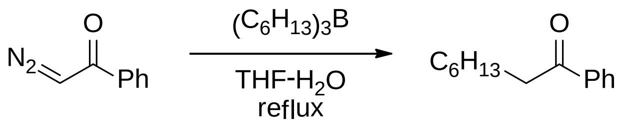

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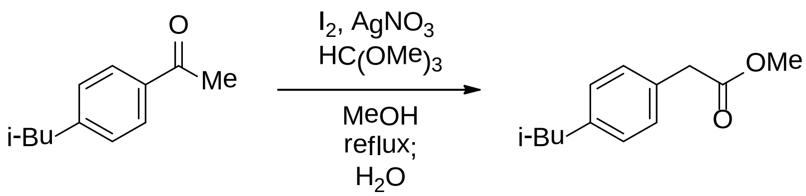

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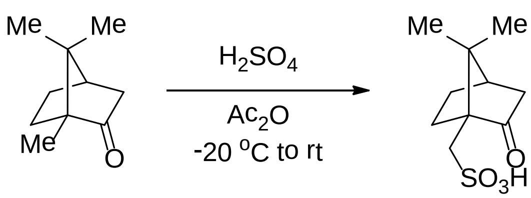

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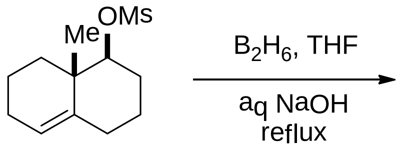

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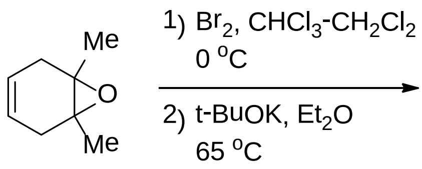

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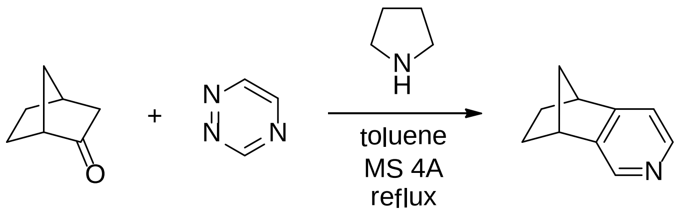

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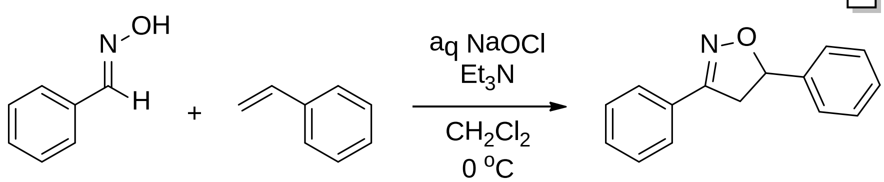

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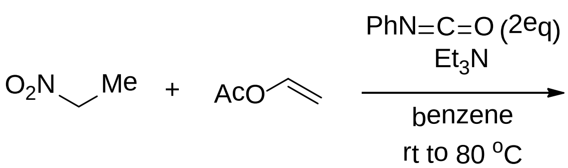

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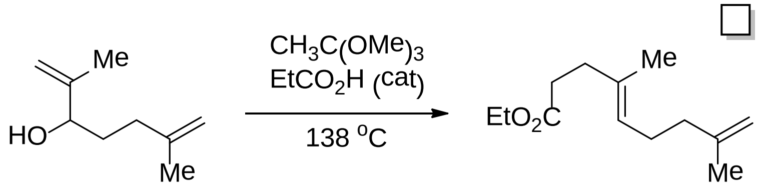

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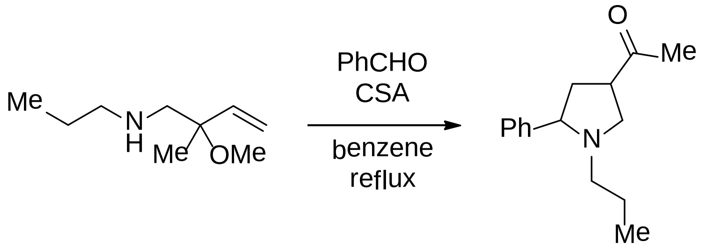

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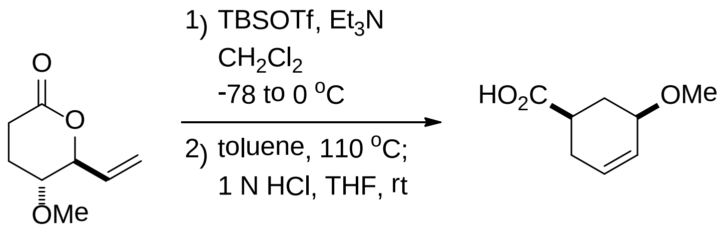

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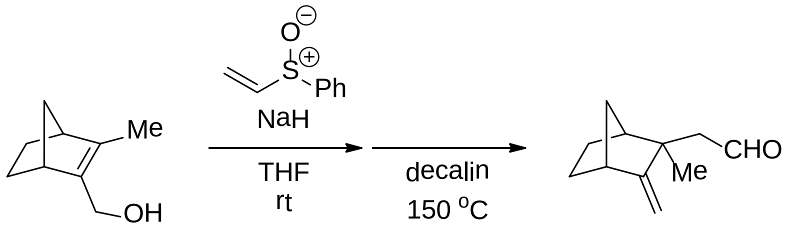

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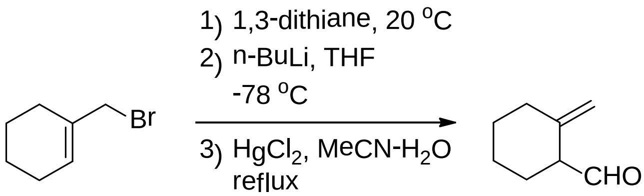

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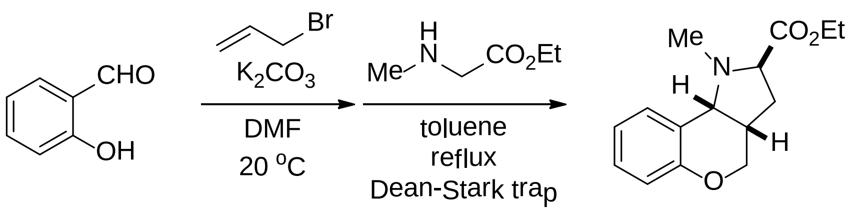

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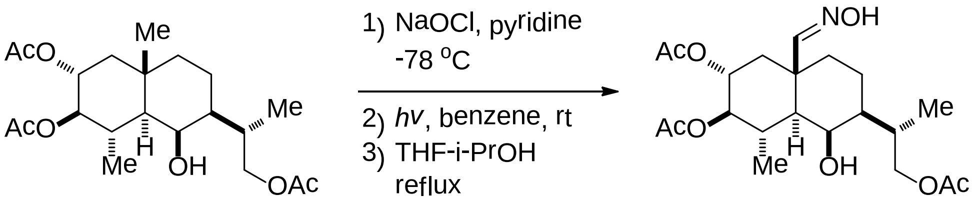

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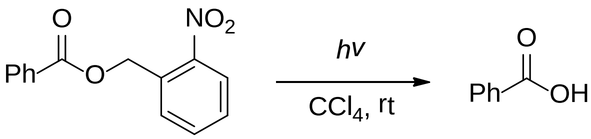

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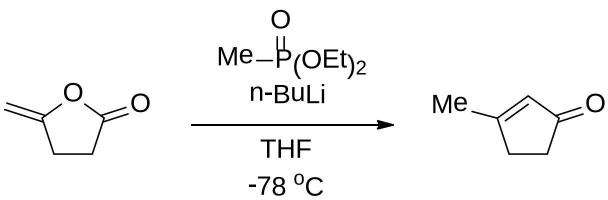

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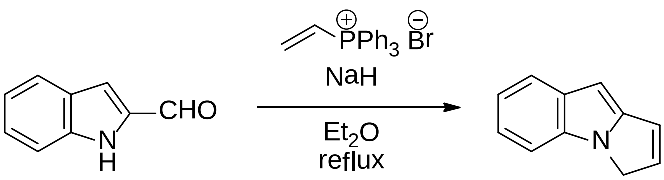

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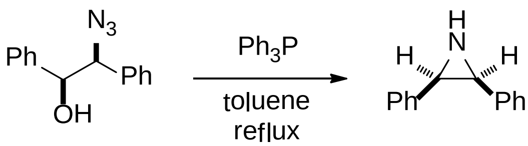

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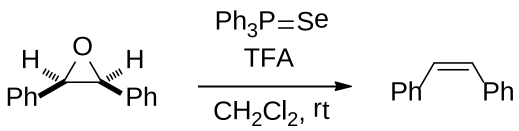

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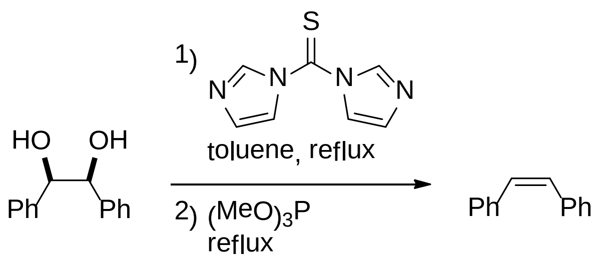

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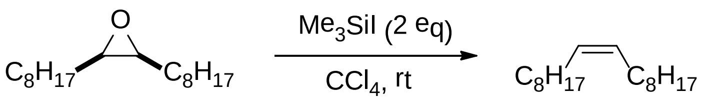

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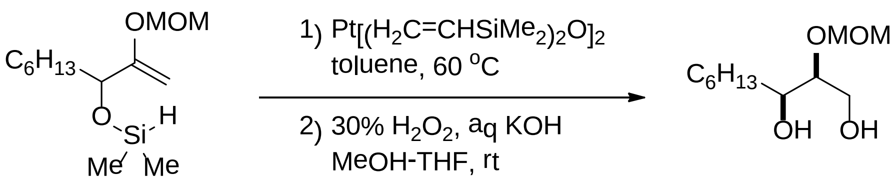

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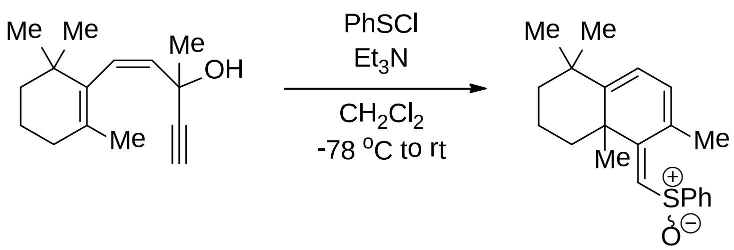

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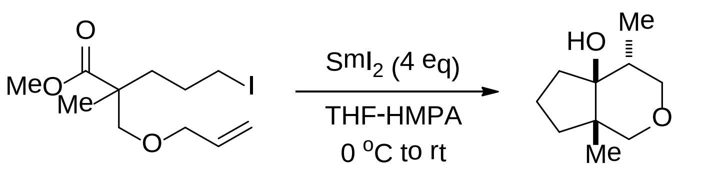

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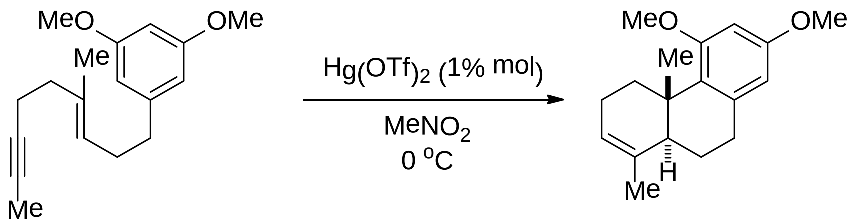

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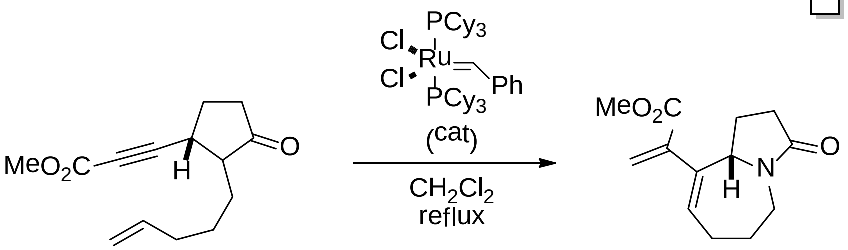

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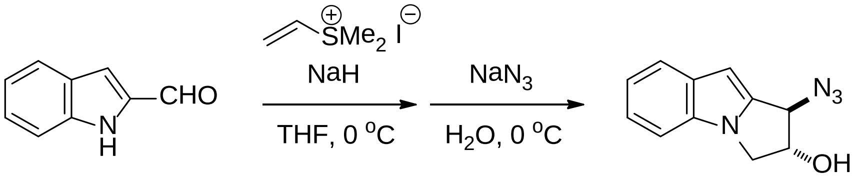

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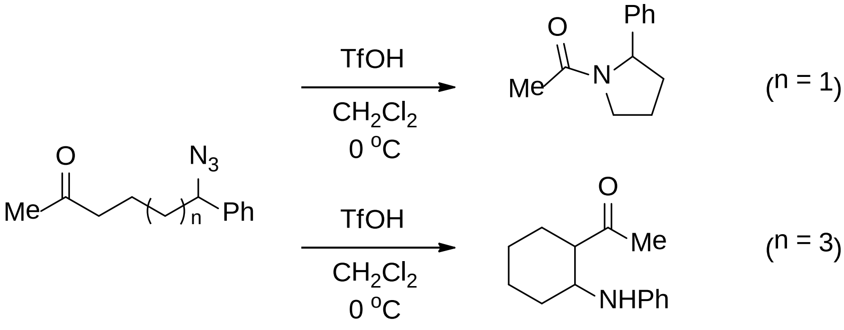

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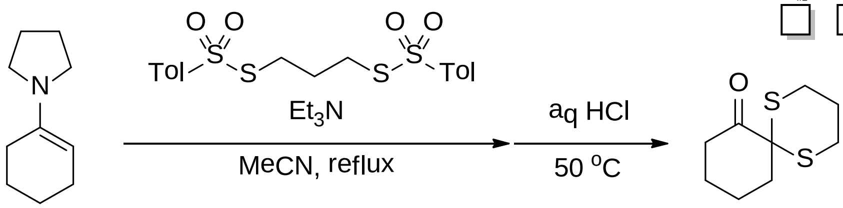

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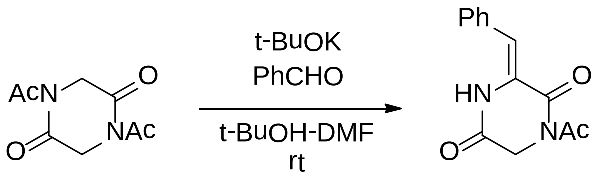

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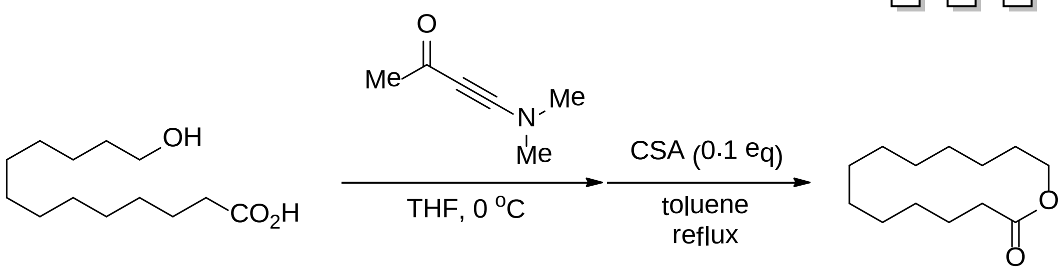

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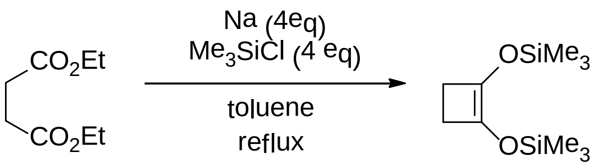

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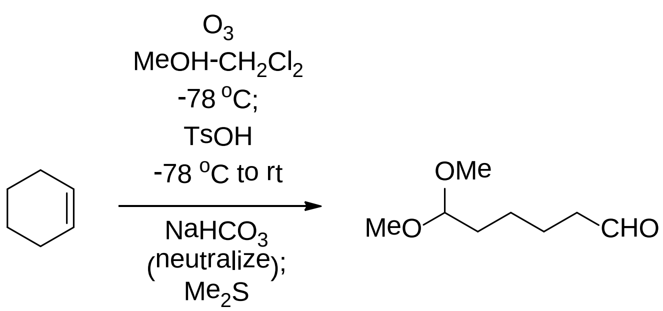

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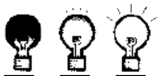

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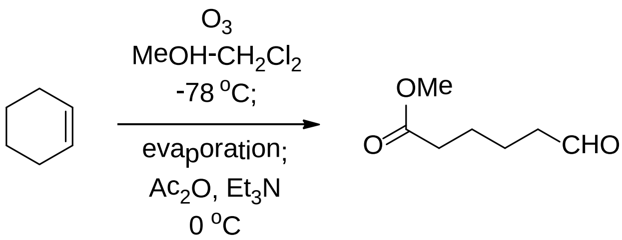

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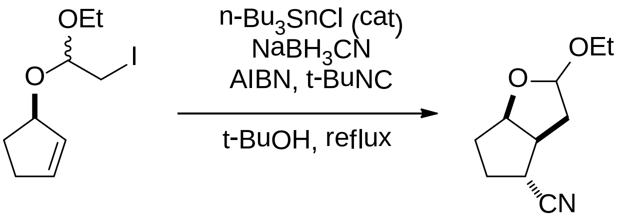

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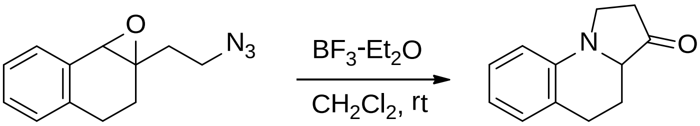

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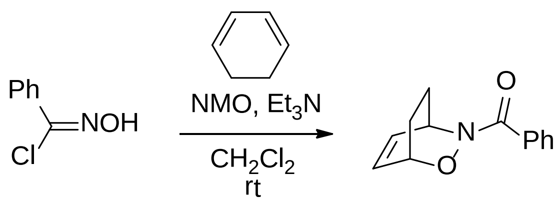

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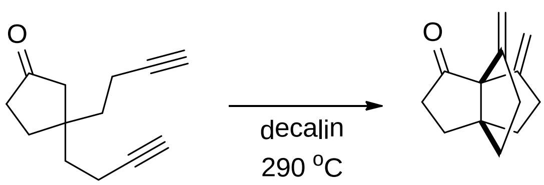

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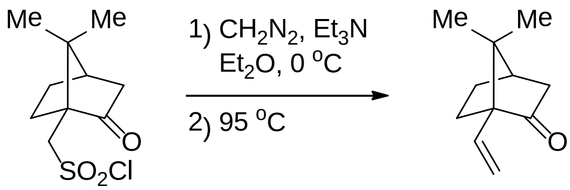

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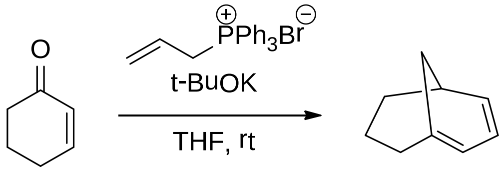

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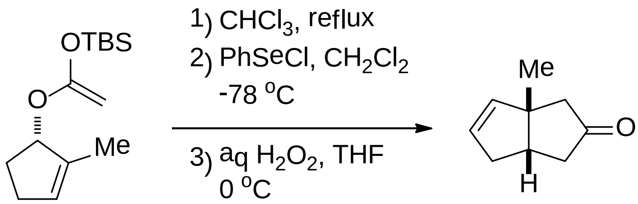

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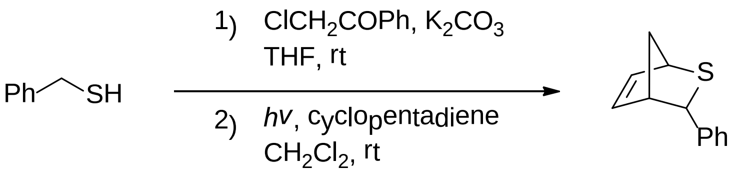

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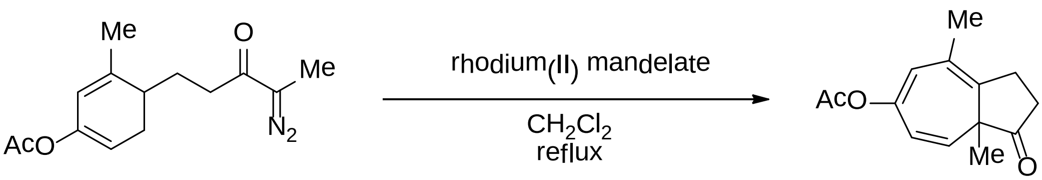

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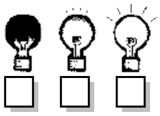

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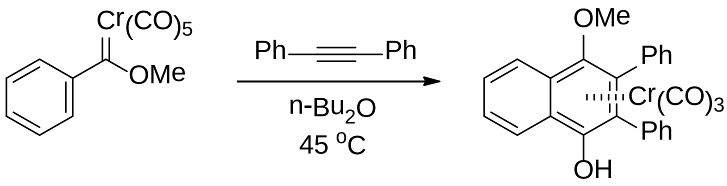

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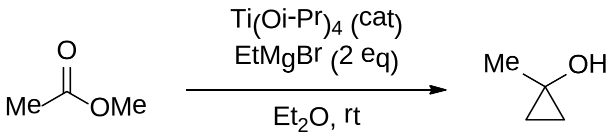


◆专栏②◆

机理书写问题的解决方法

关于解开反应机理的问题，在附录里也叙述了一样的基本的化学知识，当然本章也有一些额外的技巧。

1. 写好有机化学的结构式

写好有机化学中的结构式是一件很容易的事。需要做的就是在解决问题的时候，把当前所想到的结构式，统统写下来。无论是在脑子里出现的结构式、还是在眼前浮现的结构式，在纸上把它们写下来对下一步的推理肯定有用处。另外请一定要仔细地、用心地写好反应后的结构式，因为在分子在反应中不断长大的同时，有时有一些不起眼的官能团会被我们一不小心就省略了。最后，在实际的合成中，反应条件是根据整个分子的结构来设计的，请一定要好好看完整分子的结构，不要漏掉什么反应的重要条件。

中间体的书写方面也需要你用心去想，在头脑中想出合理的反应机理。实际上如果你只写出起始的原料和产品，你就会养成这样的坏习惯.这会导致你在反应的重要的转折点中的中间体会错过很多个结构式，因此，在每个中间体中最好请画上三个箭头。

2. 预先知道反应剂是什么

在完全不知道的反应剂的使用的方法的情况下，想要解决那种问题是很难的，关于反应剂，我们需要某种程度上的必要的的知识，所以，请多看资料书，以了解它们的用处。在反应机理的书写中的反应剂非常重要，如果不知道反应剂的作用可以类比其他已知的反应剂来书写机理。调查出反应剂的作用不只是为了解决这一个问题，是为了解决以后更多机理的书写问题打下基础。

3. 考虑多种可能性

实际的反应机理不只是单纯的一条，而是有无数的分歧点与无数的可能性。在多种可能性中考虑出即将书写的反应机理优先顺序与选择性是非常重要的。如果发现自己考虑的那种可能性不太恰当，就在分歧点中仔细观察分子的完整结构，找出下一步的反应方向。观察反应物与生成物的结构对于机理的书写很是有用。尤其是从生成物逆推，能轻松地找出几个重要的中间体来。

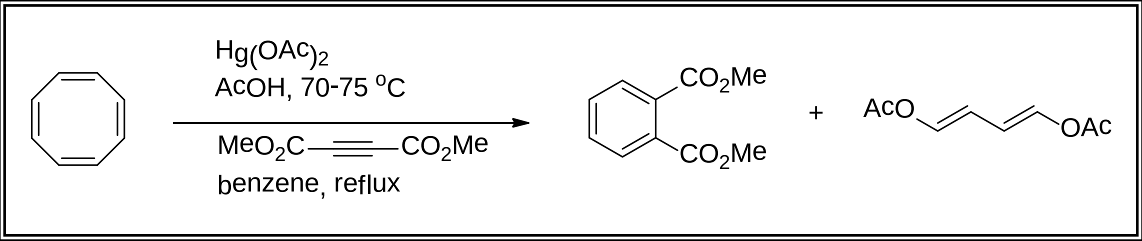
4. 试着开始数反应点

解决问题的过程中，如果突然在这种时候卡住了，可以数一下反应点。如果只有五六个原子的分子在反应，大多数发生的就是分子内反应。本研究室中如果有那样问题都想不出来学生的话，我们称之为“幼儿园没毕业的傻瓜”。毕竟幼儿园里还不会数数的小孩子都是屈指可数。

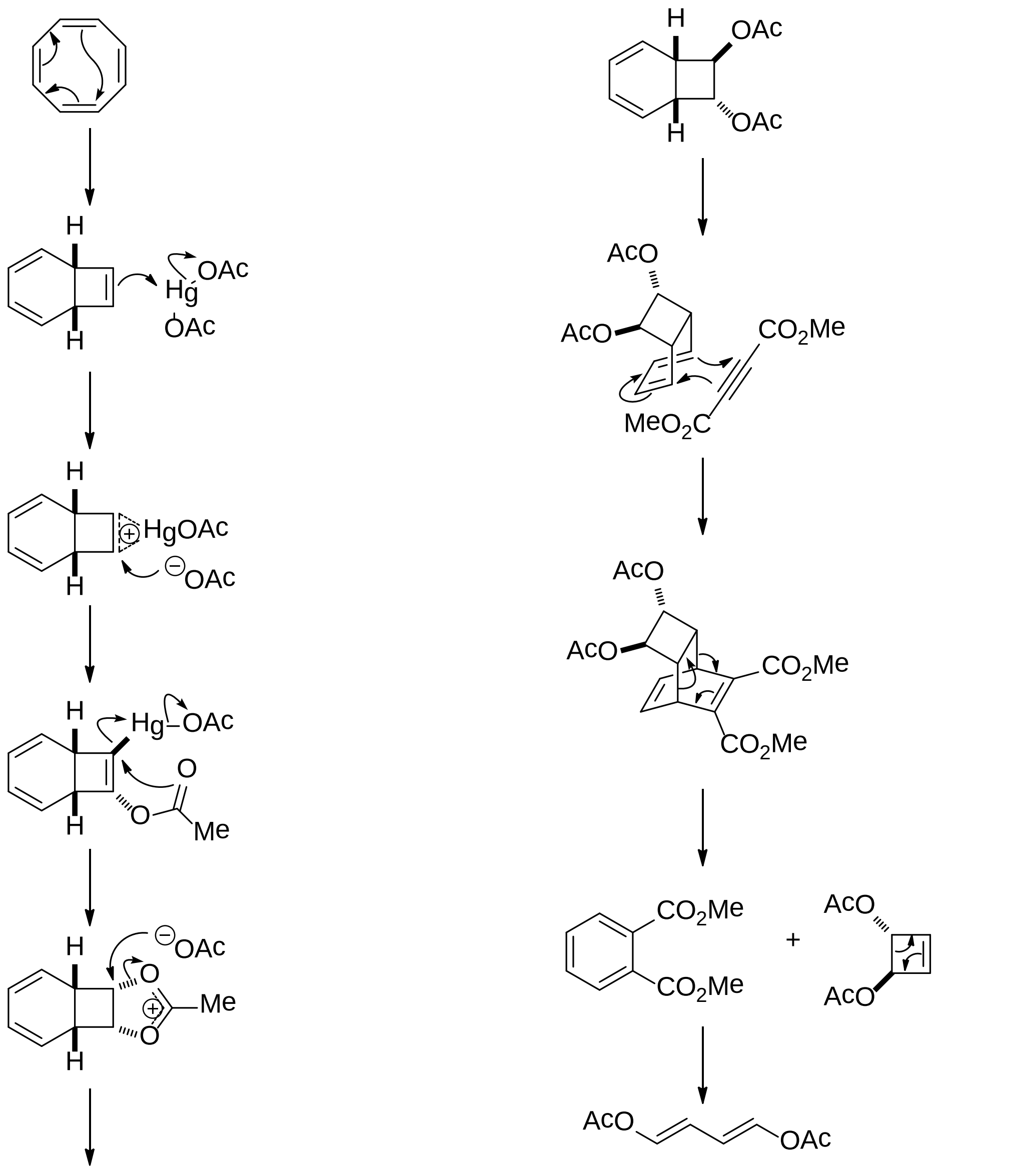
问题 上级编

上级编中的问题来自历史上最新有名的反应的论文，收录了各种反应的问题，不过如果按照基本方法去做，依然能够能找到答案。问题的顺序是完全随机配置的，大概是按着难易度顺序编排的。一个一个踏实地去做，不会做的话不要气馁，多挑战几次吧。

例 题　写出合理的反应机理



解 答



Noller, C. R;Dinsmore, R. *Org. Synth. Coll.* vol Ⅱ **1943**. 358

问 题 写出合理的反应机理

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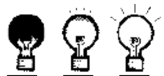

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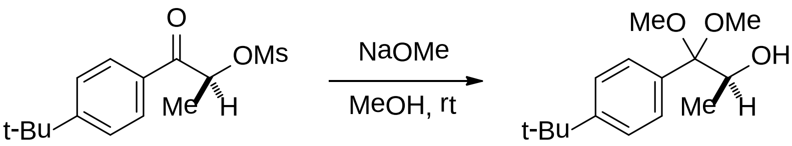

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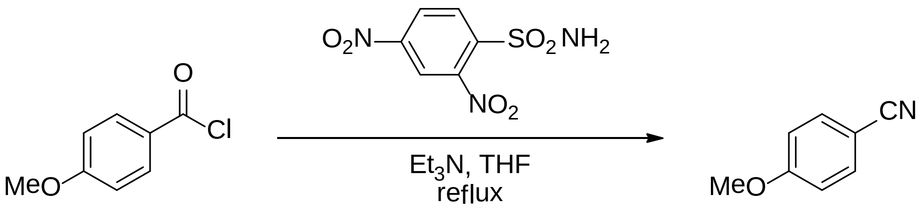

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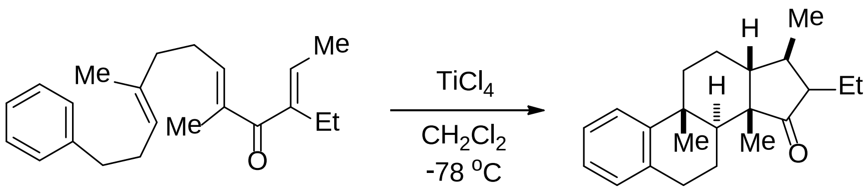

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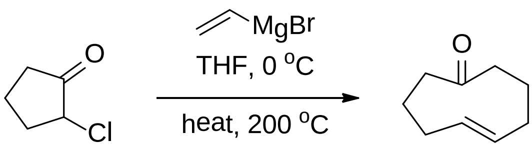

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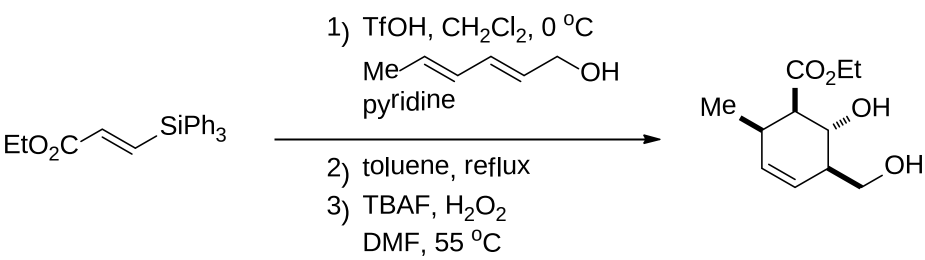

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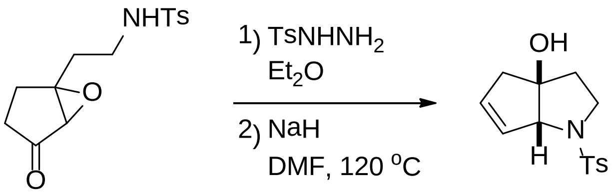

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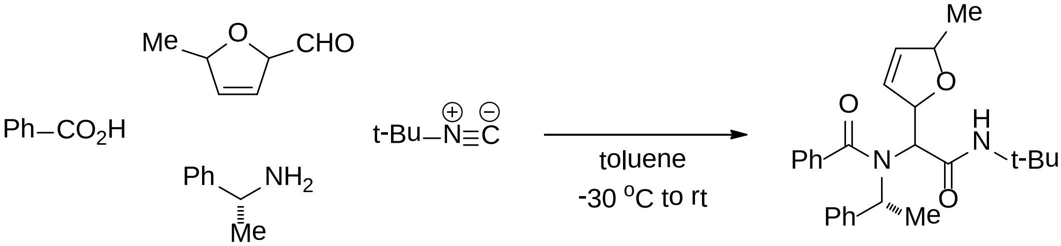

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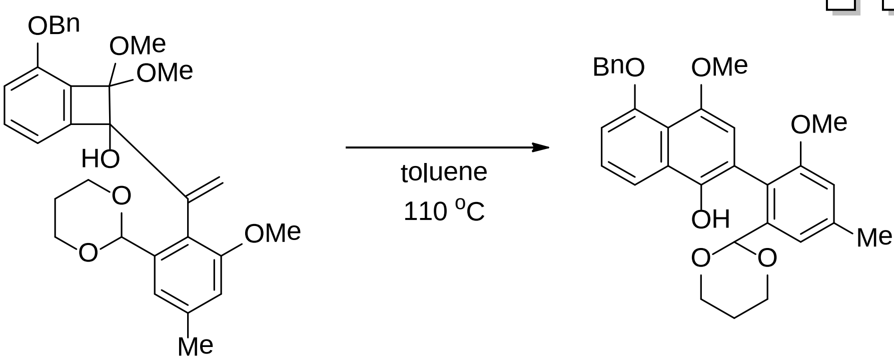

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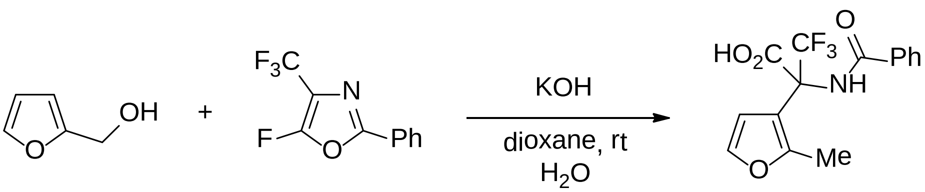

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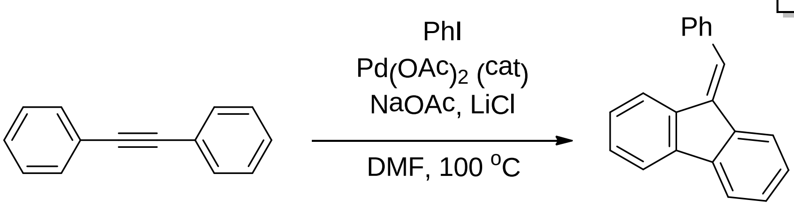

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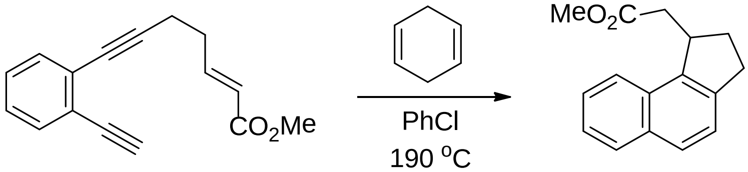

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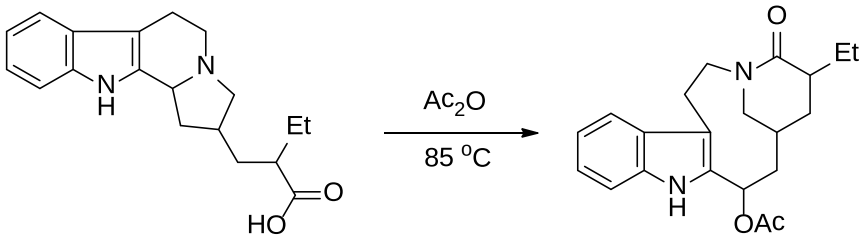

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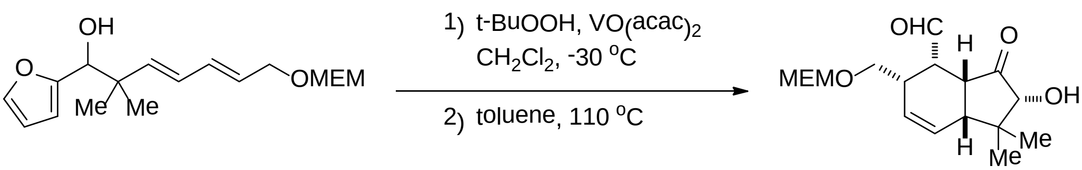

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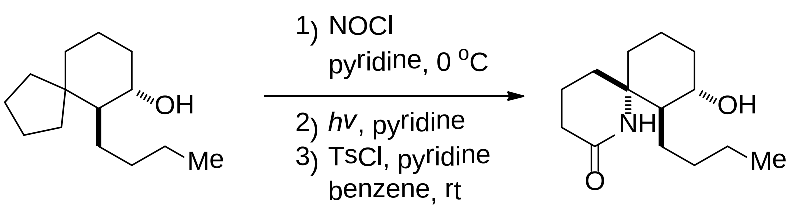

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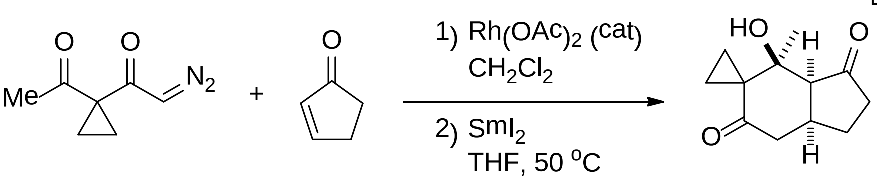

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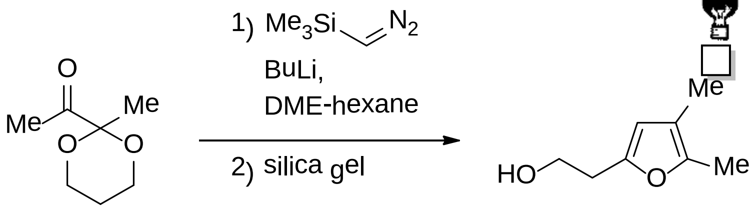

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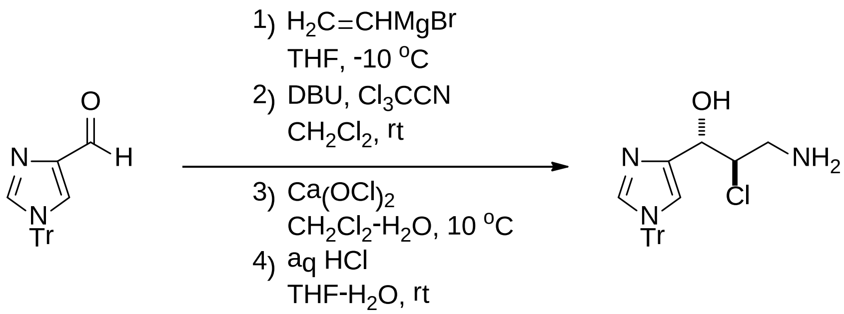

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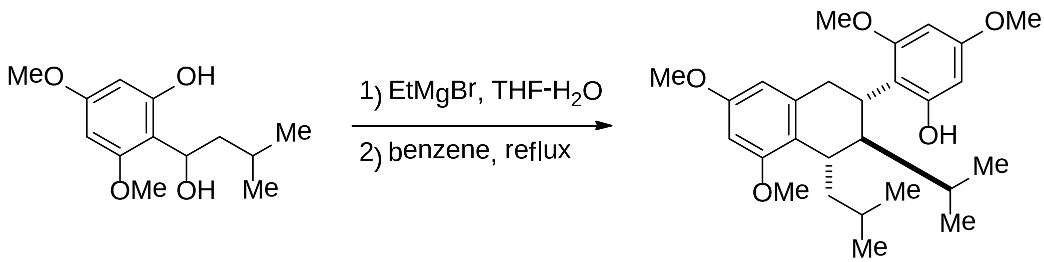

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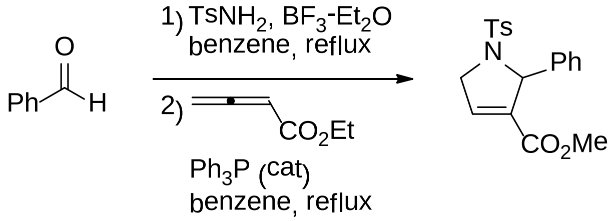

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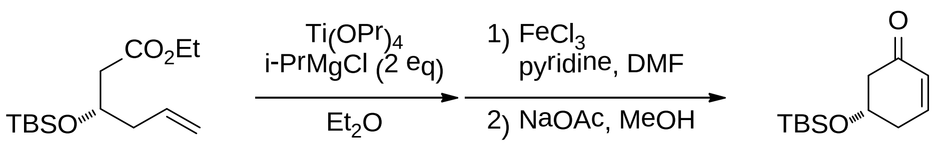

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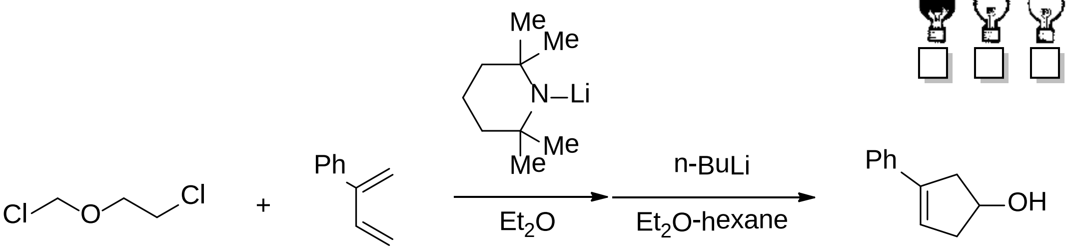

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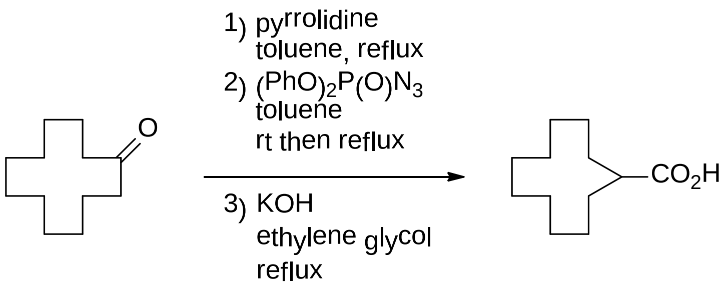

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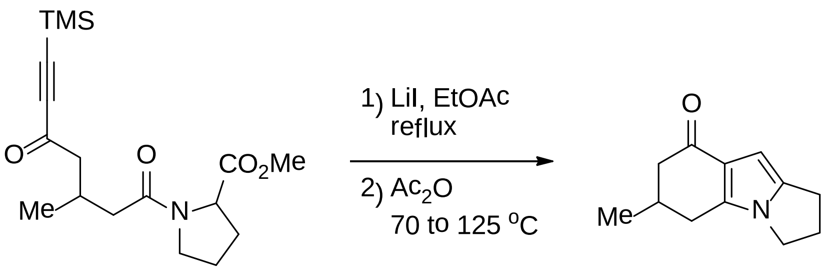

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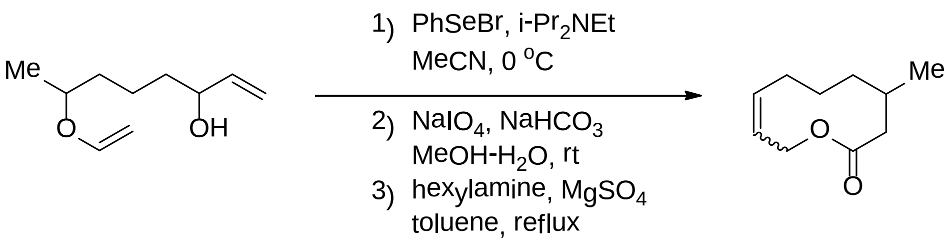

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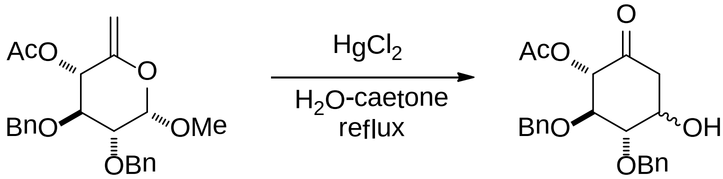

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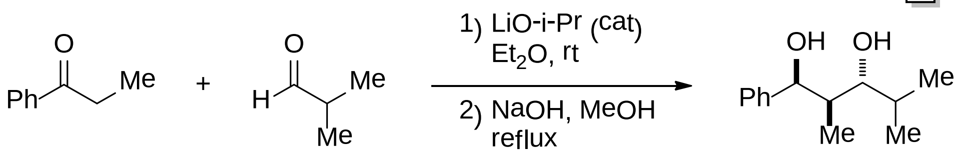

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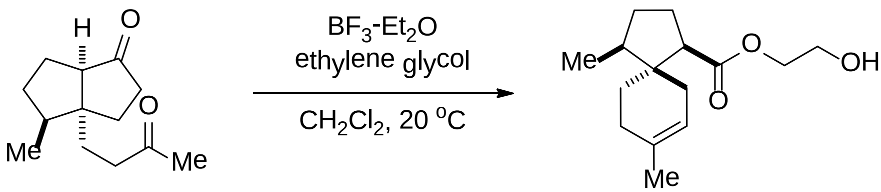

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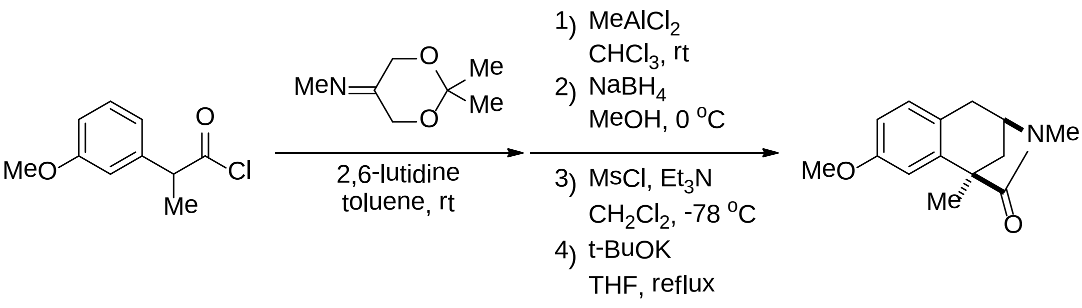

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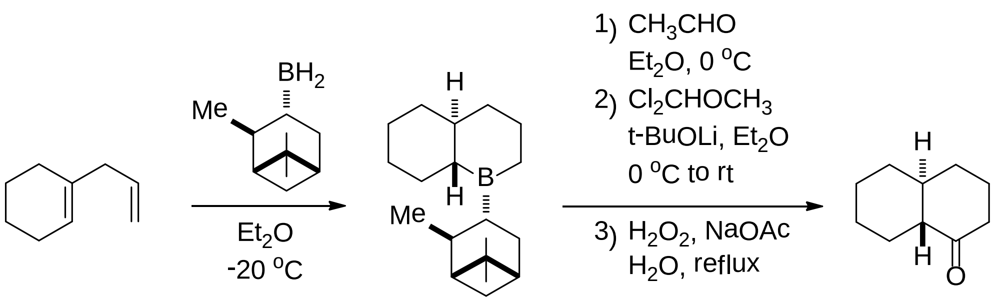

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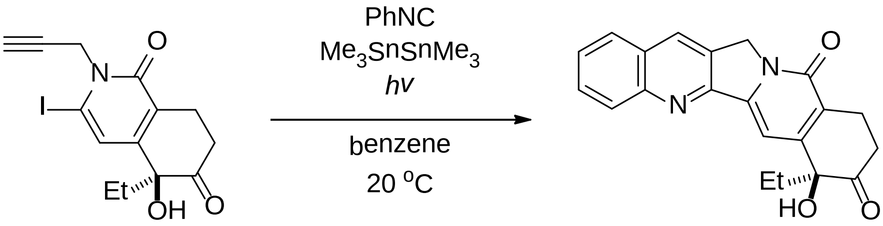

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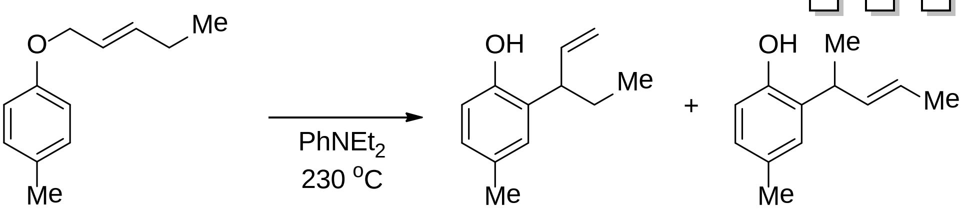

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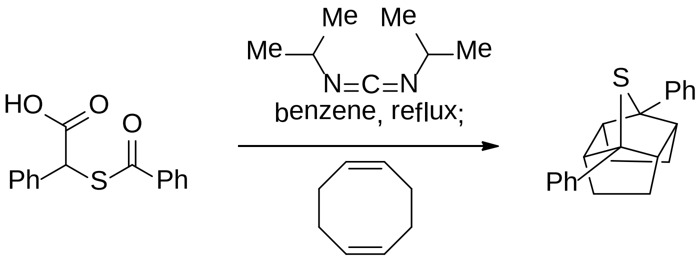

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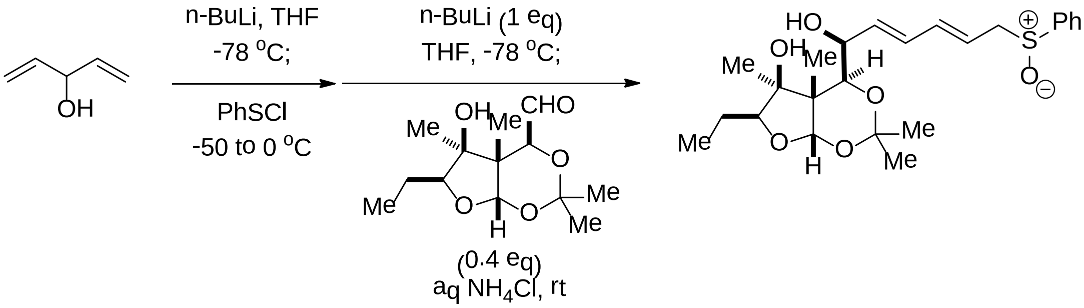

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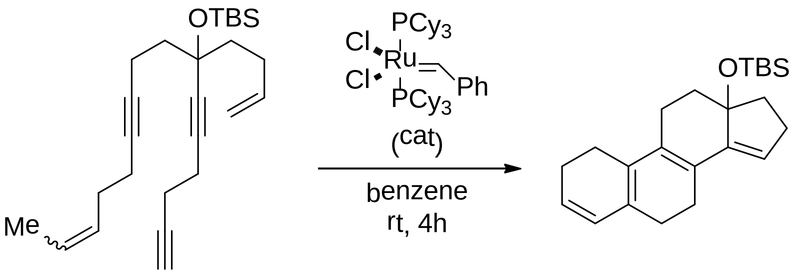

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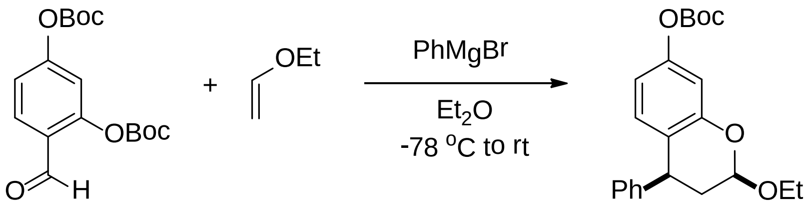

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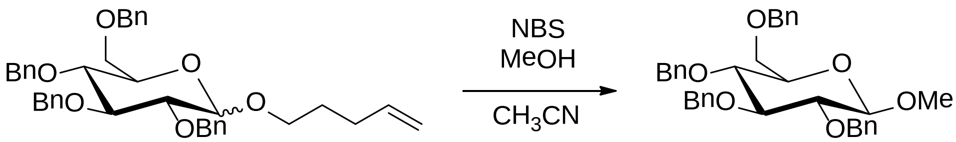

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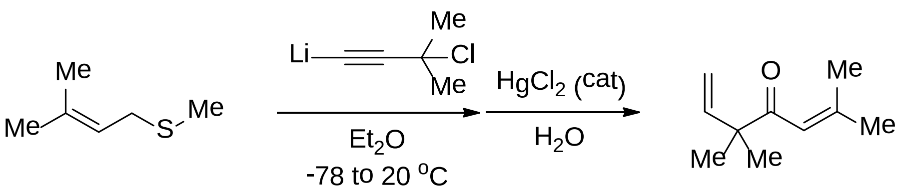

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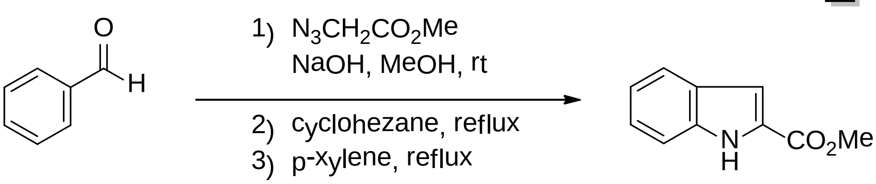

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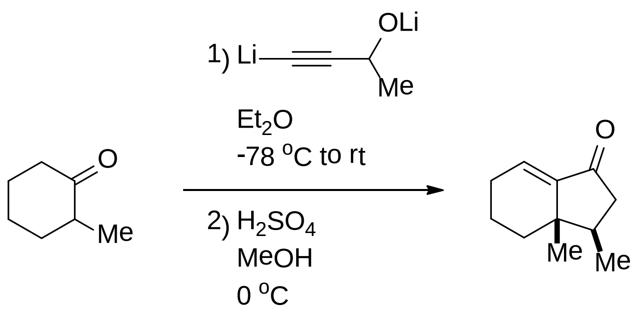

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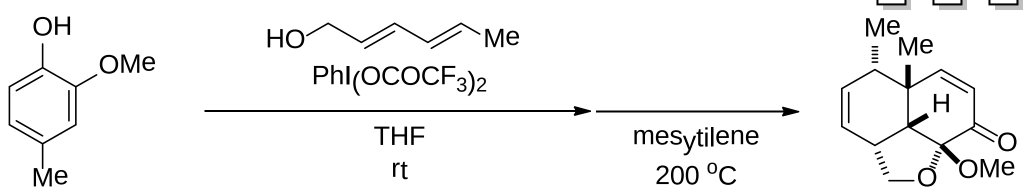

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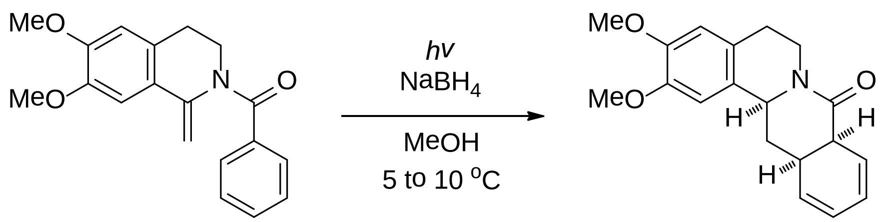

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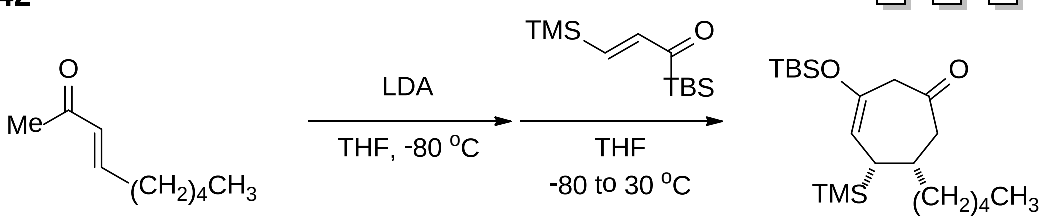

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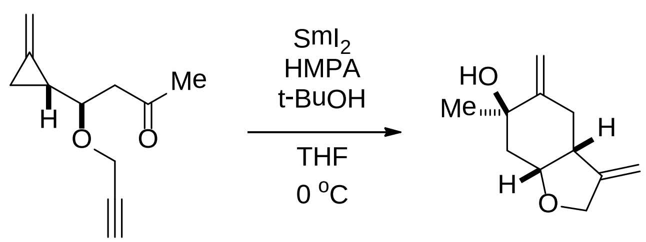

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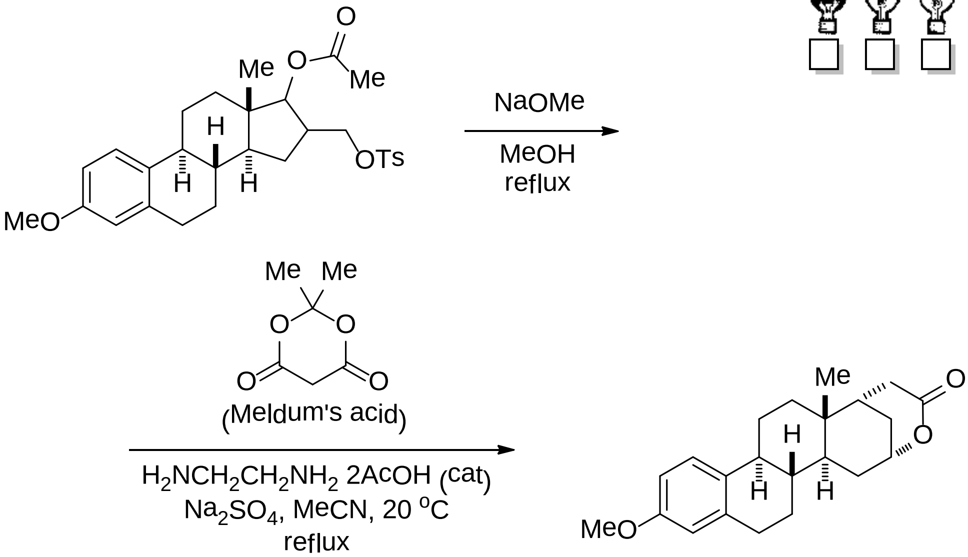

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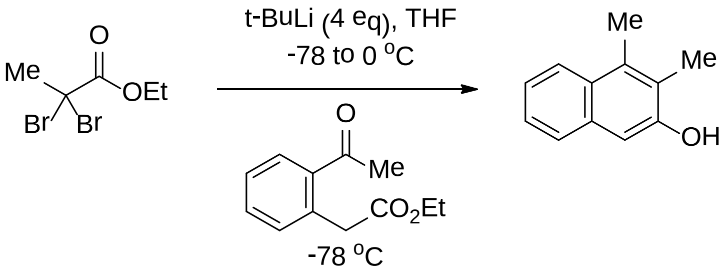

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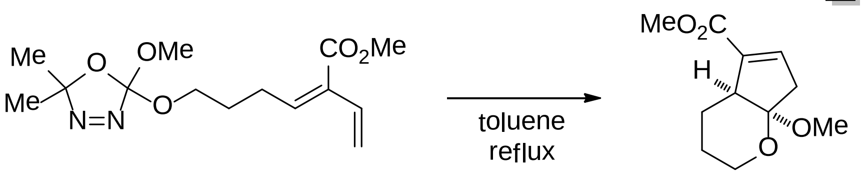

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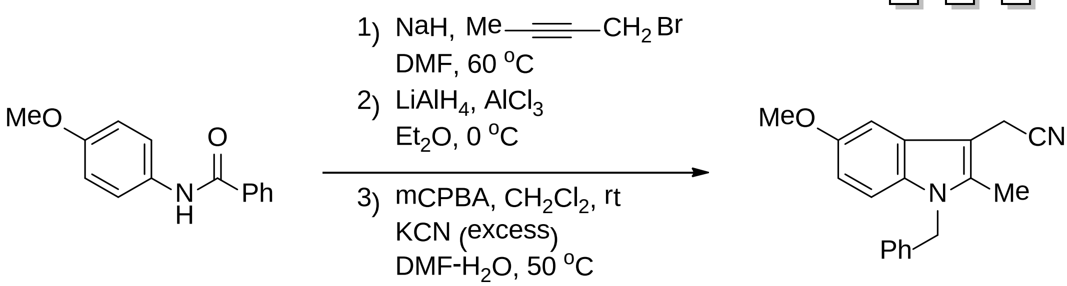

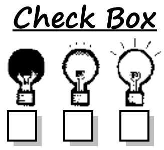

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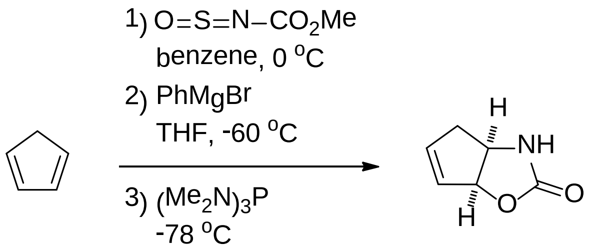

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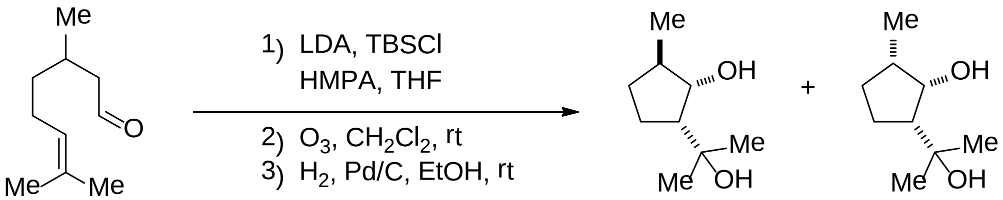

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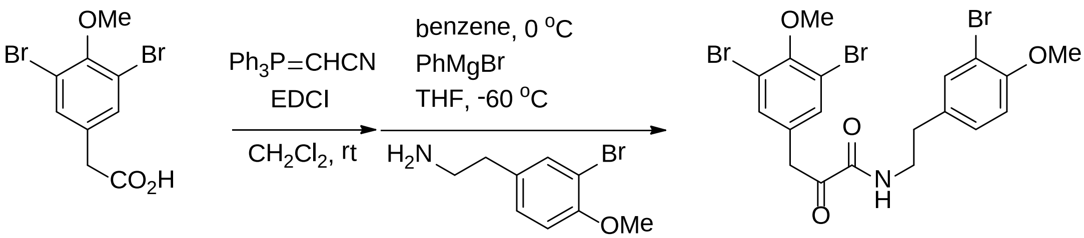

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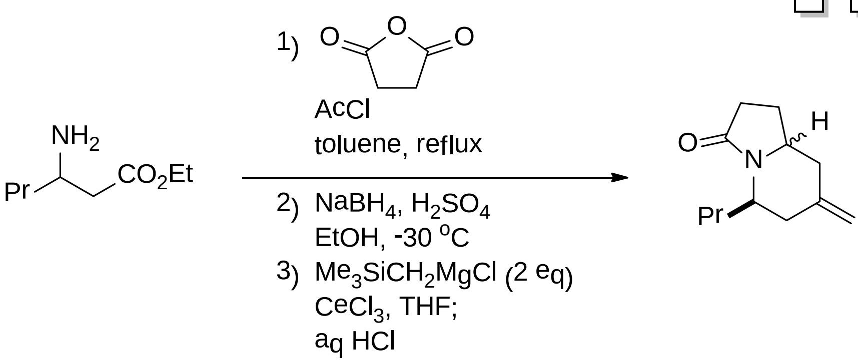

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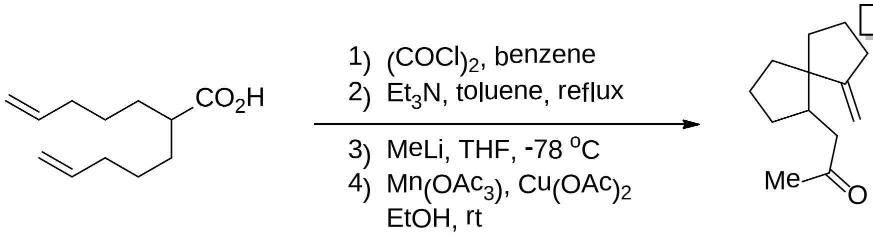

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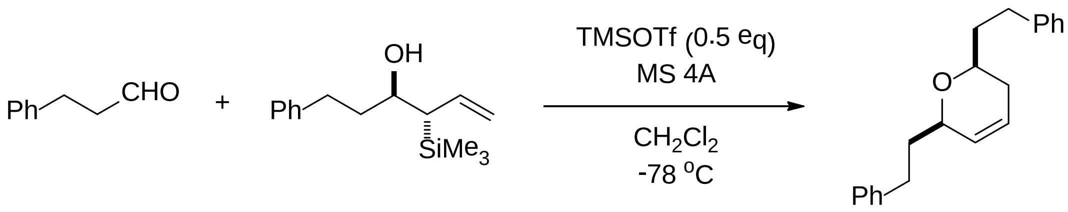

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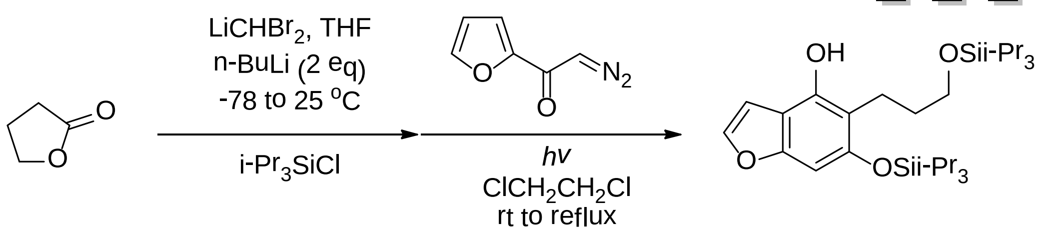

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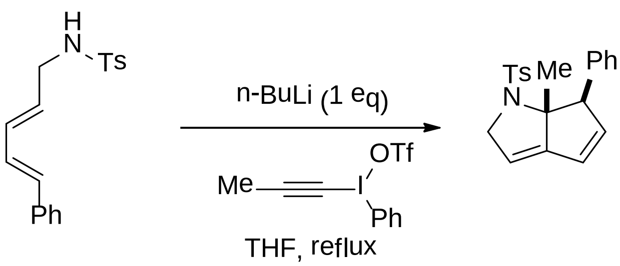

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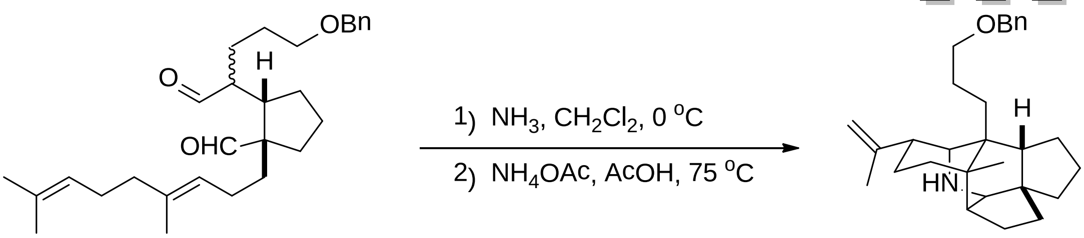

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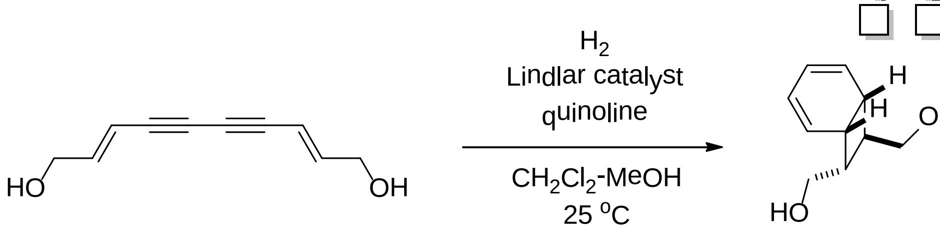

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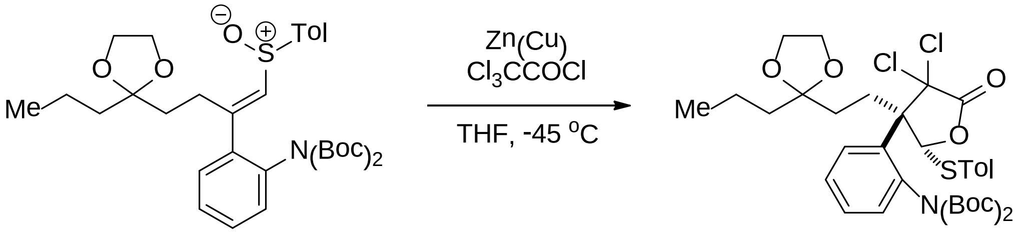

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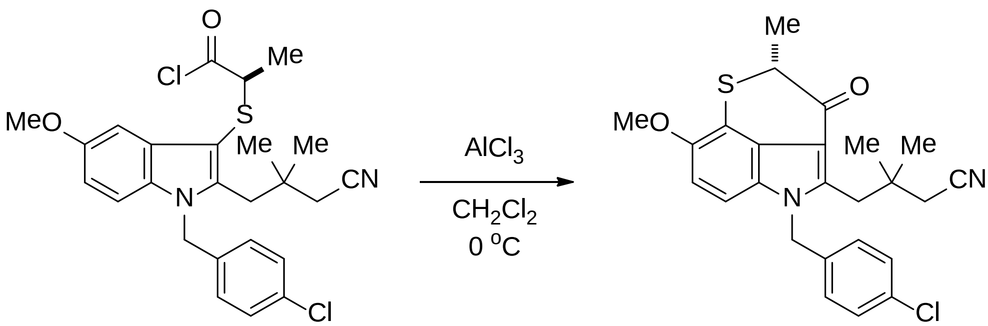

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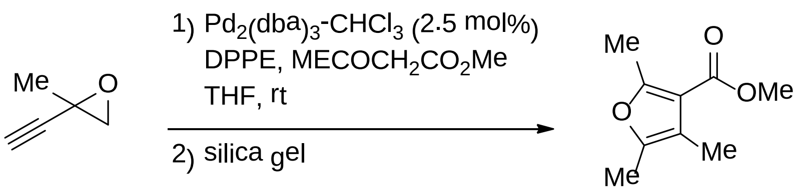

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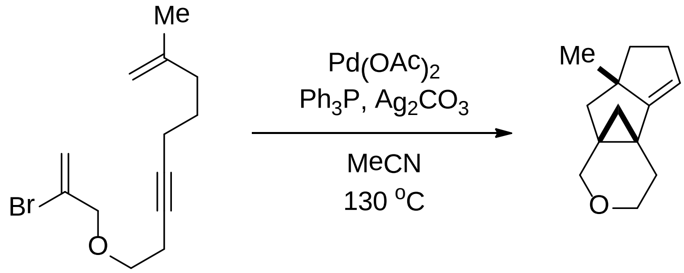

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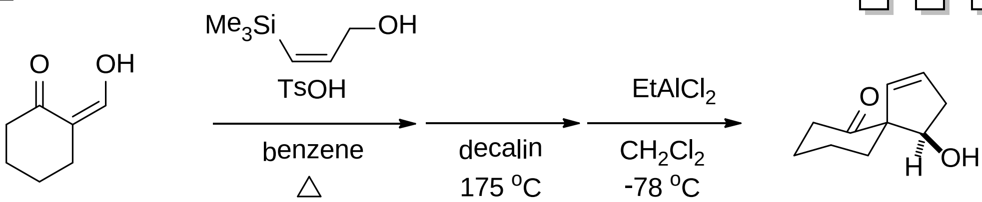

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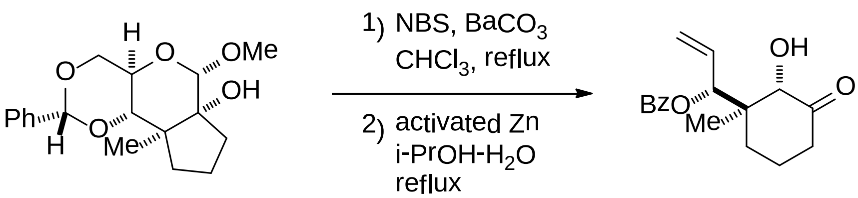

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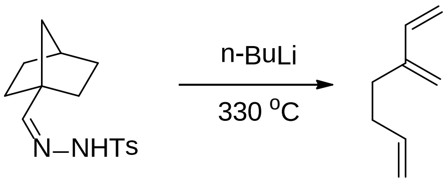

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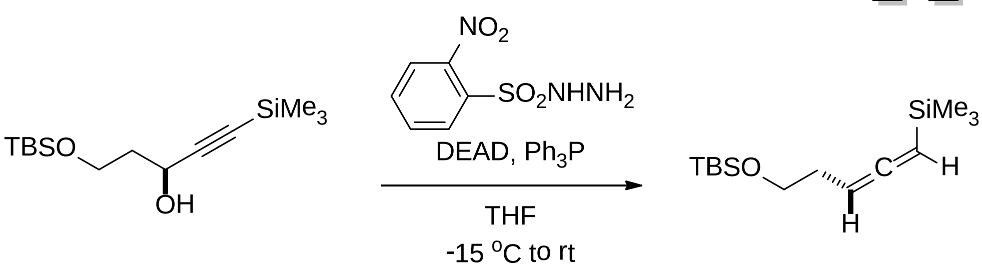

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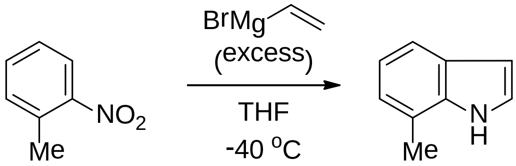

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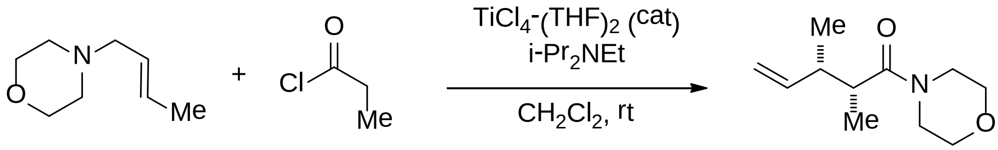

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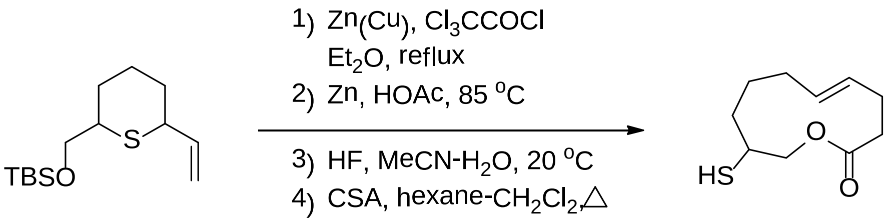

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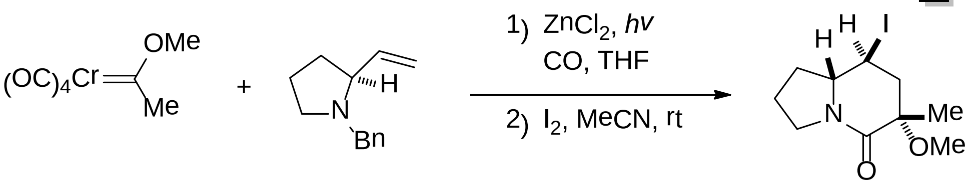

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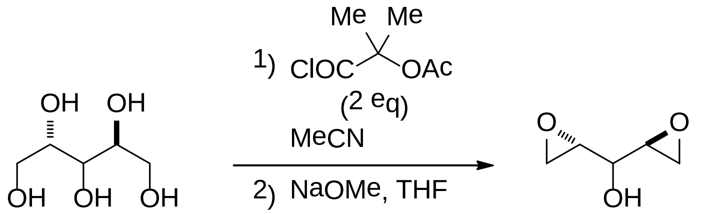

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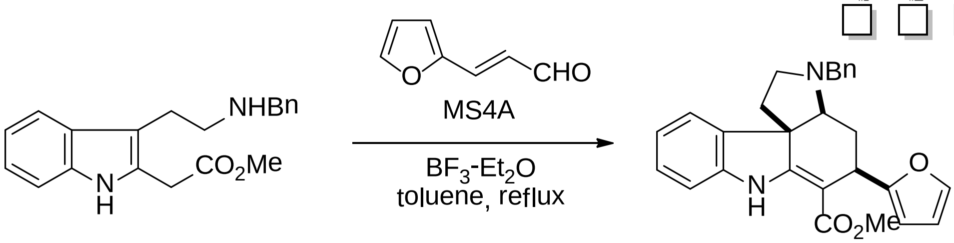

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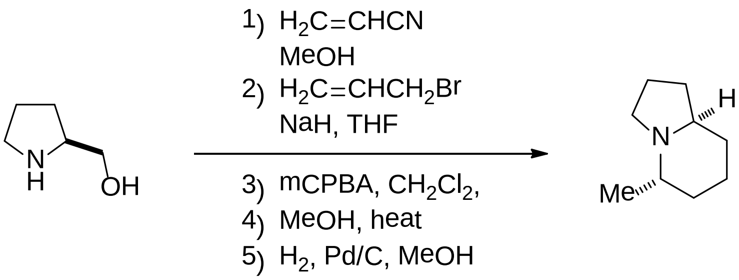

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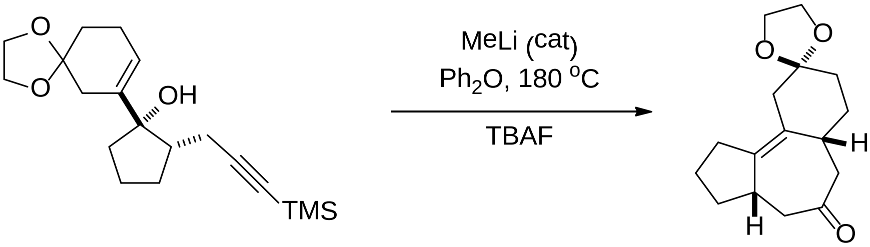

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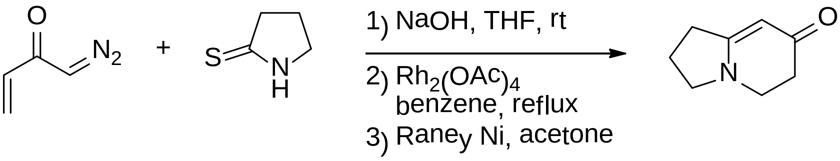

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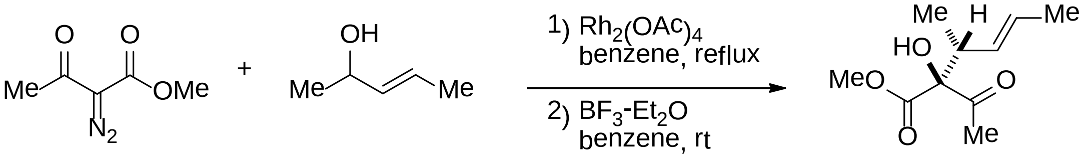

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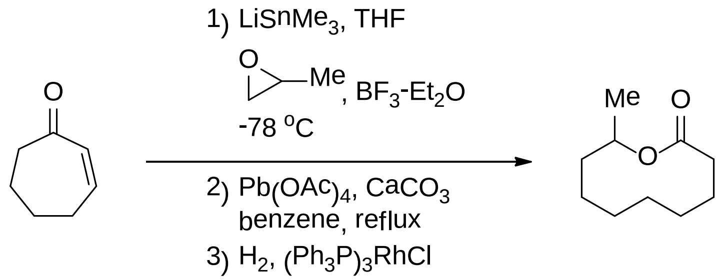

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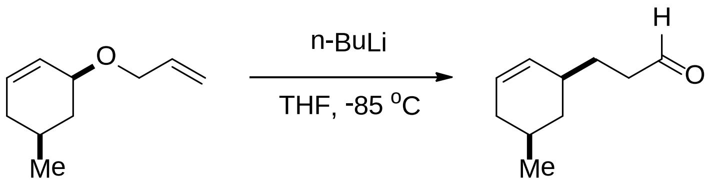

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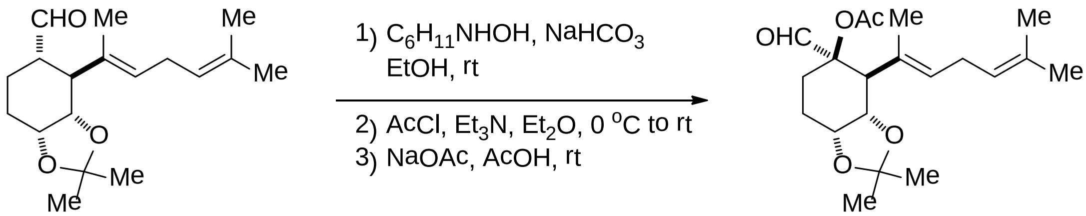

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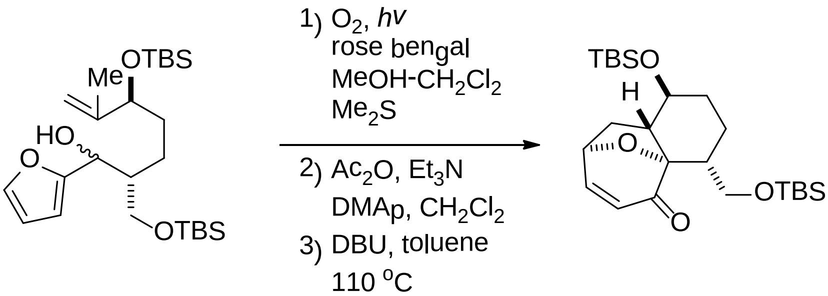

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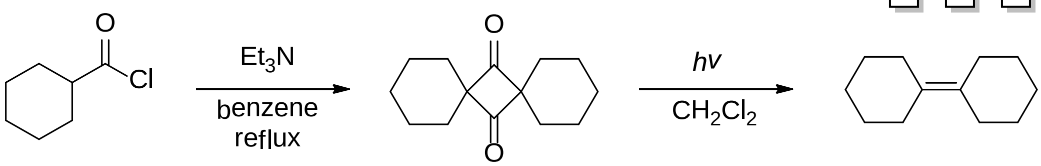

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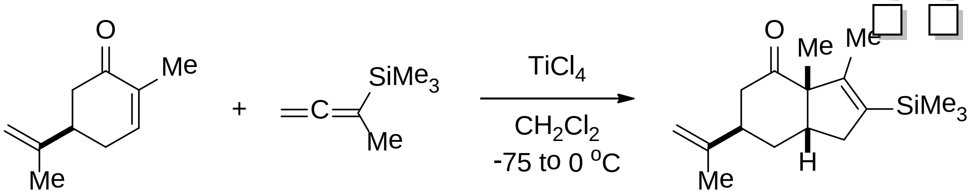

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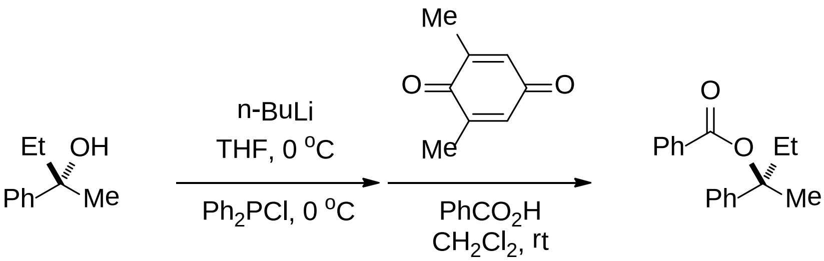

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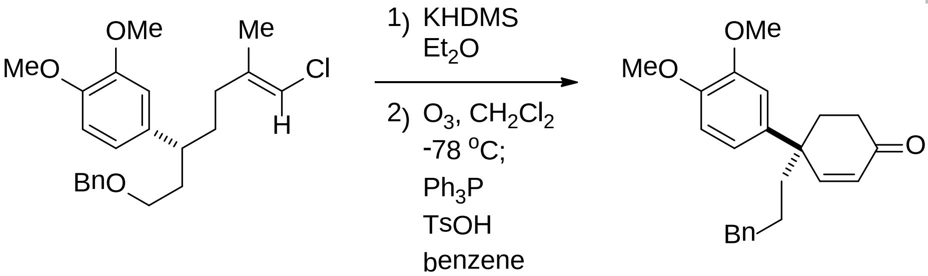

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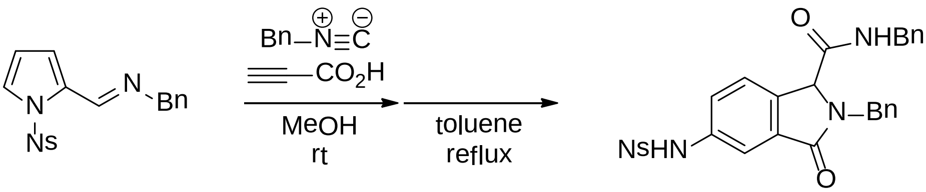

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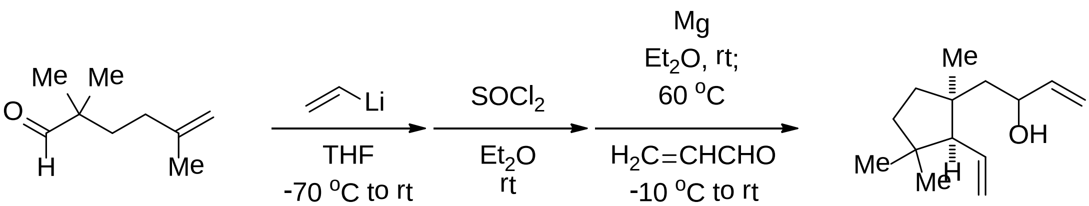

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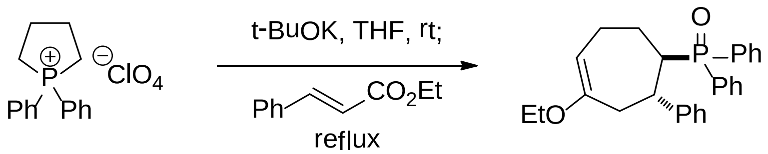

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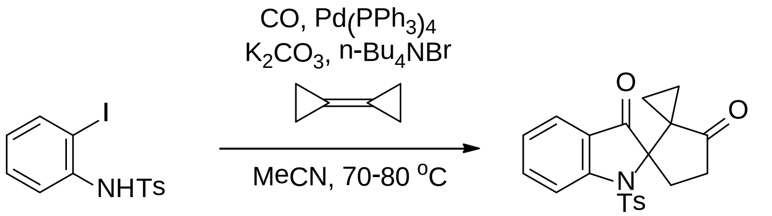

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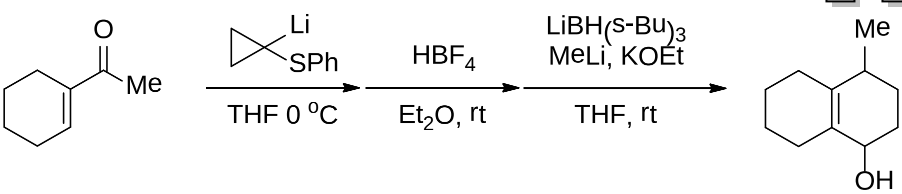

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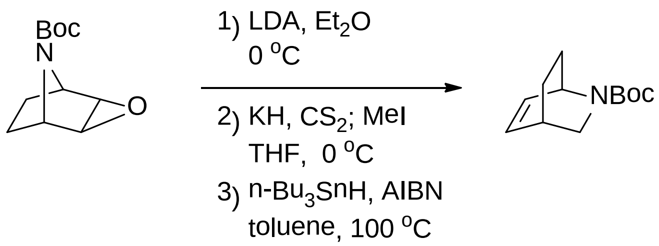

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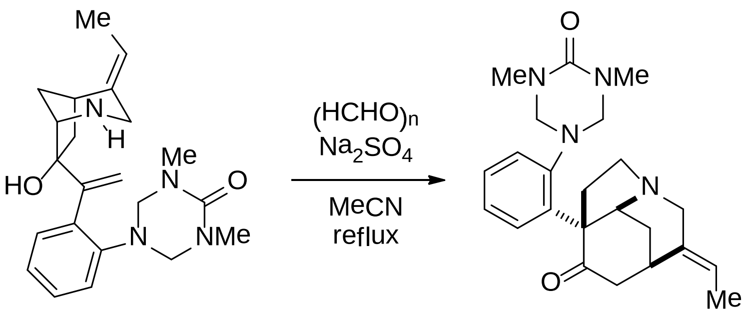

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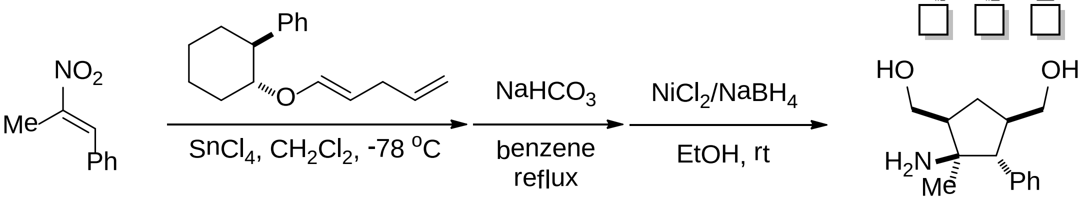

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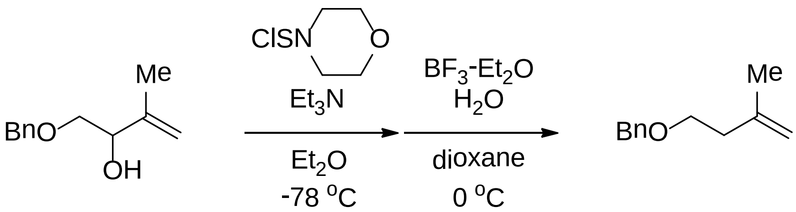

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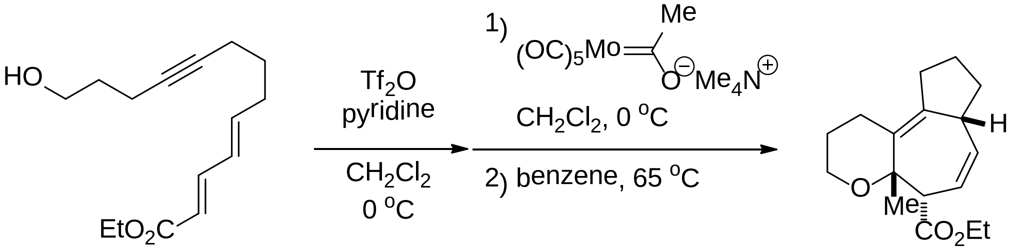

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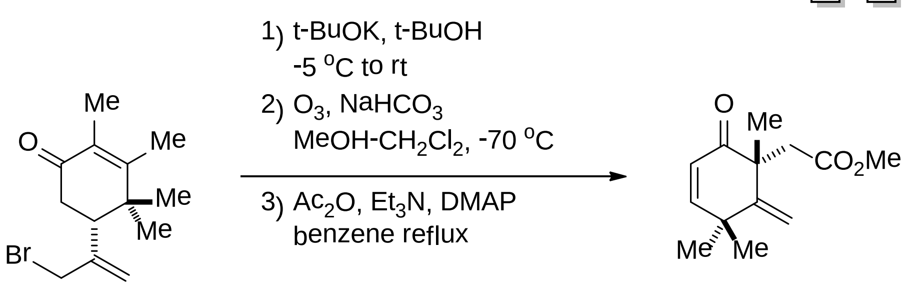

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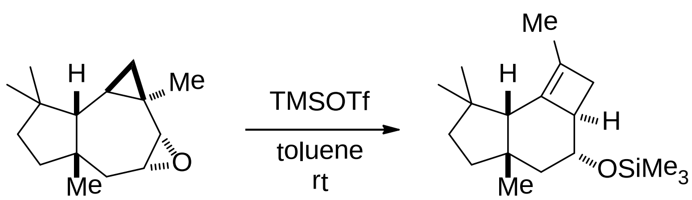

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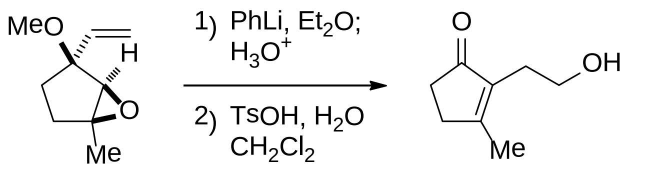

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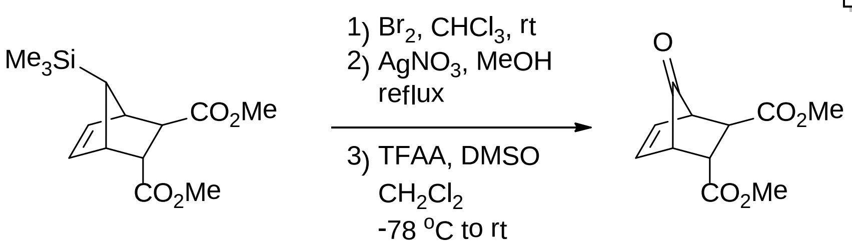

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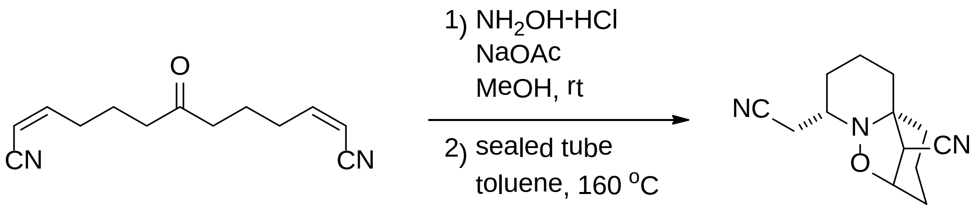

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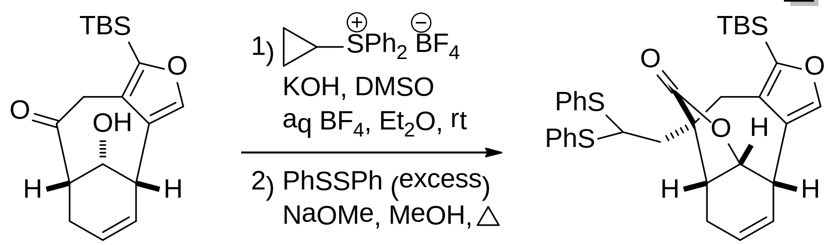
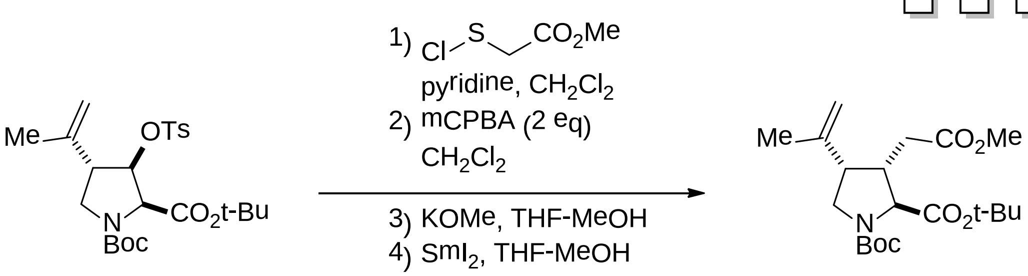
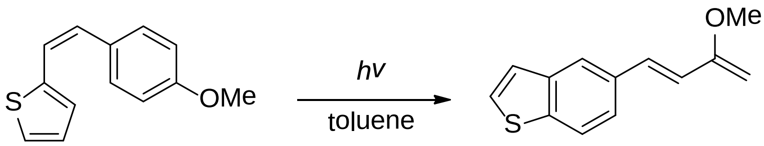


C100

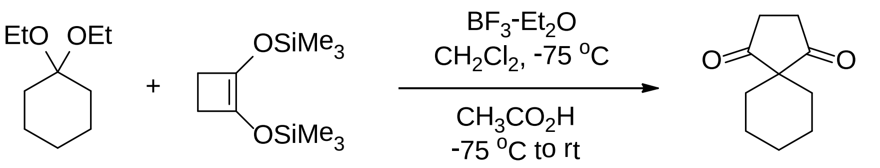


Check Box

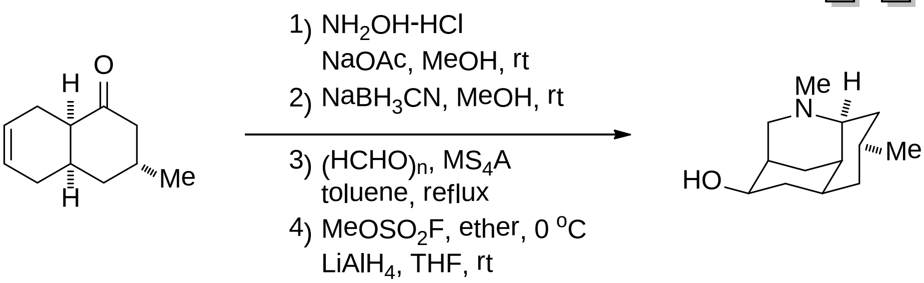
C101



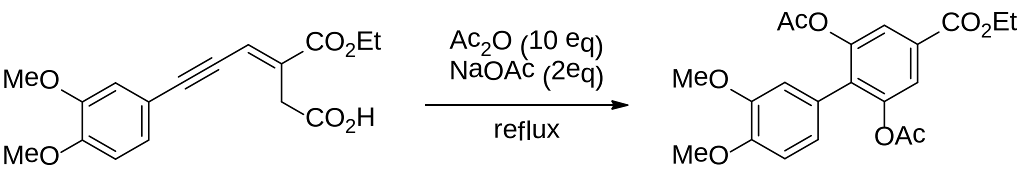
C102



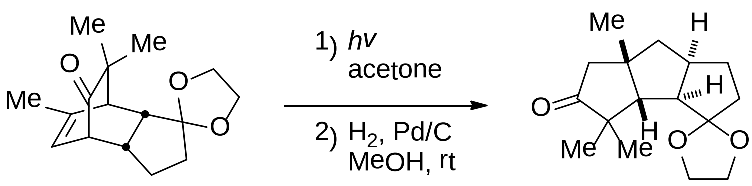
C103



C104

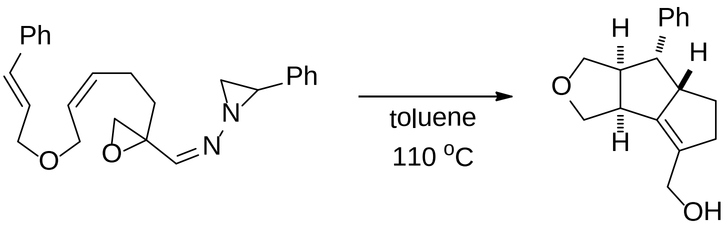


C105

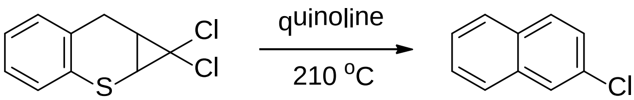


Check Box

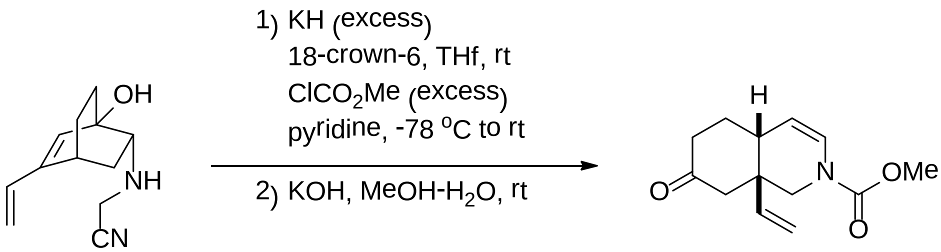
C106



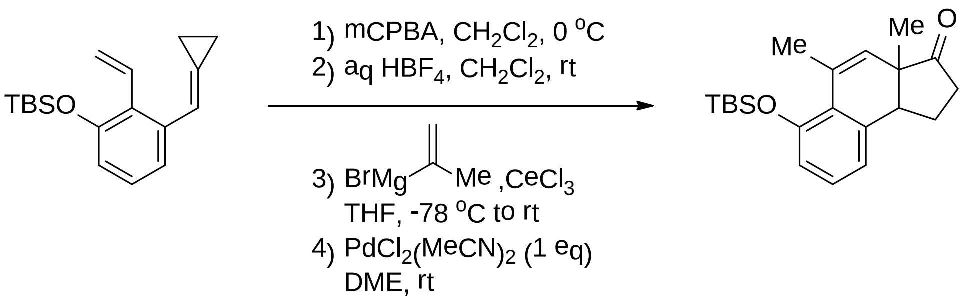
C107



C108

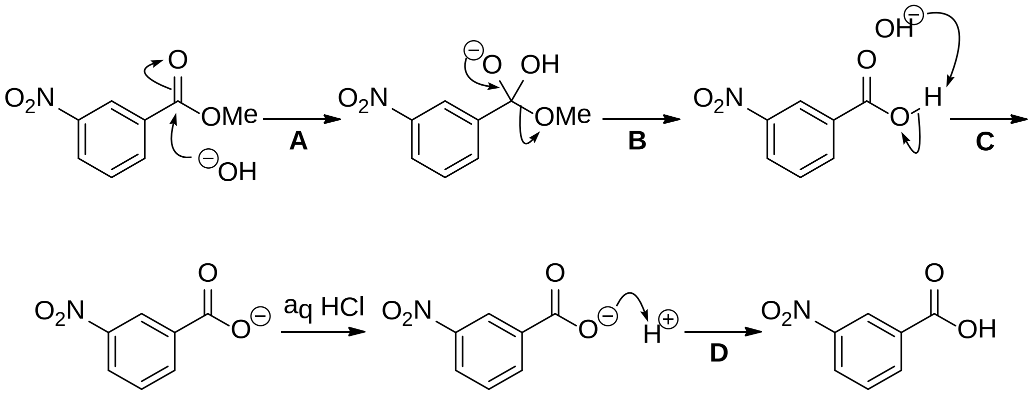


C109



解答 初级编

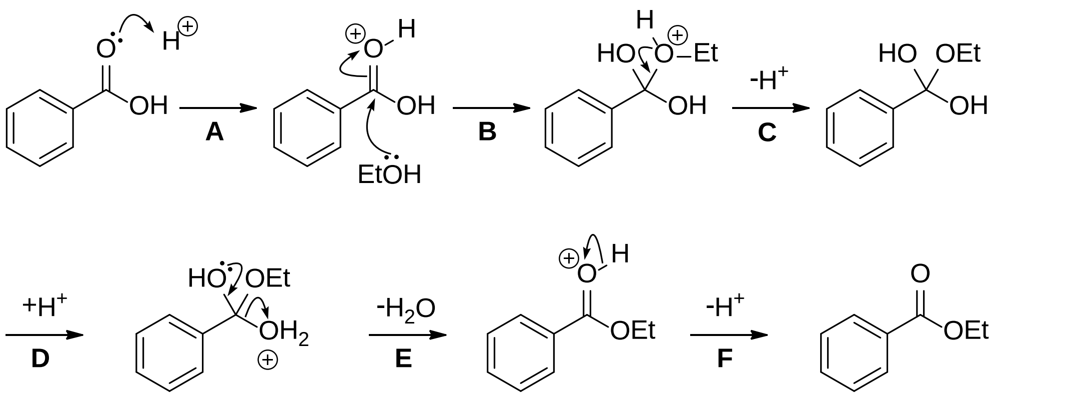
A001



Kamm, O.; Segur, J. B. *Org. Synth. Coll.* Vol. I **1941**, 391

A: Addition of hydroxide ion to the carbony group to form a tetrahedral intermediate. **B** : Elimination of methoxide ion helped by the oxygen lone pair. **C**: Deprotonation. pKa AcOH = 4.8, H_2O = 15.7. **D**: Protonation on work-up. pKa H_3O^+ = -1.7.

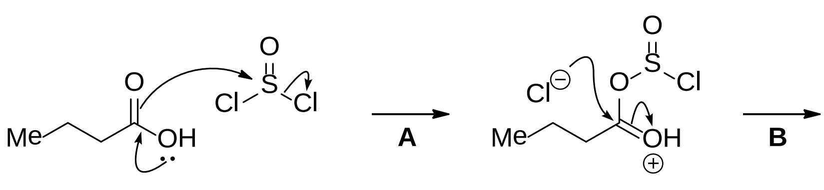
A002

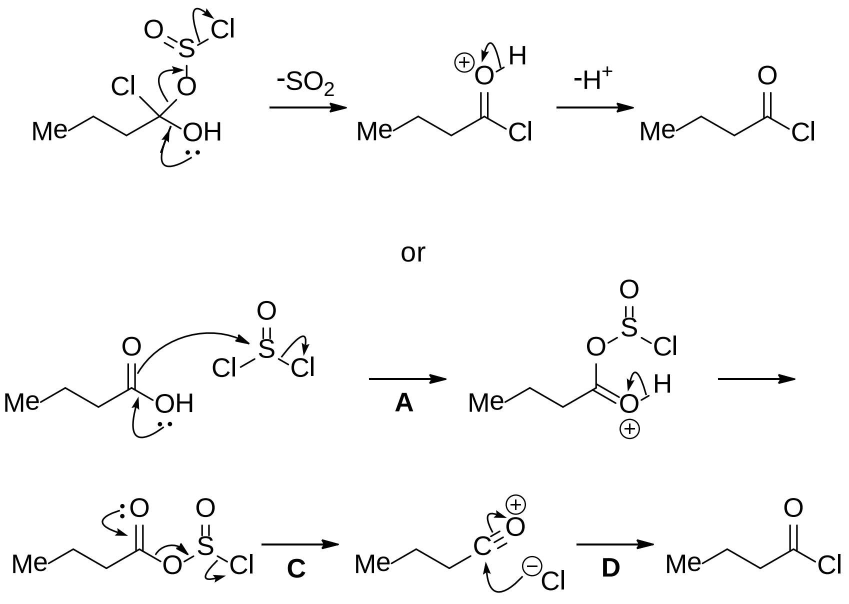


Fischer, E.; Speier, A. *Ber. Deut. Chem. Ges.* **1895**, 28, 3252

A: Activation of the carbonyl group by protonation. **B**: Additiono f EtOH to the activated carbony group. **C**: Deprotonation of the oxonium ion. **D**: Protonation makes a hydroxy group a good leaving group. **E**: Elimination of water helped by the oxygen lone pair. **F**: Deprotonation

A003

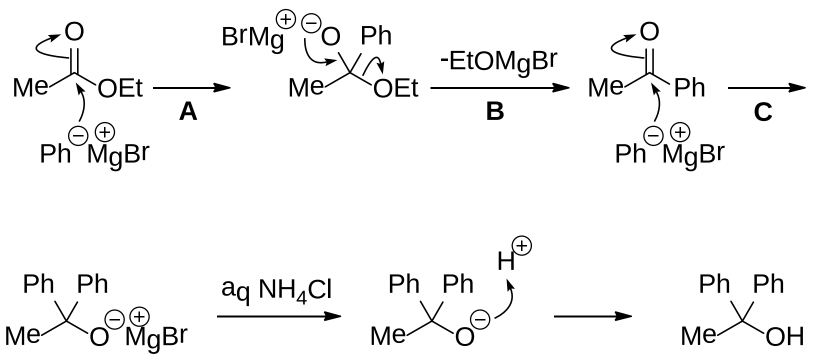




Helferich, B.; Schaefer, W. *Org. Synth., Coll* Vol Ⅰ **1941**, 147.

A : Atack of a carboxylic acid to $SOCl_2$ forms a mixed anhydride. **B**: Addition of chloride ion to the carbonyl group to form a tetrahedral intermediate. **C**: Formation of an acylium ion. **D**: Addition of chloride ion to the acylium ion

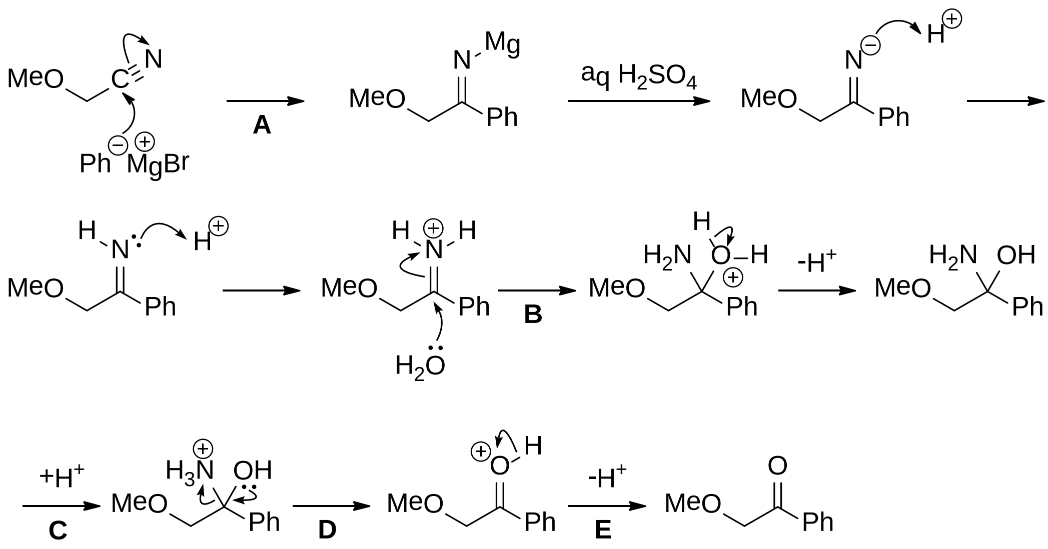
A004



Allen, C. F. H.; Converse, S. *Org. Synth., Coll*. Vol. Ⅰ **1941**, 226.

A: Addition of PhMgBr to the carbonyl group of the ester to form a tetrahedral intermediate. **B**: Elimination of ethoxide ion to form a ketone. **C**: Addition of PhMgBr to the more reactive ketone to form a tertiary alkoxide.

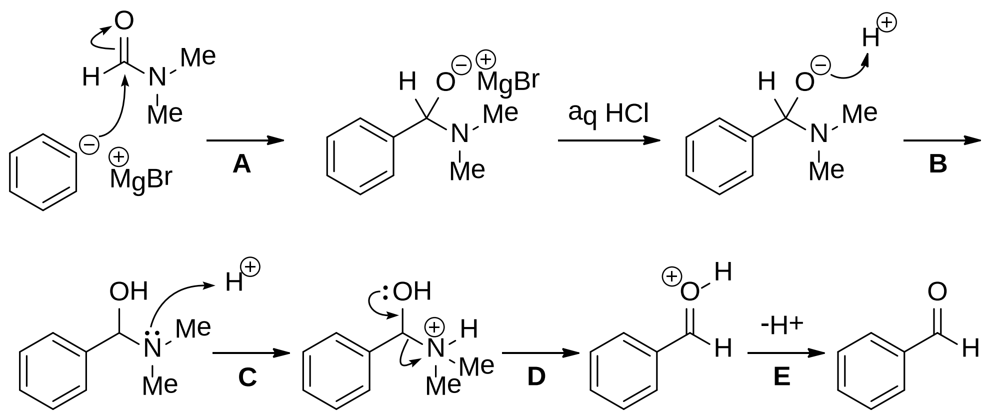
A005



Moffett, R. B.; Shriner, R. L *Org. Synth., Coll* Vol. III **1955**, 562.

A: Addition of PhMgBr to the nitrile forms an imine anion, **B**: Addition of water to the iminium ion gives a hemiaminal. **C**: Protonation occurs on a more basic amino group. pKa H_3O^+ = -1.7, $EtNH_3^+$ = 10.6. **D**: Elimination of ammonia helped by the oxygen lone pair. **E**: Deprotonation.

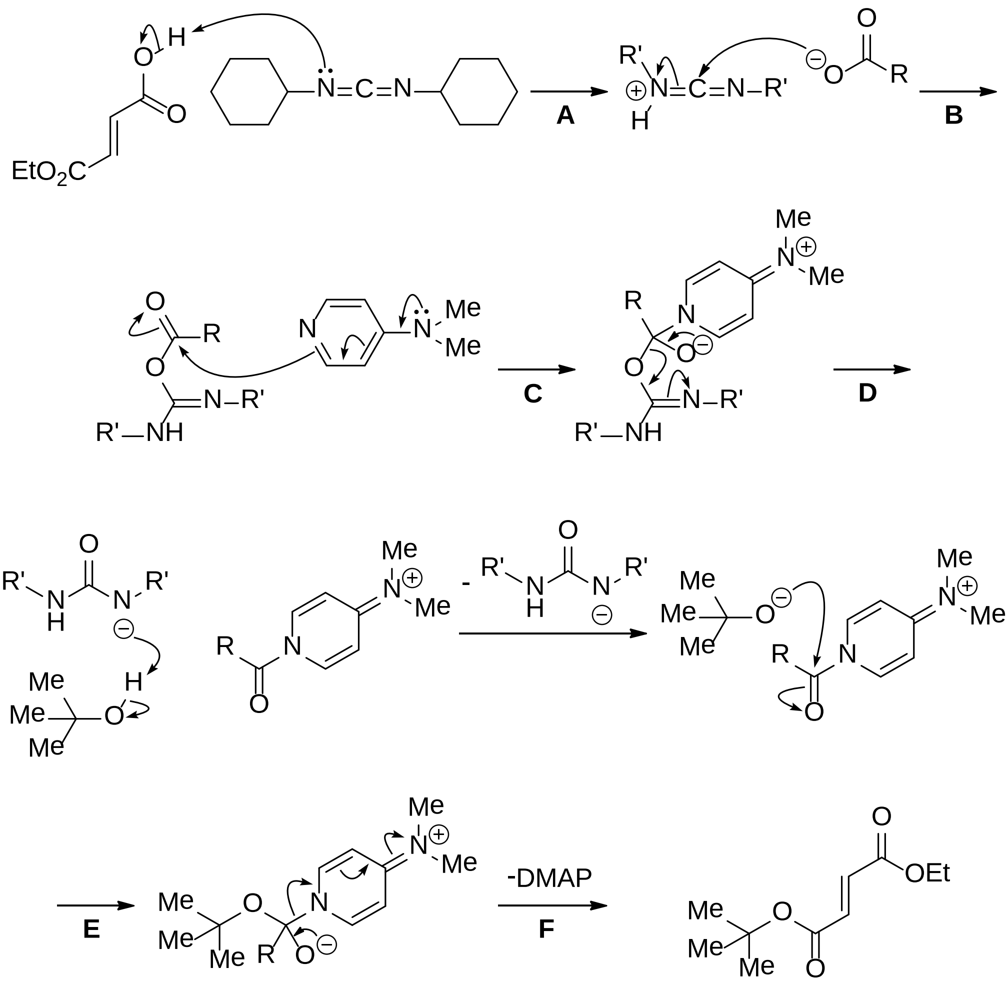
A006



Olah, G. A; Surya Prakash, G. K.; Arvanaghi, M. *Synthesis* **1984**, 228

A: Addition of PhMgBr to the carbonyl group. The resulting tetrahedral intermediate is relatively stable because the alkoxide anion cannot generate an amine anion (pKa i-PrOH = 17, Et_2NH = 36). **B**: Protonation on workup. **C**: Protonation of a more basic amino group. pKa H_3O^+ = -1.7, $EtNH_3^+$ = 10.6. **D**: Elimination of the amine helped by the oxygen lone pair **E**: Deprotonation.

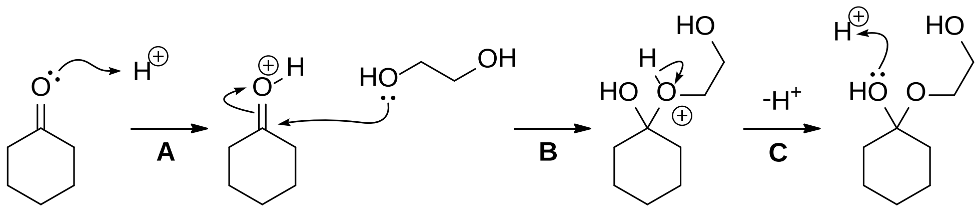
A007

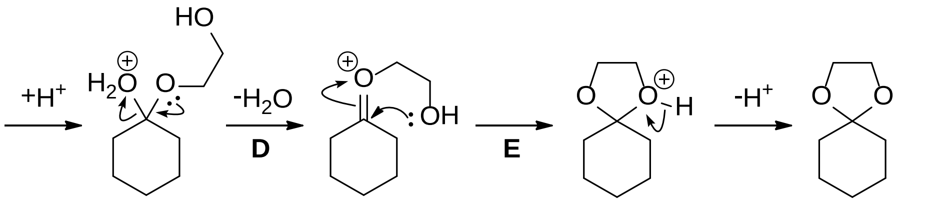


Neises, B.; Steglich, W. *Org. Synth.*, Coll. Vol. Ⅶ **1990**, 93.

A: Activation of DCC by protonation. **B**: Addition of the carboxylate to the protonated DCC. **C**: Addition of DMAP to the carbonyl group. **D**: Elimination of a urea anion which then abstracts a proton from an alcohol. **E**: Addition of the alkoxide anion to the carbonyl group to form a tetrahedral intermediate. **F**: Elimination of DMAP to form the product.

A008

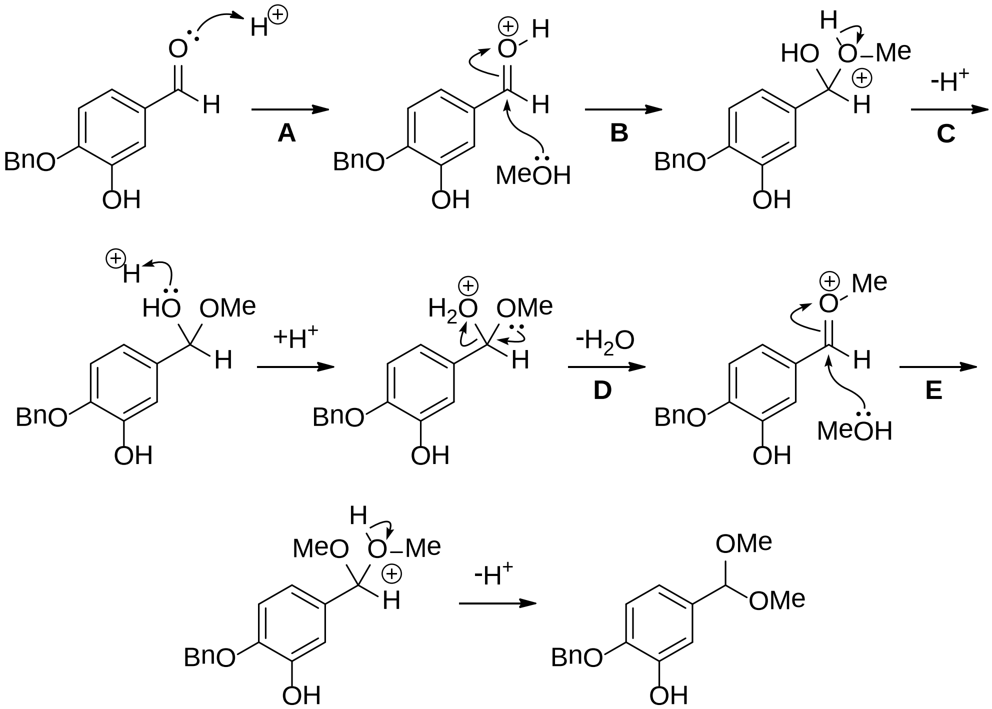


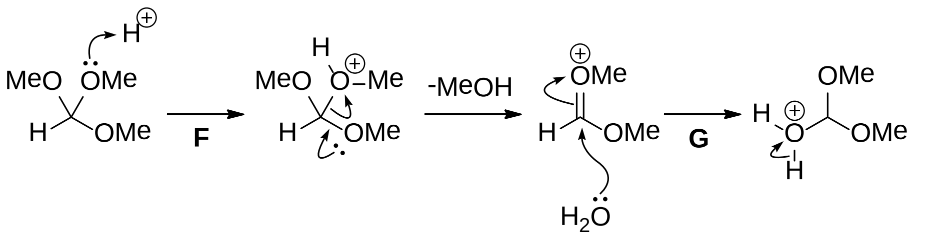


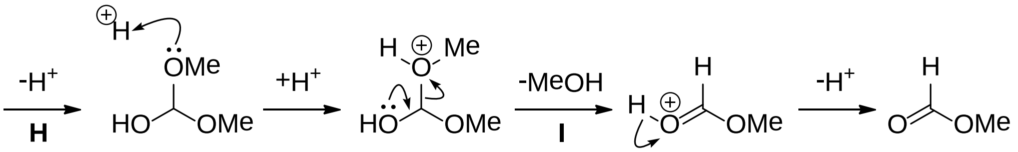
Daignault, R. A.; Eliel, E. L *Org. Synth., Coll* Vol. Ⅴ **1973**, 303.

A: Activation of the carbonyl group by protonation. **B**: Addition of ethylene glycol to the activated carbonyl group. **C**: Proton transfer. **D**: Elimination of water helped by the oxygen lone pair. **E**: Intramolecular addition of the second hydroxy group.

A009



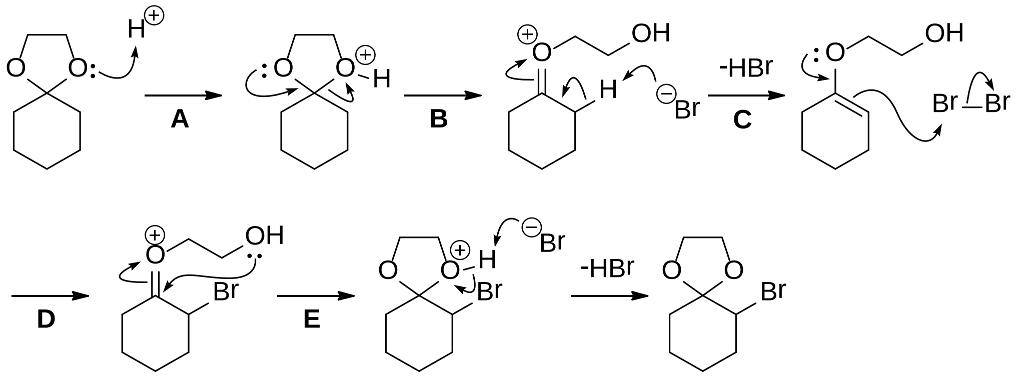




Baker, R.; Cooke, N. G.; Humphrey, G. R.; Wright, S. H. B.; Hirshfield, J. *J. Chem. Soc., Chem. Commun*. **1987**, 1102.

A: Activation of the carbonyl group by protonation. **B**: Addition of MeOH to the activated carbonyl group. C: Proton transfer. **D**: Elimination of water helped by the oxygen lone pair. **E**: Addition of MeOH and protonation to form a dimethyl acetal. **F**: Trimethyl orthoformate serves as a scavenger of water to let the equilibrium to the product side. Protonation followed by elimination of MeOH. **G**: Addition of water. **H**: Proton transfer. **I**: Elimination of MeOH followed by deprotonation to form HCO_2Me.

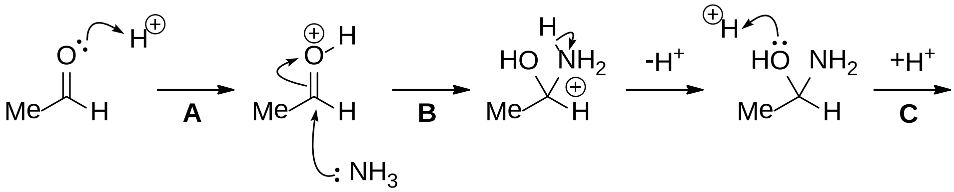
A010

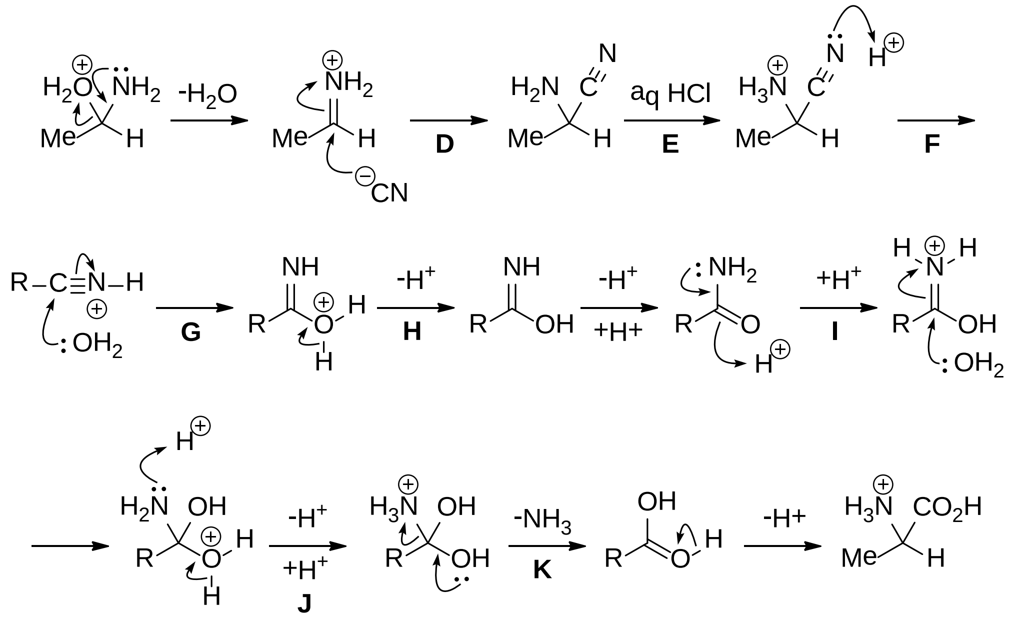


Aben, R. W. M.; Hanneman, E. J. M.; Scheeren, J. M. *Syn. Commun*. **1980**, 10, 821.

A: Protonation. **B**: Cleavage of the dioxolane ring helped by the oxygen lone pair. **C**: Deprotonation to form an enol ether. **D**: Bromination of the electron-rich enol ether. **E**: Intramolecular addition of the hydroxy group. Opening of the dioxolane ring of the product is more difficult because of the electron-withdrawing bromine atom.

A011

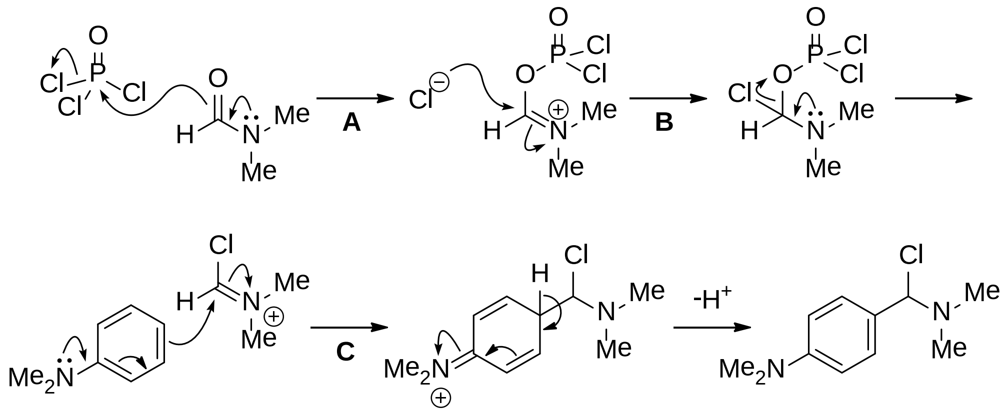


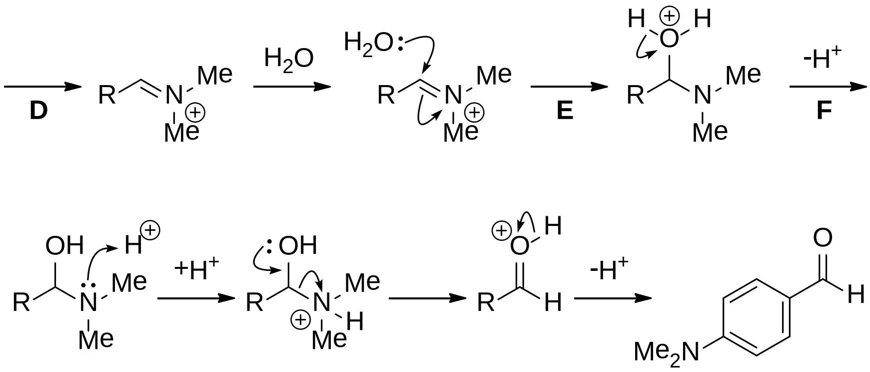


Kendall, E. C.; McKenzie, B F. *Org. Synth., Coll.* Vol. Ⅰ **1941**, 21

Strecker amino acid synthesis, **A**: Protonation of the carbonyl group. **B**: Addition of NH_3 to the carbenyl group followed by deprotonation to form a hemiaminal. **C**: Protonation followed by elimination of water is helped by the nitrogen lone pair to form an iminium ion. **D**: Addition of a cyanide ion to form an aminonitrile. **E**: Acidic hydrolysis of the nitrile. The amino group is protonated throughout the reaction. **F**: Protonation of the nitrile to form a reactive nitrilium ion. **G**: Addition of water to the nitrilium ion. **H**: Deprotonation and tautemerization. **I**: Protonation of the resulting amide followed by addition of water. **J**: Proton transfer. **K**: Elimination of NH_3 followed by deprotonation to form theproduct.

A012

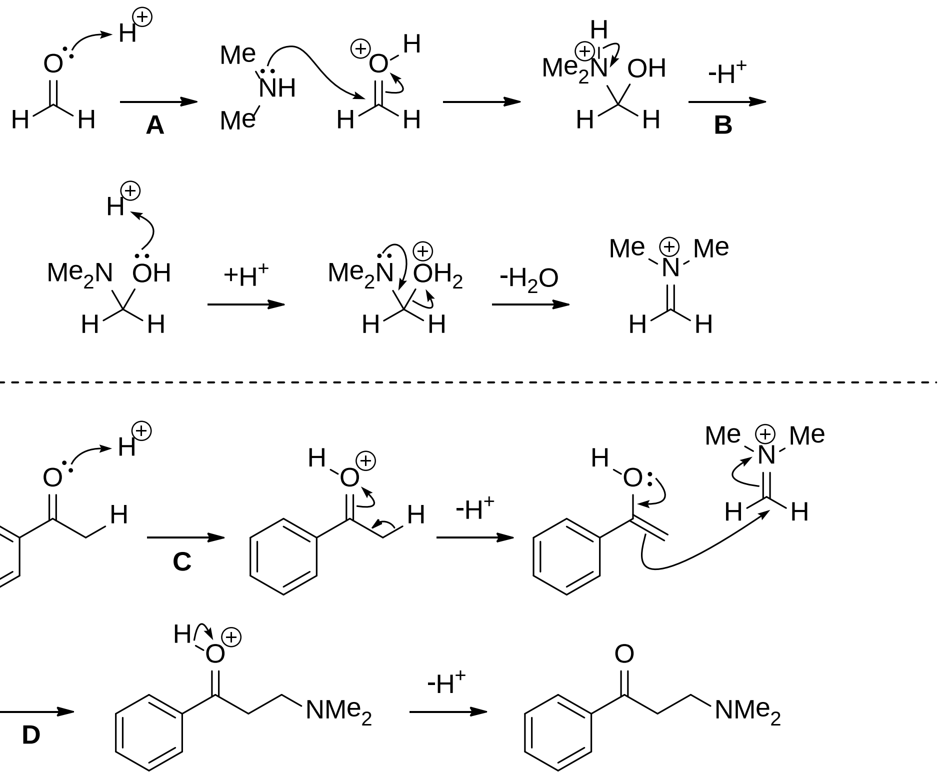




Campaigne, E.; Archer, W. L. *Org. Synth., Coll*. Vol. Ⅵ **1963**, 331

Vilsmeier reaction. **A**: The electron-rich oxygen of DMF attacks $POCl_3$ (oxygen of amides is generally more reactive toward electrophiles under neutral conditions). **B**: Addition of chloride ion followed by eation of a dichlorophosphate ion to form the Vilsmeier reagent. **C**: Addition of an electron-rich aromatic ring to Vilsmeier reagent followed by rearomatizatien **D**: Elimination of chloride ion helped by nitrogen lone pair leads to the formation of an iminium ion **E**: Addition of water to the iminium ion. F: Proton transfer followed by elimination of Me_2NH.

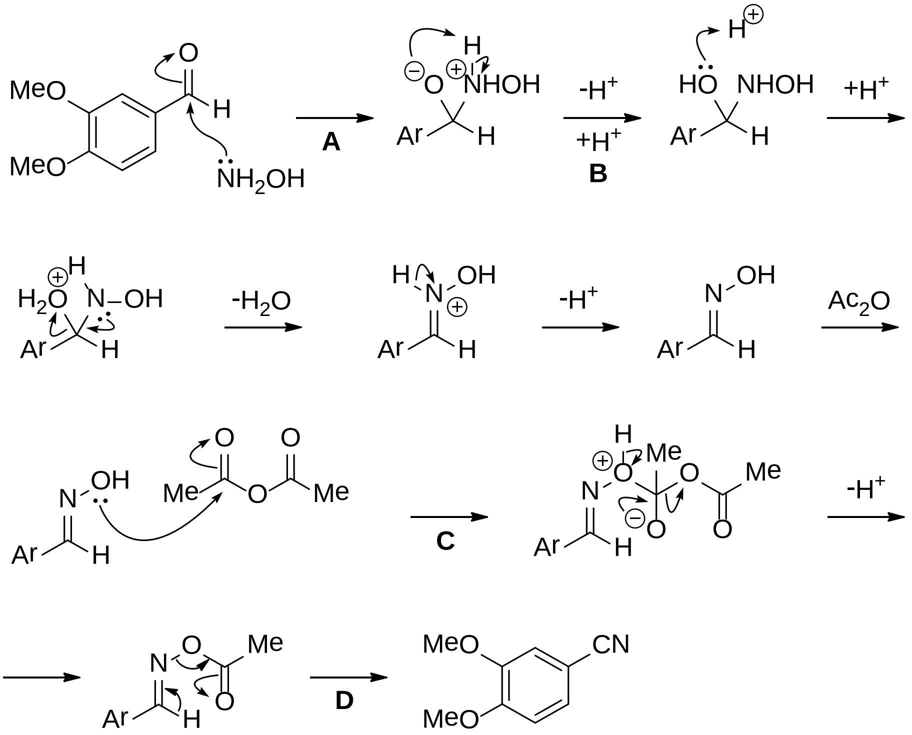
A013



Maxwell, C. E. *Org Synth., Coll*. Vol. Ⅲ **1955**, 305.

Mannich reactien. A: Protonation of formaldehyde followed by addition of Me_2NH to the carbonyl group. B: Proton transfer followed by elimination of water to form an iminium ion. C: Tautomerization of the carbonyl goroup to form an enol. D: Attack of the electron-rich enol to the iminium ion.

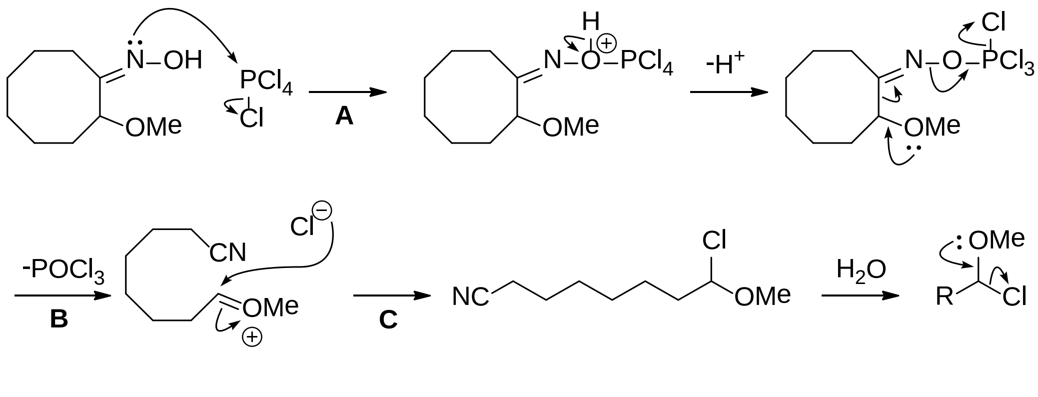
A014

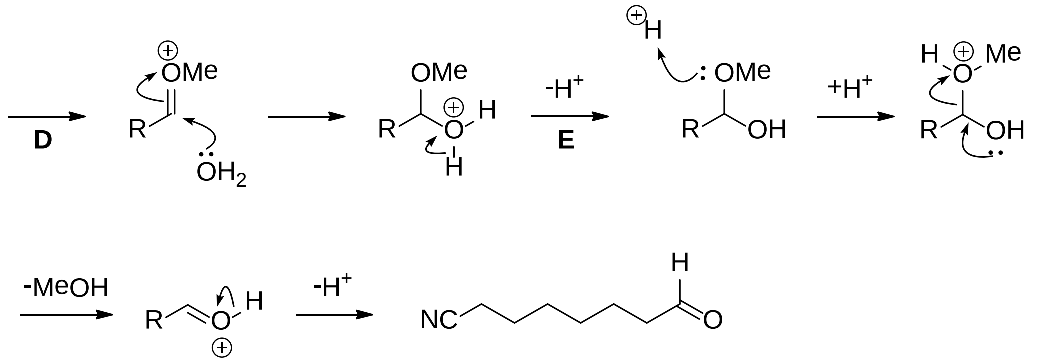


Buck, J. S,; Ide, W. S. *Org. Synth., Coll* Vol. Ⅱ **1943**, 622

A: Addition of NH_2OH to the aldehyde. **B**: Proton transfer followed by elimination of water to form an oxime. **C**: Acetylation of the oxime. **D**: syn-Elimination of AcOH to form a nitrile.

A015

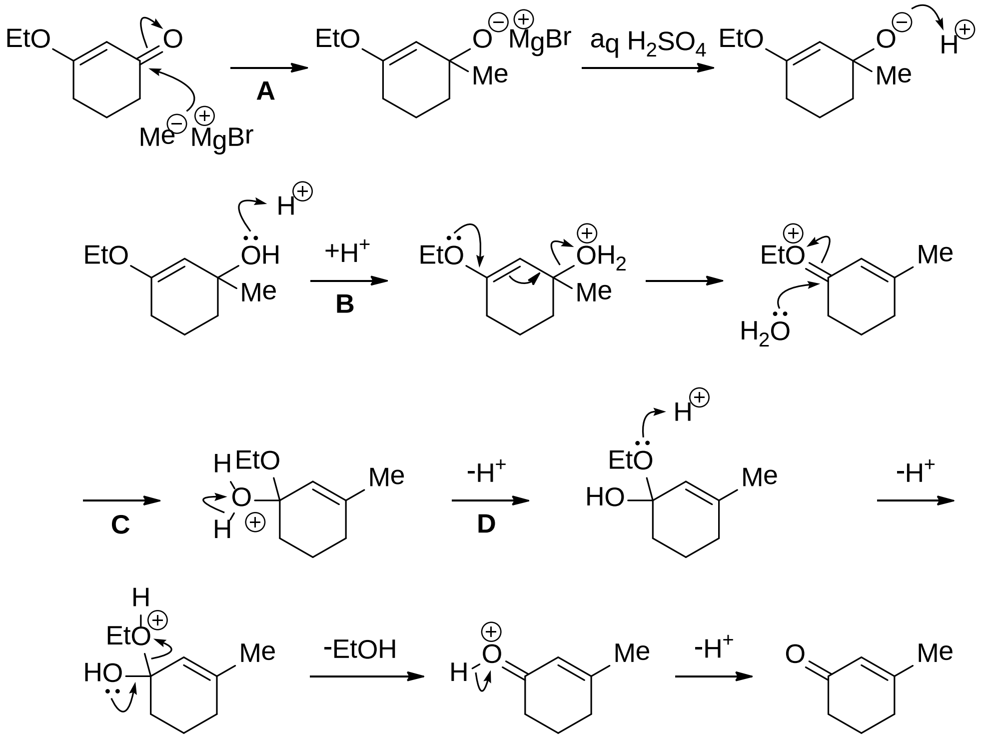




Ohno, M.; Naruse, N.; Terasawa, I. *Org. Synth., Coll*. Vol. V **1973**, 266

Beckmann fragmentation. **A**: Attack of the oxime to PCl_5. **B**: Elimination of $POCl_3$ is helped by the oxygen lone pair of the methoxy group, causing the cleavage of the C-C bond. **C**: Addition of chloride ion. **D**: Elimination of chloride ion followed by addition of water. **E**: Proton transfer followed by elimination of MeOH.

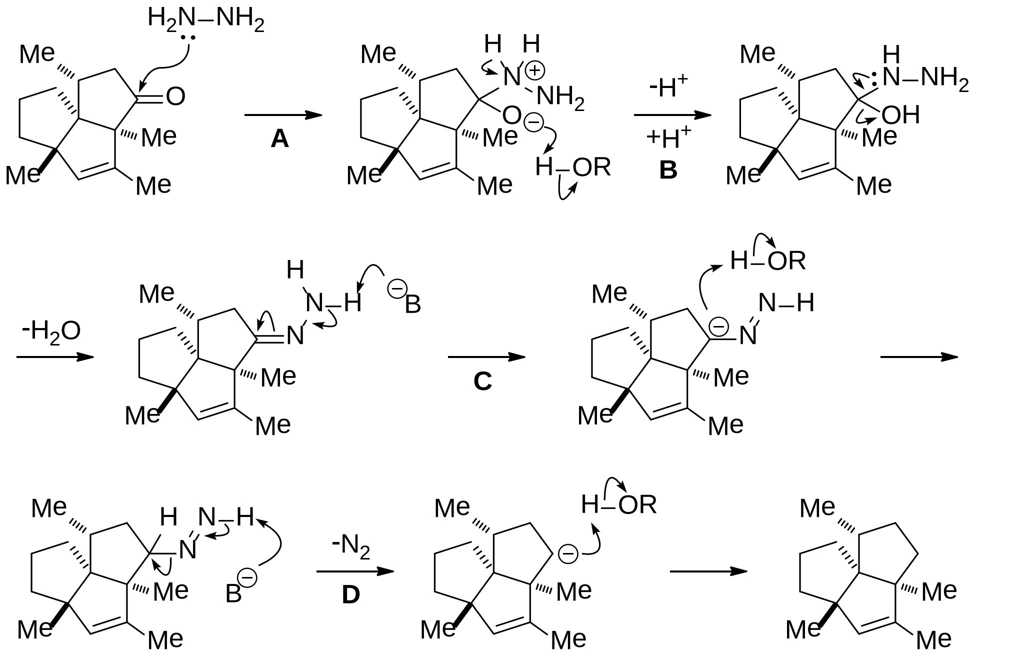
A016



Woods, G. F.; Griswold, P. H., Jr.; Armbrecht, B. H.; Blumenthal, D. I.' Plapinger, R *J. Am. Chem. Soc.* **1949**, 71, 2028

A: 1,2-Addition of MeMgBr to the carbonyl group. **B**: Protonation followed by elimination of water helped by the oxygen lone pair of the ethoxy group. **C**: Addition of water. **D**: Proton transfer followed by elimination of EtOH.

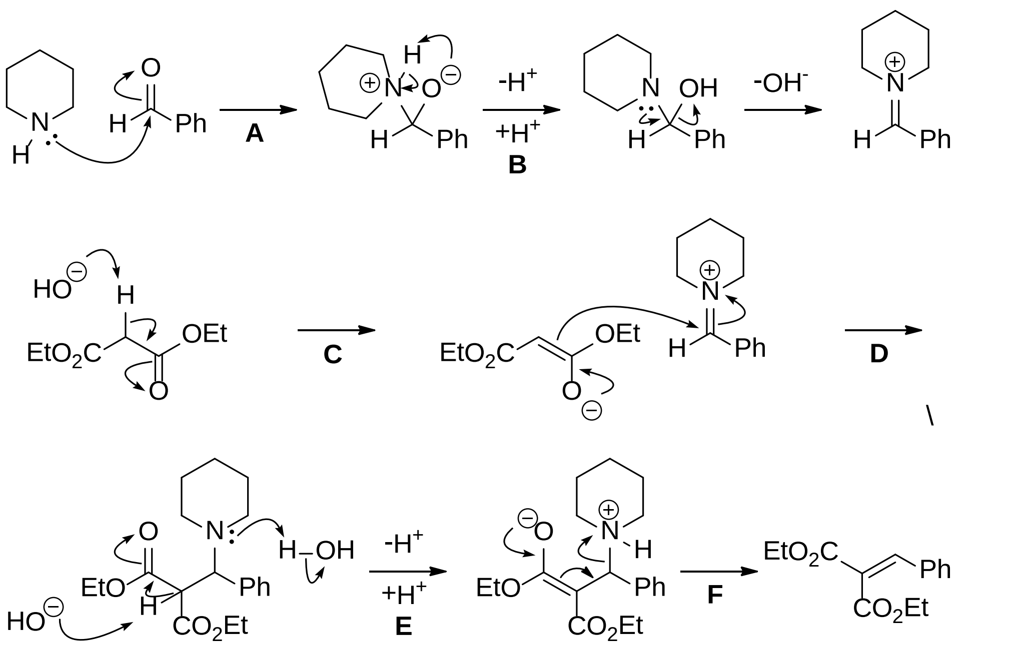
A017



Paquette, L. A.; Han, Y. K. *J. Org. Chem*. **1979**, 44, 4014.

Wolff-Kishner reduction **A**: Addition of H_2NNH_2 to the carbonyl group. **B**: Proton transfer followed by elimination of hydroxide ion to form a hydrazone. **C**: Deprotonation of the hydrazone. **D**: Elimination of N_2, an extremely good leaving group.

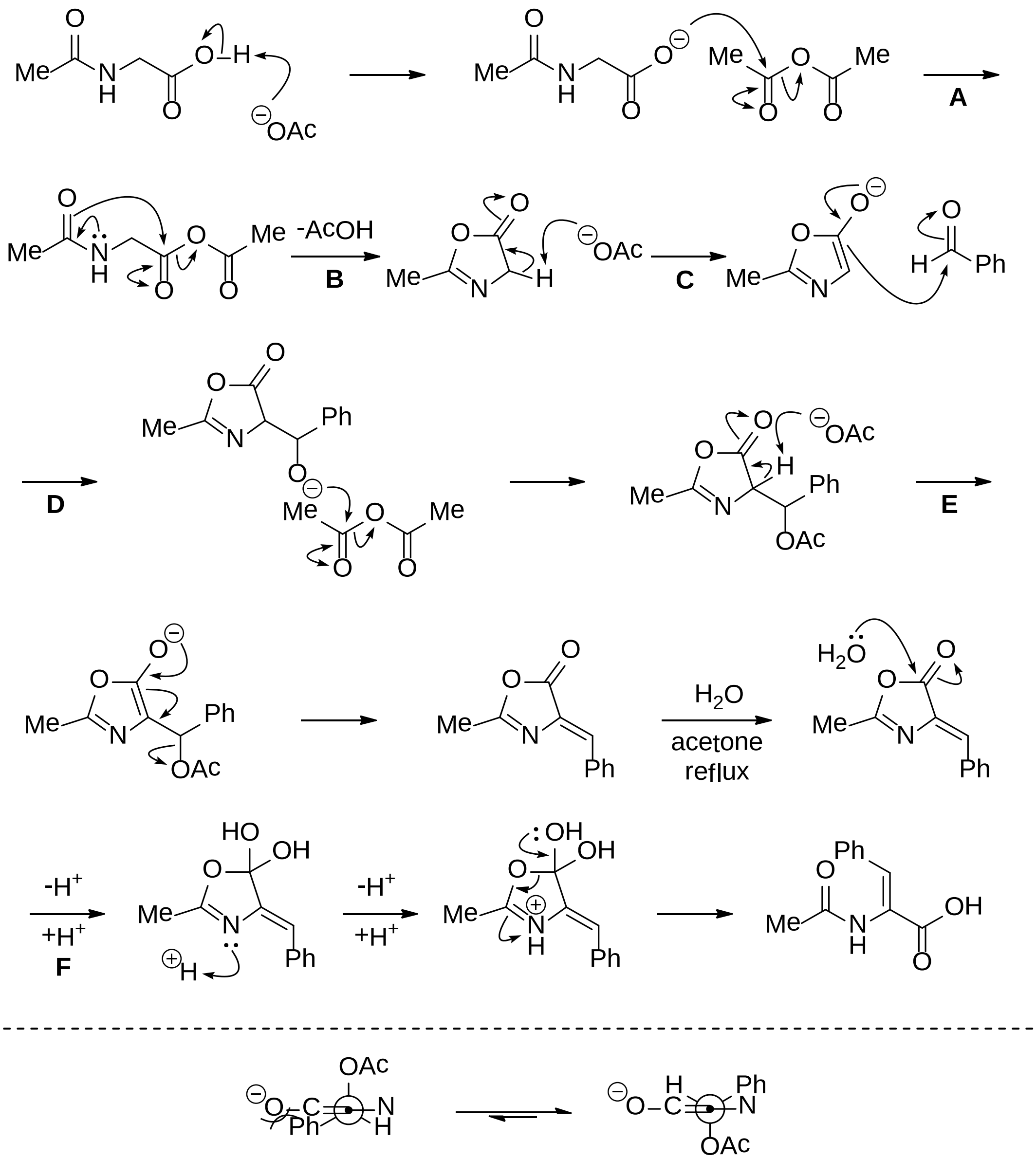
A018



Allen, C. F. H.: Spangler, F. W. *Org. Synth., Coll*. Vol. III **1955**, 37

Knoevenagel condensation **A**: Addition of piperidine to the aldehyde. **B**: Proton transfer followed byelimination of hydroxide ion to form an iminium ion. **C**: Deprotonation of a malonate to form an enolate (pKa $RO_2CCH_2CO_2R$ = 13, H_2O = 15.7). **D**: Addition of the enelate to the iminium ion. **E**: Profonation of the amine and deprotonation of the malonate. **F**: Elimination of piperidine.

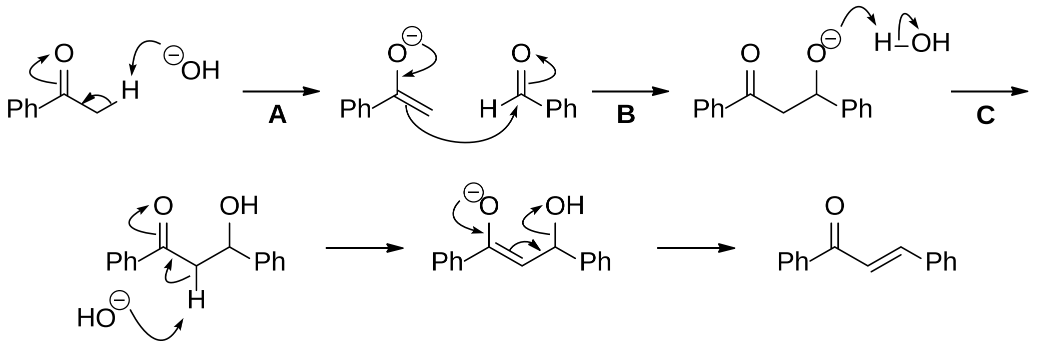
A019

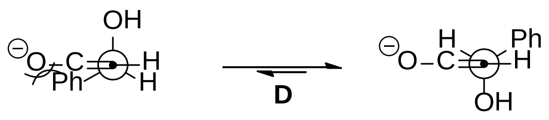


Herbst, R. M.; Shemin, D. *Org Synth., Coll*, Vol. II **1943**, 1

A: formation of a mixed anhydride. **B**: Intramolecular attack of the amide oxygen to the mixed anhydride to form an azlactone. **C**: Facile deprotonation of the azlactone (aromatization). **D**: Addition the enolate to an aldehyde followed by acetylation. **E**: Deprotonation followed by elimination of an enolate anion. **F**: Hydrolysis of the azlactone

A020

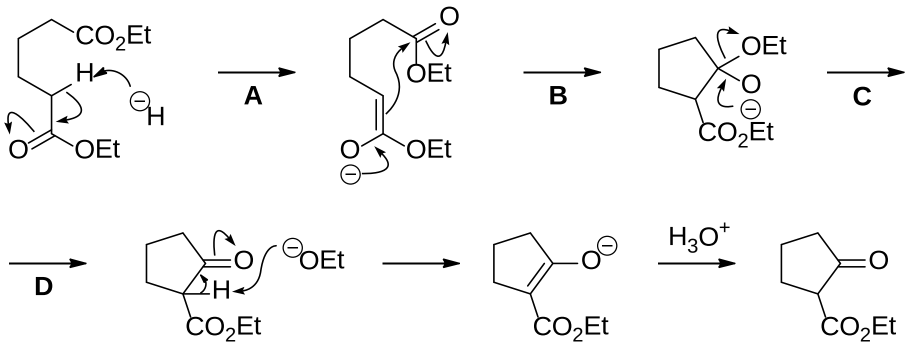




Kohler, E. P.; Chadwell, H. M. *Org. Synth., Coll* Vol. Ⅰ **1941**, 78

Aldol reaction. **A**: Deprotonation of the ketone to form an enolate. **B**: Attack of the enolate to an aldhyde **C**: Protonation and deprotonation followed by elimination of a hydroxy ion. **D**: Newman projection.

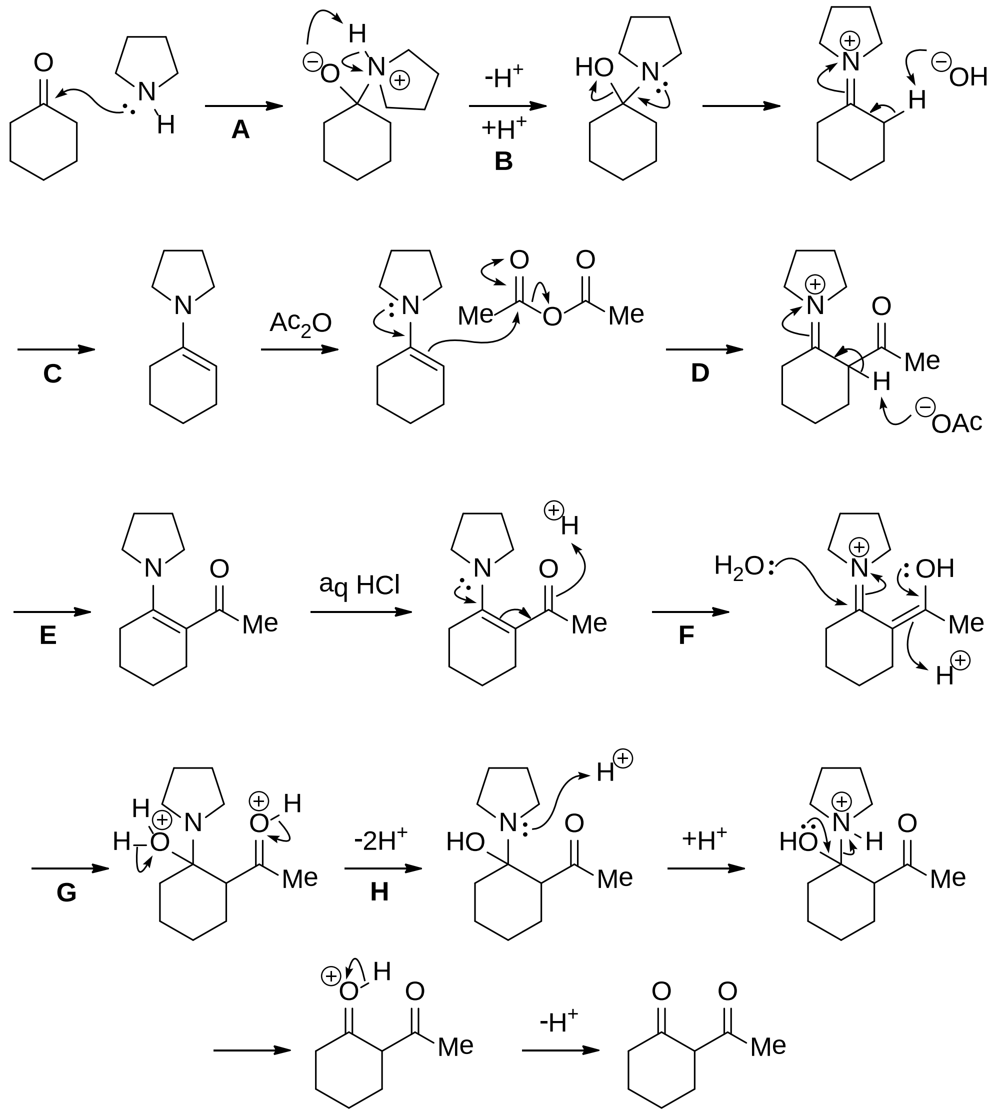
A021



Schaefer, J. P.; Bloomfield, J. J. *Org. React*. **1967**, 15 14

Dieckmann condensation. **A**: Deprotonation of the ester to form an enolate. **B**: Intramolecular addition of the enolate to the other ester, **C**: Elimination of ethoxide ion. **D**: pKa $RCOCH_2CO_2R$ = 18. EtOH = 16.

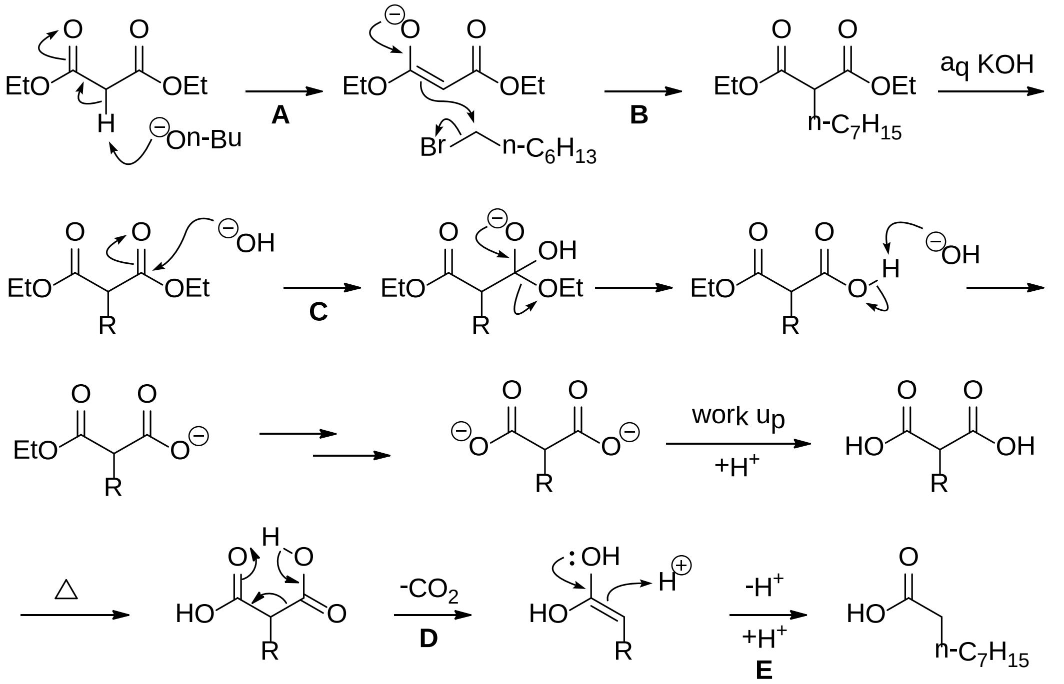
A022



Stork, G.; Brizzolara, A.; Landesman, H.; Szmuszkovicz, J.; Terrell, R.
J. Am. Chem. Soc. **1963**, 85, 207.

Stork enamine reaction. **A**: Addition of pyrrolidine to the ketone. **B**: Proton transfer followed by elimination of hydroxide ion. **C**: Deprotonation to form an enamine. **D**: Attack of the enamine to acetic anhydride. **E**: Deprotonation to form a vinylogous amide. **F**: Protonation of the vinylogous amide. **G**: Addition of water to the resulting iminium ion. **H**: Proton transfer followed by elimination of pyrrolidine.

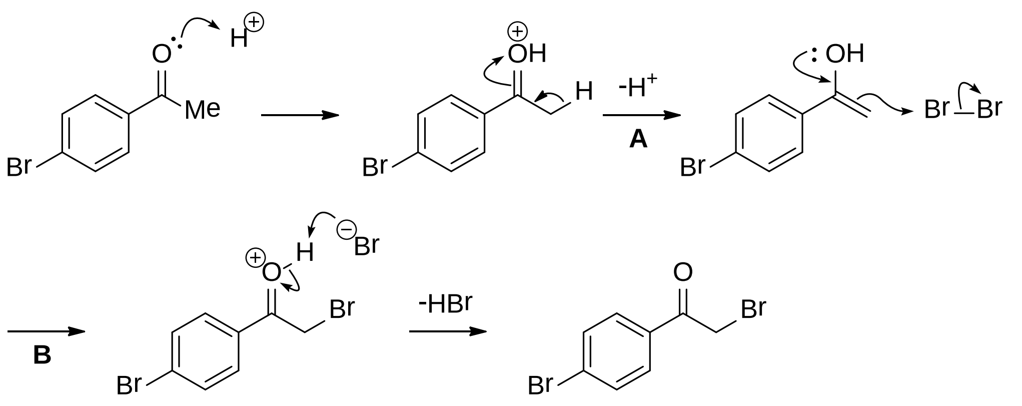
A023



Reid, E. E.; Ruhoff, J. R. *Org. Synth., Coll*. Vol. Ⅱ **1943**, 474.

A: Deprotonation of the malonate to form an enolate (pKa ROH = 16, $RO_2CCH_2CO_2R$ = 13). **B**: Attack of the enolate to an alkyl bromide. **C**: Hydrolysis of the esters. **D**: Decarboxylation through a six-membered transition state. **E**: Tautomerization.

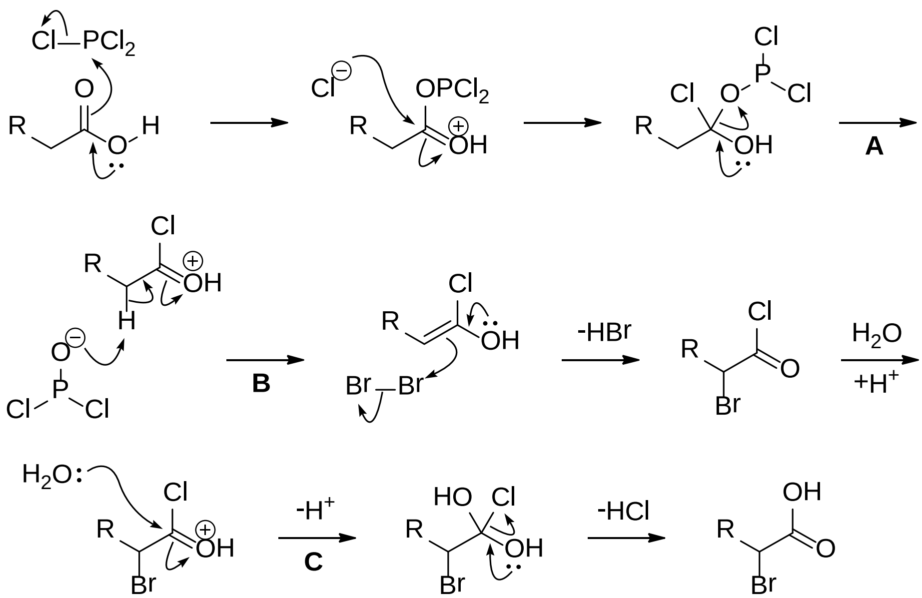
A024



Langley, W. D. *Org. Synth., Coll*. Vol. Ⅰ **1941**, 127

A: Acid-catalyzed formation of an enol. **B**: Bromination of the electron-rich enol.

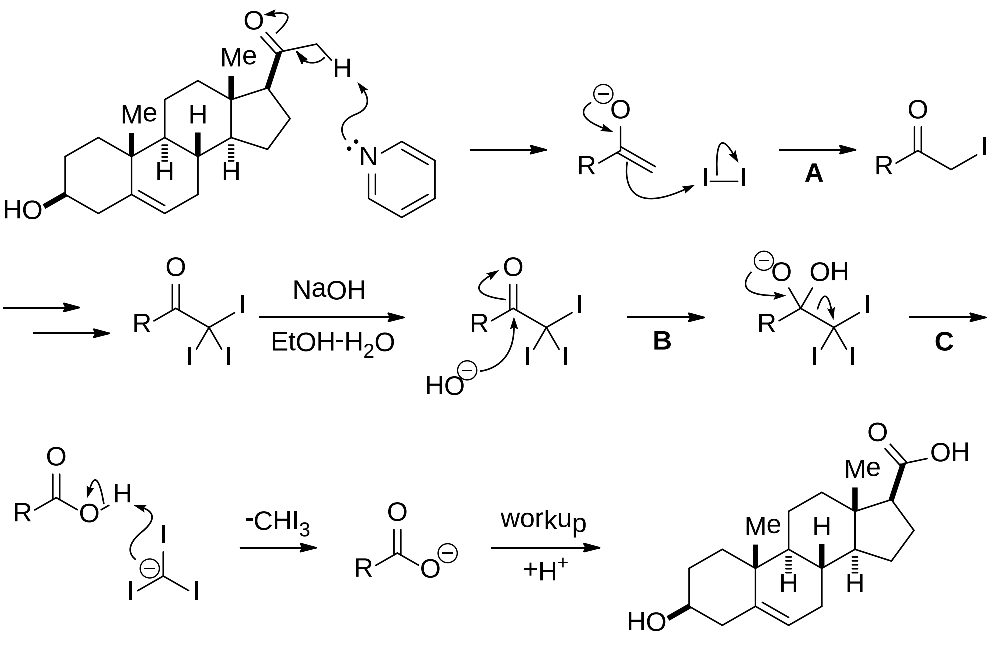
A025



Clarke, H. T.; Taylor, E. R. *Org. Synth., Coll.* Vol. Ⅰ **1941**, 115

Hell-Volhard-Zelinsky reactlon **A**: Formation of an acid chloride. **B**: pKa CH_3COCl = 16, CH_3CO_2R = 24. Formattion of an electron-rich enol followed by bromination. **C**: Hydrolysis of the acid chloride.

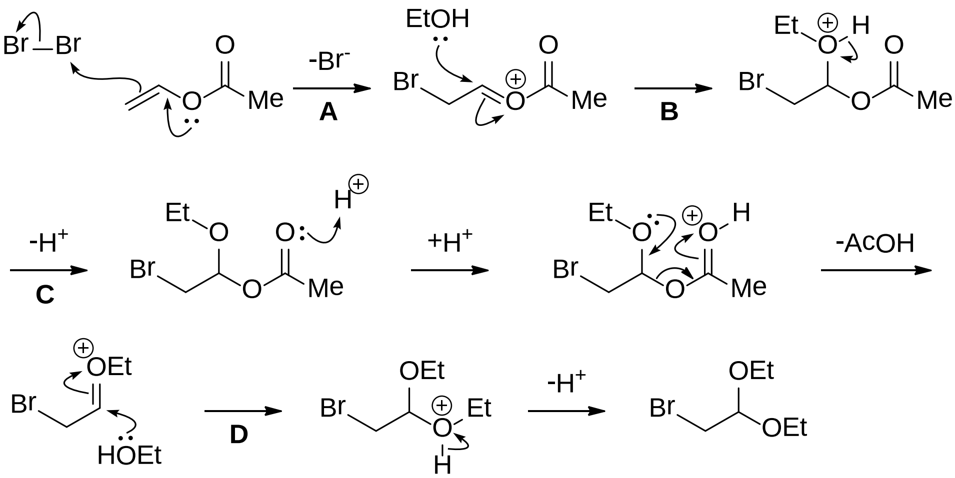
A026



Bergmann, E. D.; Rabinovitz, M.; Levinson, Z. H. *J. Am. Chem. Soc.* **1959**, 81, 1239.

Idioform reaction. **A**: lodination of the α-position of the ketone. **B**: Addition of hydroxide ion. **C**: Elimination of an iodoform anion.

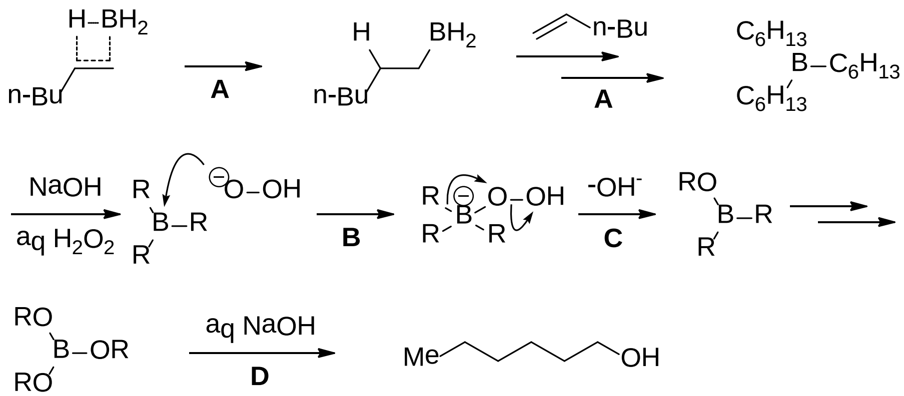
A027



McElvain, S. M.; Kundiger, D, *Org. Synth., Coll.* Vol. III **1955**, 123

A: Bromination of the electron-rich enol ester. **B**: Addition of EtOH. **C**: Proton transfer followed by elimination of AcOH. **D**: Addition of EtOH.

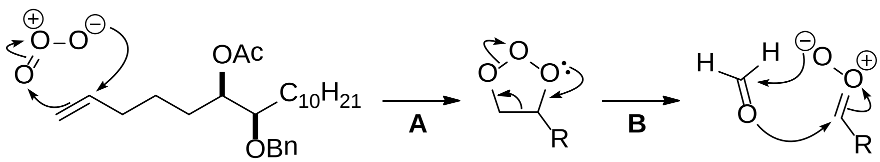
A028

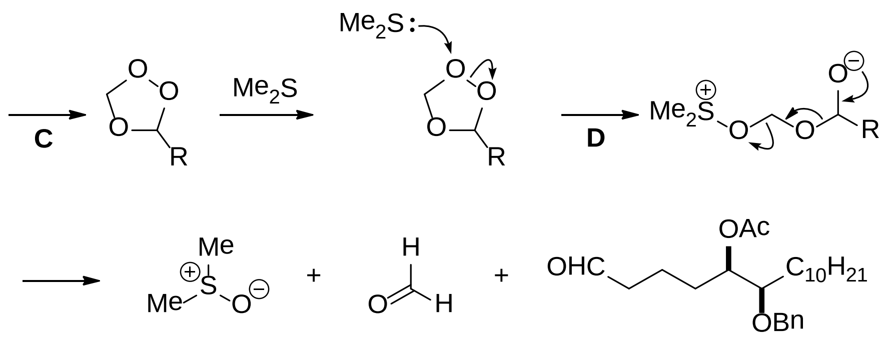


Kono, H.;Hooz, J *Org. Synth., Coll*, Vol, VI **1988**, 919

A: Hydroboration through a four-membered transition state. **B**: Attack of a hydroperoxide anion to the borane to form an ate complex, **C**: Migration of an alkyl group. **D**: Hydrolysis of the borate.

A029

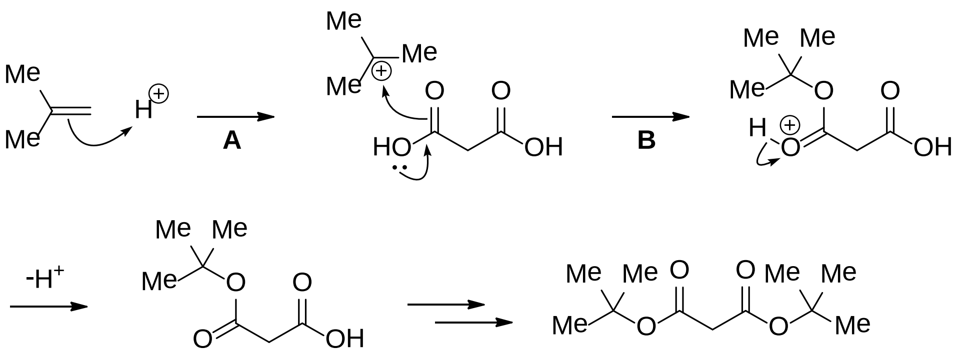




Ko, K.-Y.; Eliel, E. L. *J Org. Chem*. **1986**, 51, 5353

A: 1,3-Dipolar cycloaddition of ozone to the olefin. **B**: Heterolytic cleavage of the initial ozenide. **C**: Recombination of the resulting 1,3-dipole and the aldehyde to form an ozonide. **D**: Reductive cleavage of the O-O bond of the ozonide with Me_2S.

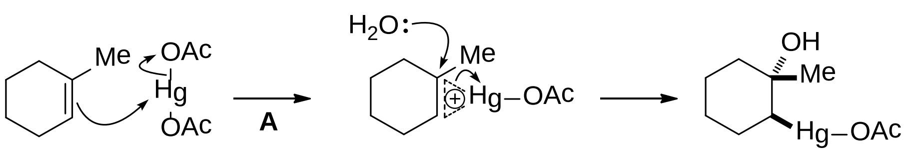
A030

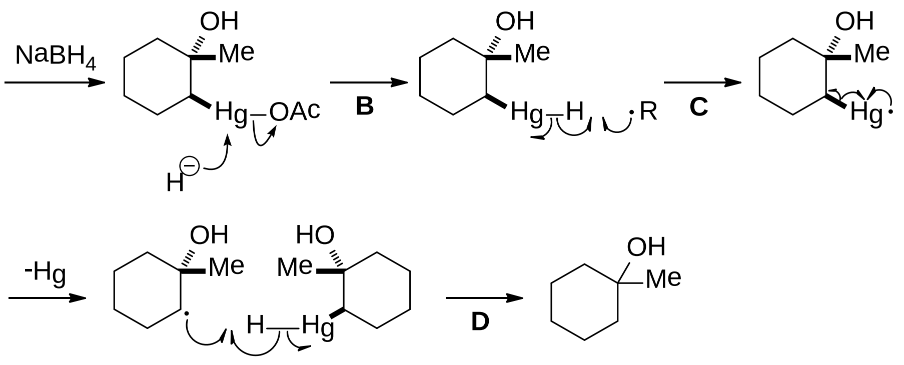


McCloskey, A. L.; Fonken, G. S.; Kluiber, R. W.; Johnson, W. S. *Org. Synth., Coll*. Vol. Ⅳ **1963**, 261.

A: Protonation of isobutylene to form a stable tertiary carbocation. **B**: Attack of a carboxylic acid to the esterication.

A031

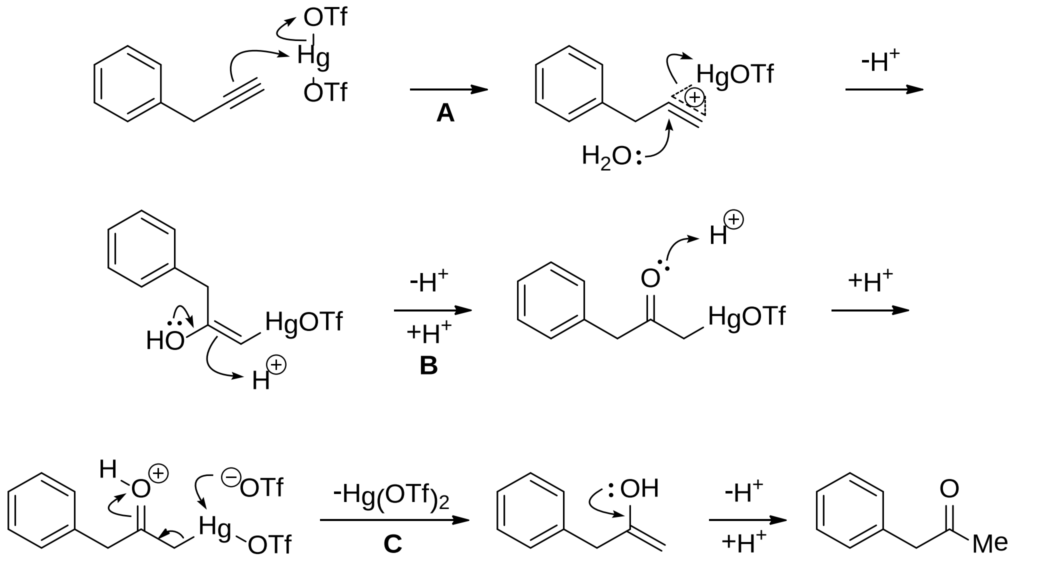




Jerkunica, J. M.; Traylor, T. G. *Org. Synth., Coll.* Vol. Ⅵ **1988**, 766.

A :Oxymercuration of the olefin. **B**: Reduction with $NaBH_4$ to form a Hg-H bond. **C**: Cleavage of the Hg-H bond followed by extrusion of Hg to form a secondary carbon radical. **D**: Abstraction of a Hydrogen atom.

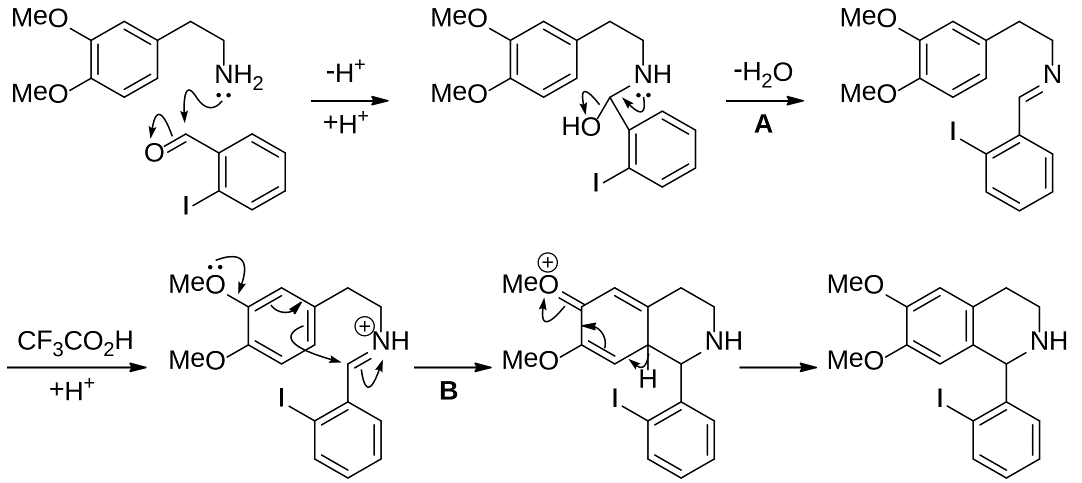
A032



Nishizawa, M.; Skwarczynski, M.; Imagawa, H.; Sugihara, T. *Chem. Lett.* 2002, 12.

A: Oxymercuration of the alkyne. **B**: Tautomerization of the enol. **C**: Demercuration to regenerate $Hg(OTf)_2$.

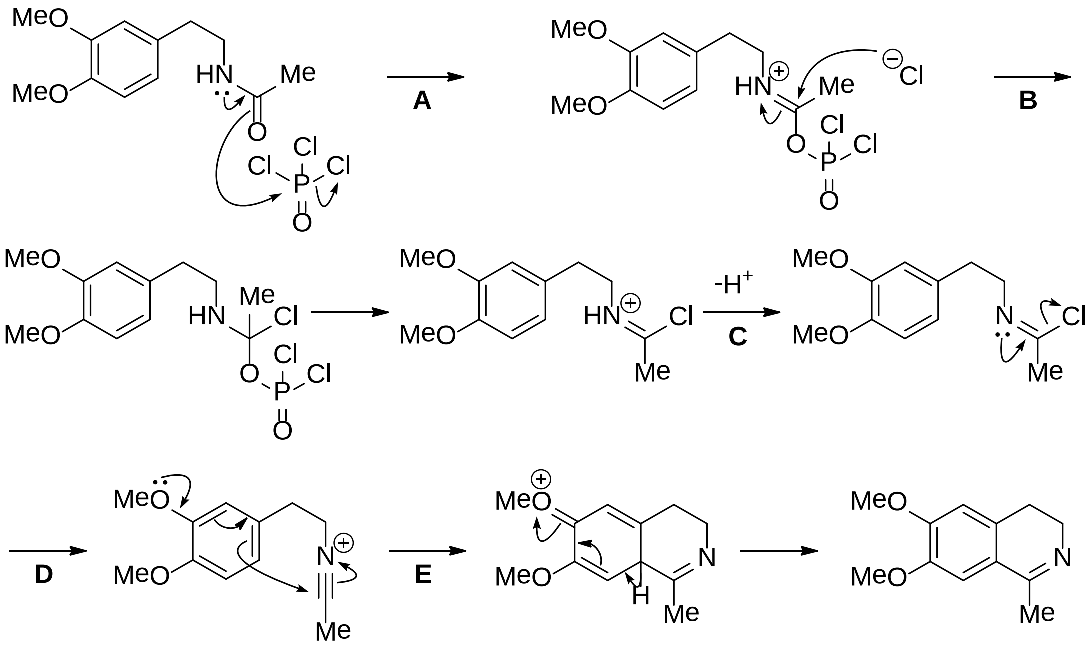
A033



Whaley, W. M.; Govindachari, T. R. *Org, React.* **1951**, 6, 151.

Pictet-Spengler reaction. **A**: Formation of an imine. **B**: Addition of an electron-rich aromatic ring to the iminium ion followed by aromatization.

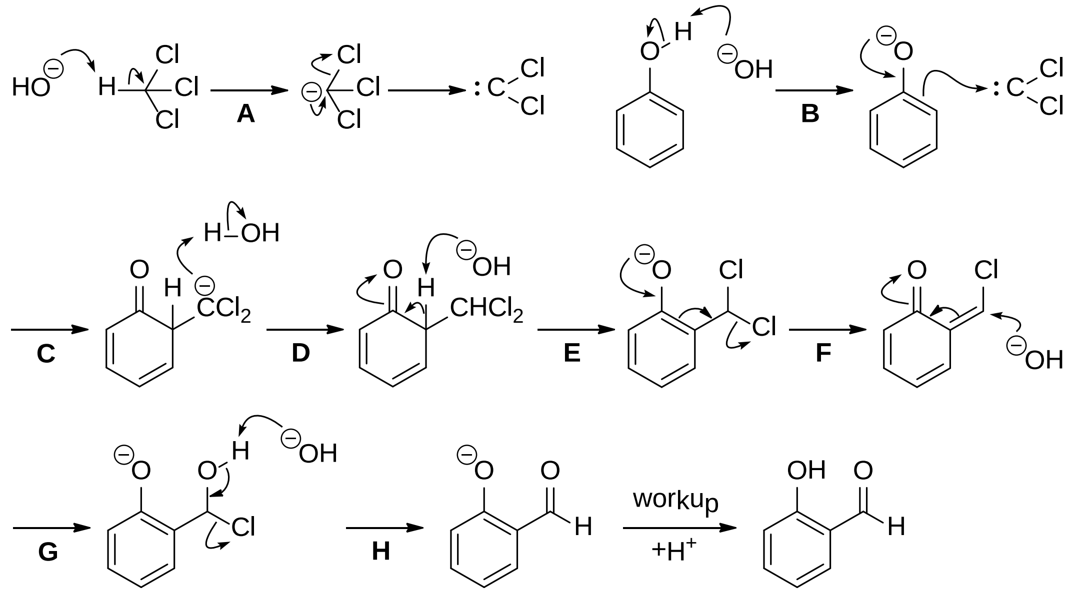
A034



Brossi, A: Dolan, L. A.; Teitel, S. *Org. Synth., Coll* Vol. Ⅵ **1988** 1

Bischler-Napieralski reaction. **A**: Attack of the oxygen atom of the amide to $POCl_3$. **B**: Addition of chloride ion followed by elimination of dichlorophosphate ion. **C**: Deprotonation. **D**: Elimination of chloride ion to form a nitrilium ion. **E**: Attack of an electron-rich aromatic ring to the nitrilium ion.

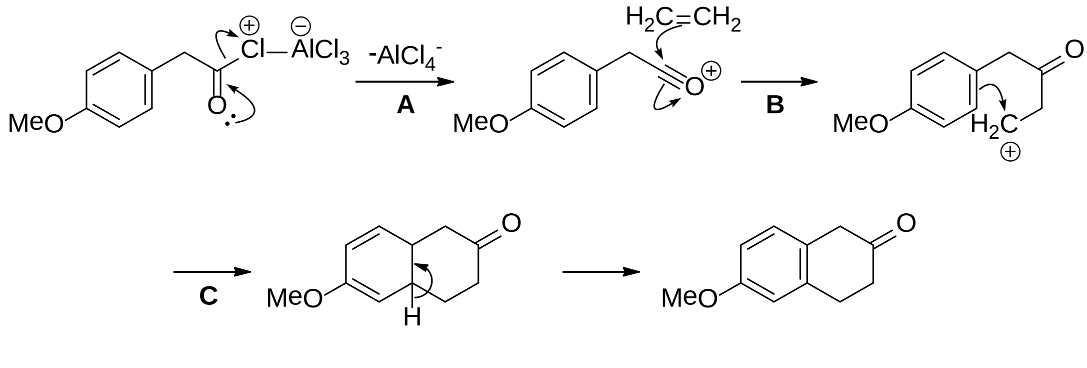
A035



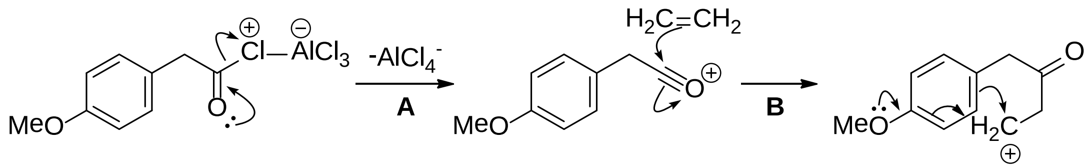
Wynberg, H.; Meijer, E. W. *Org. React.* **1982**, 28, 1.

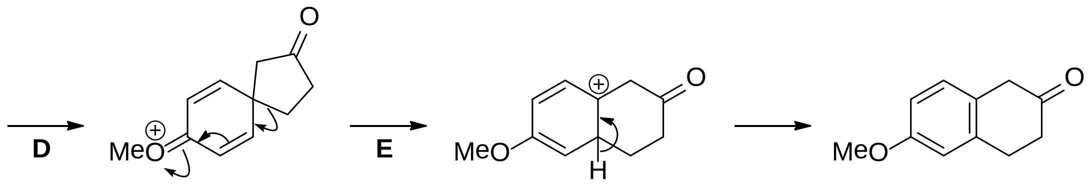
Reimer-Tiemann reaction. **A**: Deprotonation of $CHCl_3$ followed by α-elimination to form dichlorocarbene (pKa $CHCl_3$ = 13.6, H_2O = 15.7). **B**: Formation of phenoxide ion (pKa PhOH = 10). **C**: Attack of the phenoxide ion to dichlorocarbene. **D**: Protonation. **E**: Aromatization. **F**: Elimination of chloride ion helped by the oxygen lone pair of the phenoxide ion. **G**: Conjugate addition of hydroxide ion. **H**: Elimination of chloride ion.

A036



or

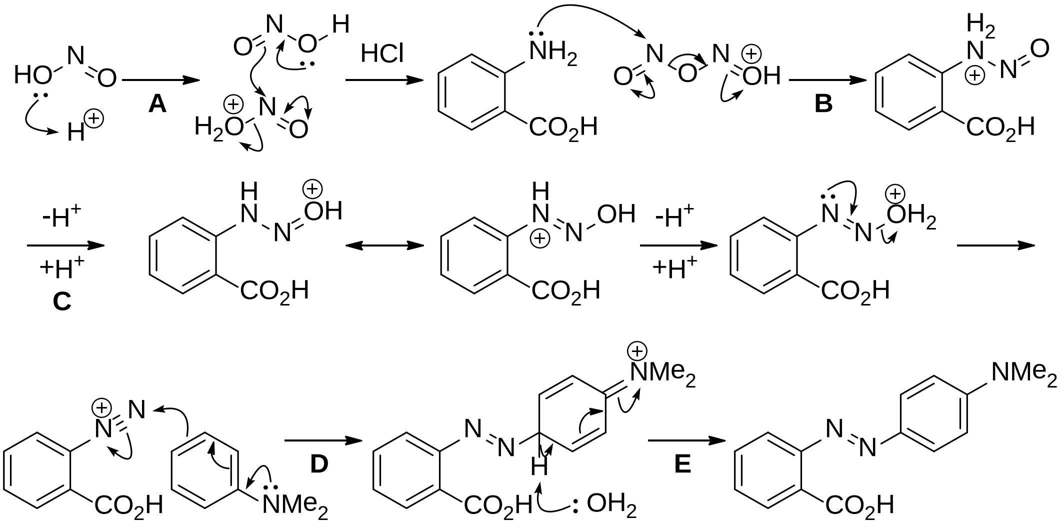




Sims, J. J.; Selman, L. H.; Cadogan, M. *Org. Synth, Coll.* Vol. Ⅵ **1988**, 744

Intramolecular Friedel-Crafts acylation. **A**: Formation of an acylium ion. **B**: Addition of ethylene to the aeylium ion. **C**: Attack of the aromatic ring to the resulting primary carbocatian. **D**: Attack of the aromatic ring at the para position of the methoxy group to the primary carbocation. **E**: 1,2-Alkyl shift.

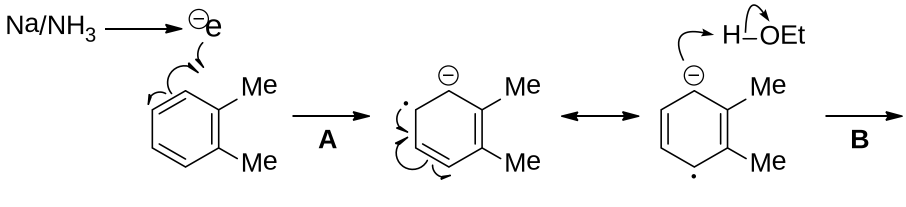
A037

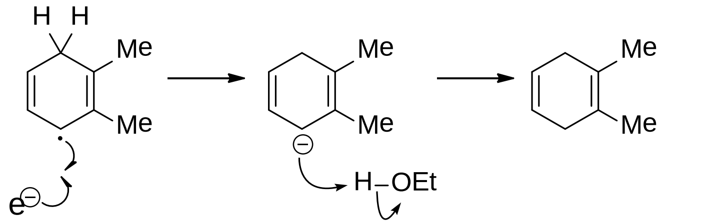


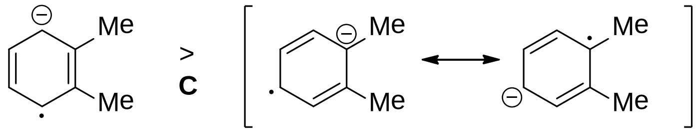
Clarke, H. T.; Kimer, W. R. *Org. Synth., Coll.* Vol. Ⅰ **1941**, 3. 4,

A: Formation of nitrous anhydride. **B**: Addition of the aniline to nitrous anhydride. **C**: Proton transfers fallowed by elimination of water to form a diazonium salt. **D**: Addition of electron-rich dimethylaniline to the diazonium salt. **E**: Aromatization.

A038



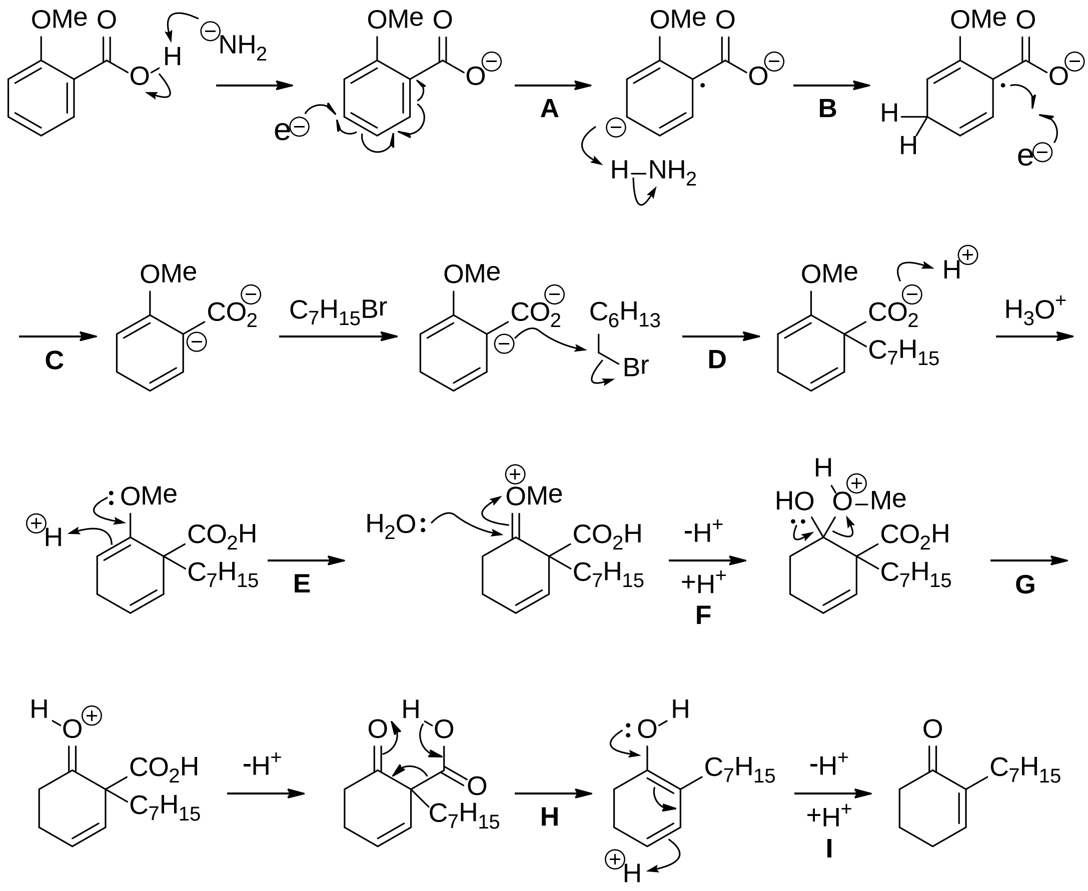




Paquette, L. A.; Barrett, J. H. Org. Synth., Coll. Vol. Ⅴ **1973**, 467.

Birch reduction. **A**: Single electron transfer (SET) from Na to the aromatic ring to form a radical anion. **B**: Protonation. **C**: More substituted olefins are formed because alkyl groups destabilize a carbanion.

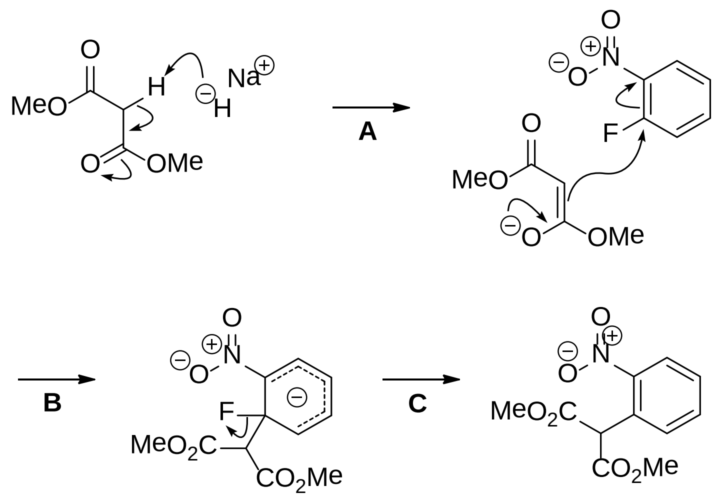
A039



Taber, D. F.; Gunn, B. P.; Chiu, I.-C. *Org. Synth., Coll* Vol. Ⅵ **1983**, 249.

Birch reduction **A**: Single electron transfer (SET) to form a radical stabilized by the carboxylate. **B**: Protonation of the radical anion, **C**: SET to form a dianion species. **D**: Alkylation of the dianionic species. **E**: Protonation of the electron-rich enol ether. **F**: Addition of water followed by proton transfer. G: Elimination of MeOH. H: Decarboxylation through a six-membered transition state. **I**: Tautomerization.

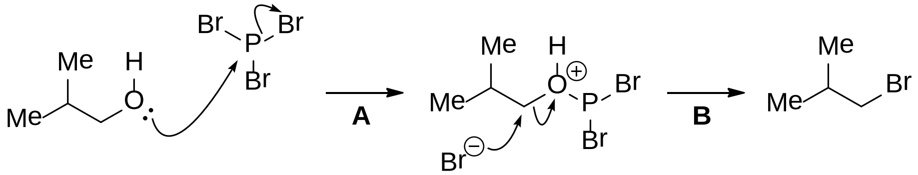
A040



Selvakumar, N.; Reddy, B. Y.; Azhagan, A. M.; Khera, M. K.; Babu, J. M.; Iqbal, J *Tetrahedron Lett.* **2003**, 44, 7065

A: Deprotonation of the malonate to form an enolate (pKa $RO_2CCH_2CO_2R$ = 13, H_2 = 35), **B**: Nucleophilic addition of the enolate to the electron-deficient aromatic ring. **C**: Elimination of fluoride ion.

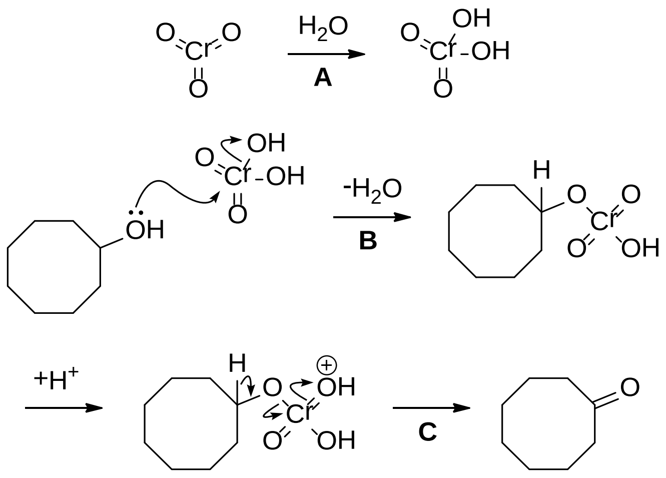
A041



Noller, C. R.; Dinsmore, R. *Org. Synth., Coll*. Vol. Ⅱ **1943**, 358

A: Attack of the alcohol to PBr_3. **B**: S_N2 reaction.

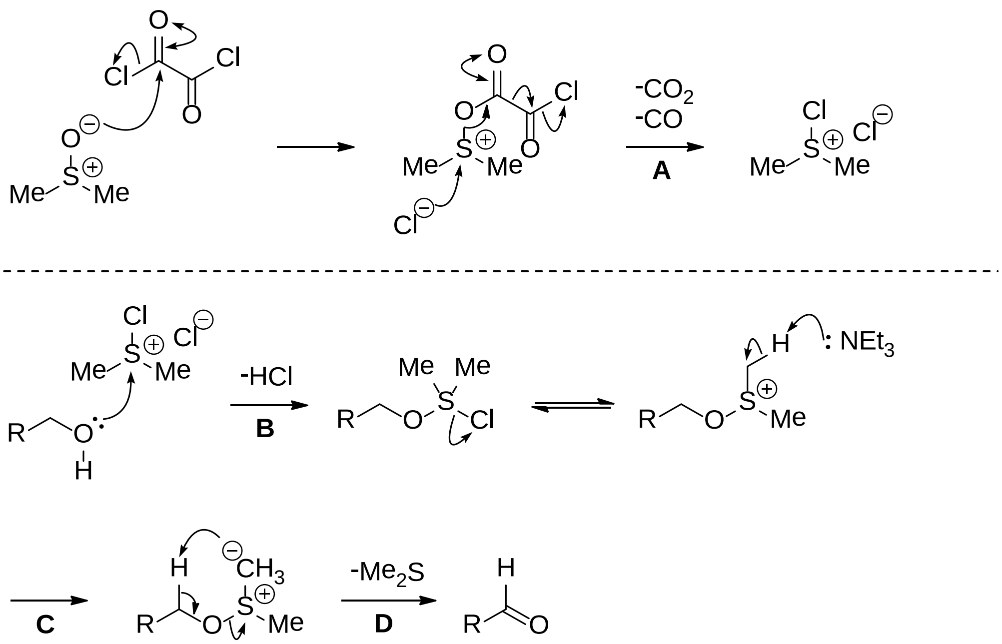
A042



Eisenbraun, E. J. *Org. Synth., Coll*. Vol. Ⅴ **1973**, 310.

Jones oxidation. **A**: Hydration of CrO_3. **B**:Attack of the alcohol to H_2CrO_4. **C**: Elimination of H_2CrO_3.

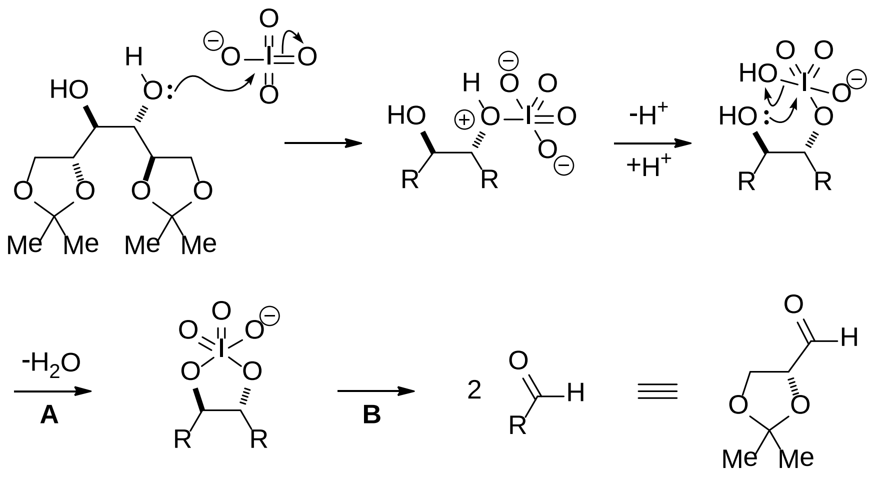
A043



LeopoLd, E. J. *Org. Synth., Coll*. Vol. Ⅶ **1990**, 258.

Swern Oxidation. **A**: Attack of DMSO to $(COCl)_2$ to form a chlorosulfonium ion with generation of CO and CO_2. **B**: Attack of an alcohol to the chlorosulfonium ion. **C**: Formation of a sulfur ylide. **D**: β-Elimination of Me_2S.

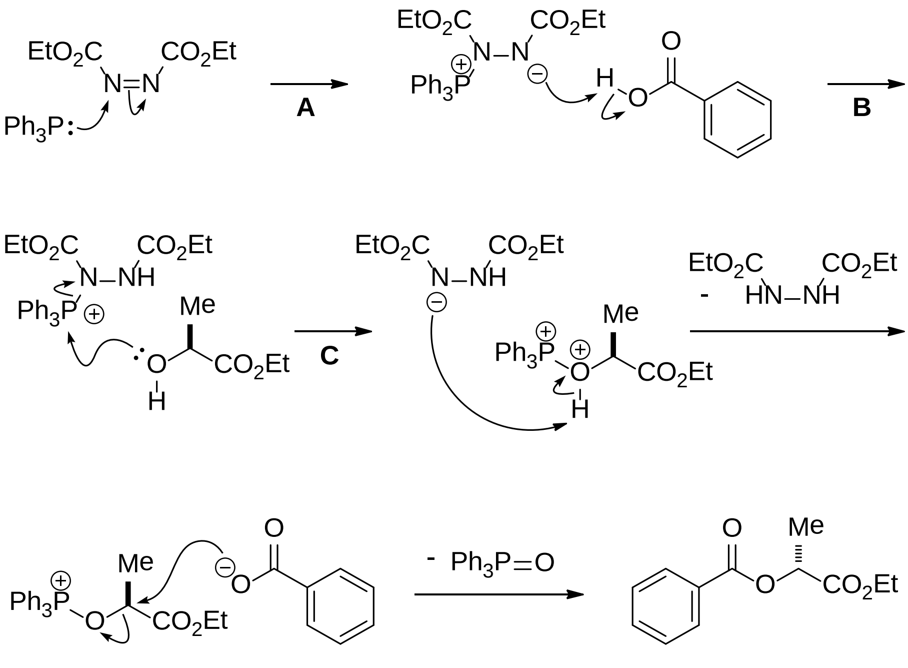
A044



Schmid, C. R.; Bryant, J. D. *Org. Synth., Coll*. Vol Ⅷ **1995**, 450

A: Formation of a cyclic intermediate. **B**: Cleavage of the C-C bond to form two molecules of the aldehyde,

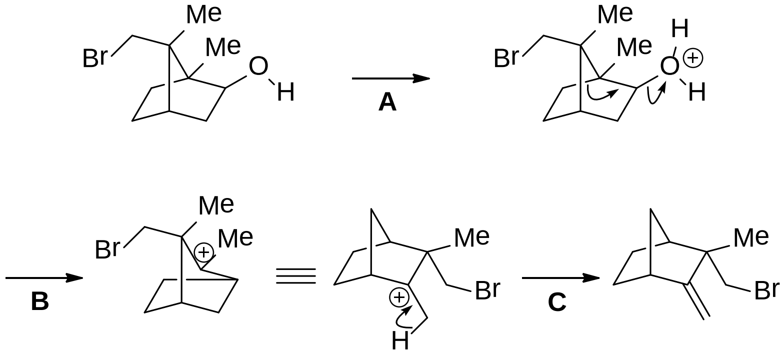
A045



Mitsunobu, O. *Synthesis* **1981** 1

Mitsunobu reaction. **A**: Conjugate addition of Ph_3P to DEAD to form a zwitter ion. **B**: Deprotonation to the most acidic proton in the reaction system. **C**: Attack of the alcohol to the activated reagent followed by deprotonation. **D**: Attack of the carboxylate with inversion of configuration.

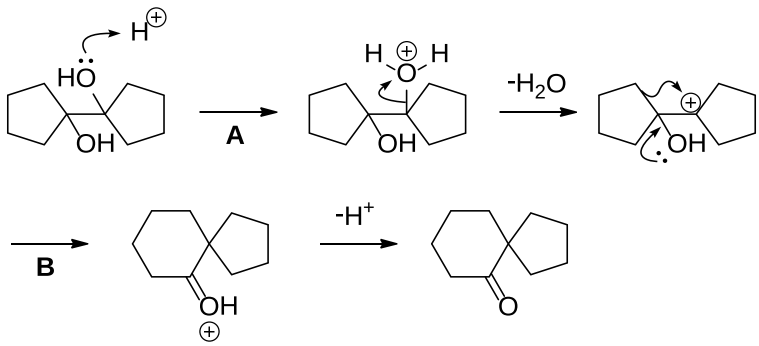
A046



Zhong, G.-F.; Schlosser, M. *Synlett*. **1994**, 173

Wanger-Meerwein rearrangement. **A**: Protonation of the alcohol. **B**: Elimination of water assisted by cleavage of the C-C bond to form a stable tertiary carbocation **C**: Deprotonation to form an olefin.

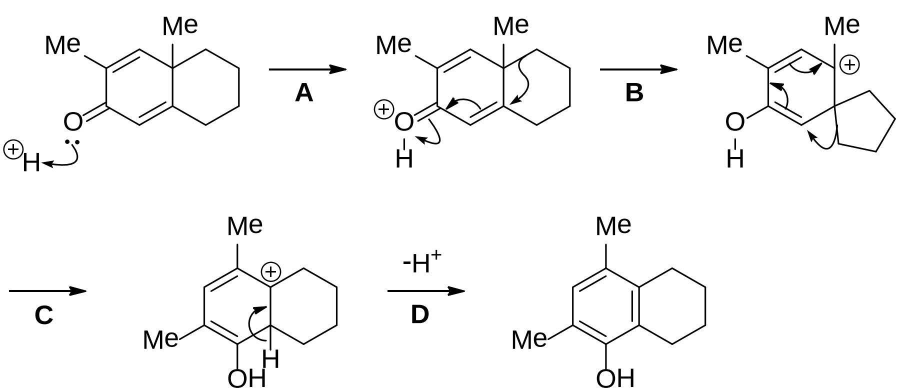
A047



Walter, C. R., Jr. *J. Am. Chem. Soc.* **1952**, 74, 5185.

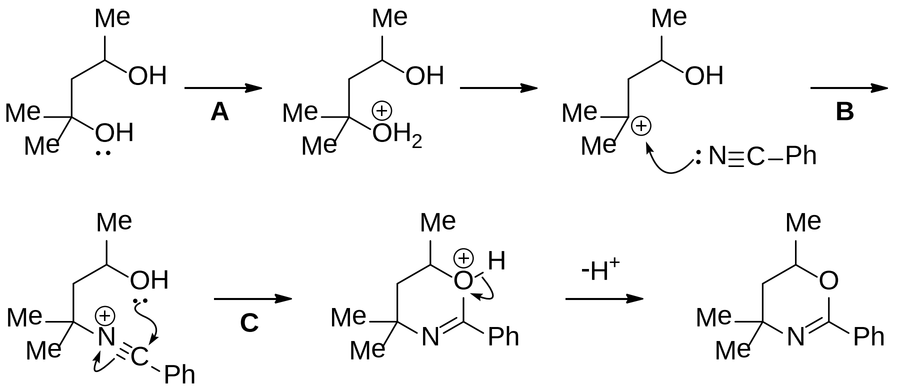
pinacol rearangement. **A**: Protonation of the alcohol followed by elimination of water to form a tertiary center. **B**: 1,2-Alkyl shift helped by the oxygen lone pair of the hydroxy group.

A048



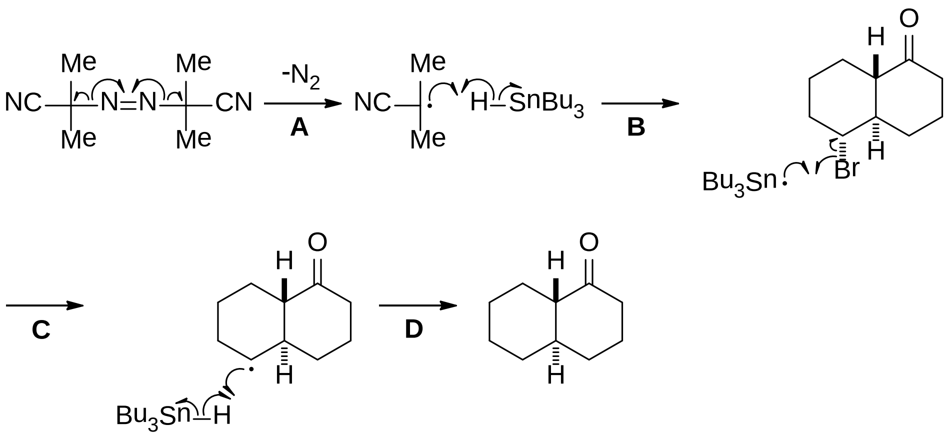
Waring, A.J.; Zaidi, J. H.; Pilkington, J. W. *J. Chem. Soc., Perkin Trans.* I **1981**, 1454.
Dienone-phenol rearrangement. **A**: Protonation of the ketone. **B**: 1,2-Alkyl shift to form a stable tertiary carbocation. **C**: 1,2-Alkyl shift to form a stable tertiary carbocation. **D**: Aromatization by deprotonation.

A049



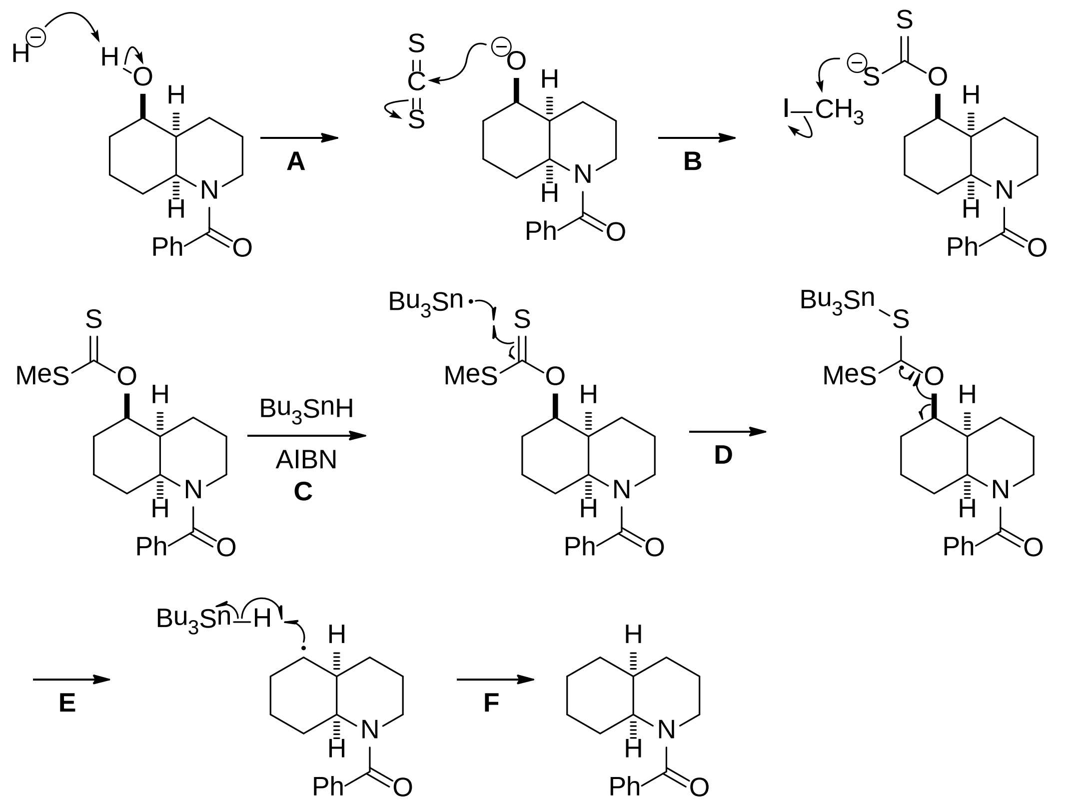
Tillmanns, E.-J.; Ritter, J. J. *J. Org. Chem*. **1957**, 22, 839
Ritter reaction. **A**: Protonation of the tertiary alcohol followed by elimination of water to form a more stable tertiary carbocation. **B**: Attack of PhCN to the carbocation to form a nitrilium ion. **C** Intramolecular addition of the hydroxy group to the nitrilium ion.

A050



Hamon, D. P. G.; Richards, K. R. *Aust. J. Chem*. **1953**, 36, 2243
A: Thermal decomposition of AIBN to give the stable tertiary radicals. **B**: Abstraction of a hydrogen atom from Bu_3SnH. **C**: The resulting tin radical reacts with a halide to form a carbon radical. **D**: Abstraction of a hydrogen atom from Bu_3SnH to continue the radical chain reaction.

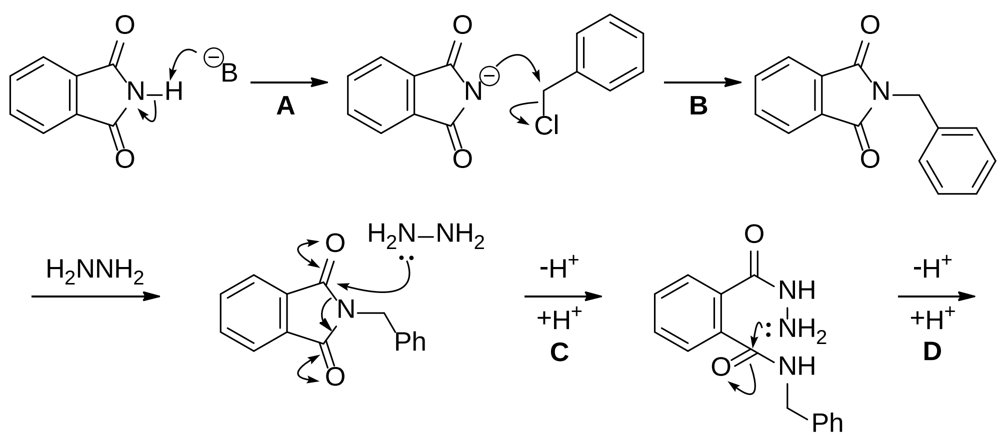
A051

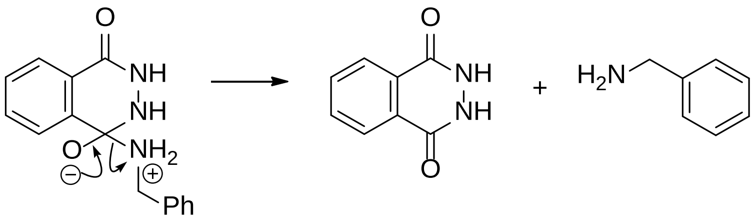


Comins, D, L.; Abdullah, A. H. *Tetrahedron Lett.* **1985**, 26, 43.

Barton-McCombie deoxygenation. **A**: Deprotonation of an alcohol. **B**: Addition of the alkoxide ion to CS_2 followed by methylation to form a xanthate. **C**: Generation of a tin radical. **D**: Attack of the radical to the sulfur atom of the xanthate to form a stable carbon radical. **E**: Cleavage of the C-O bond to form a secondary carbon radical. **F**: Abstraction of a hydrogen from Bu_3SnH.

A052

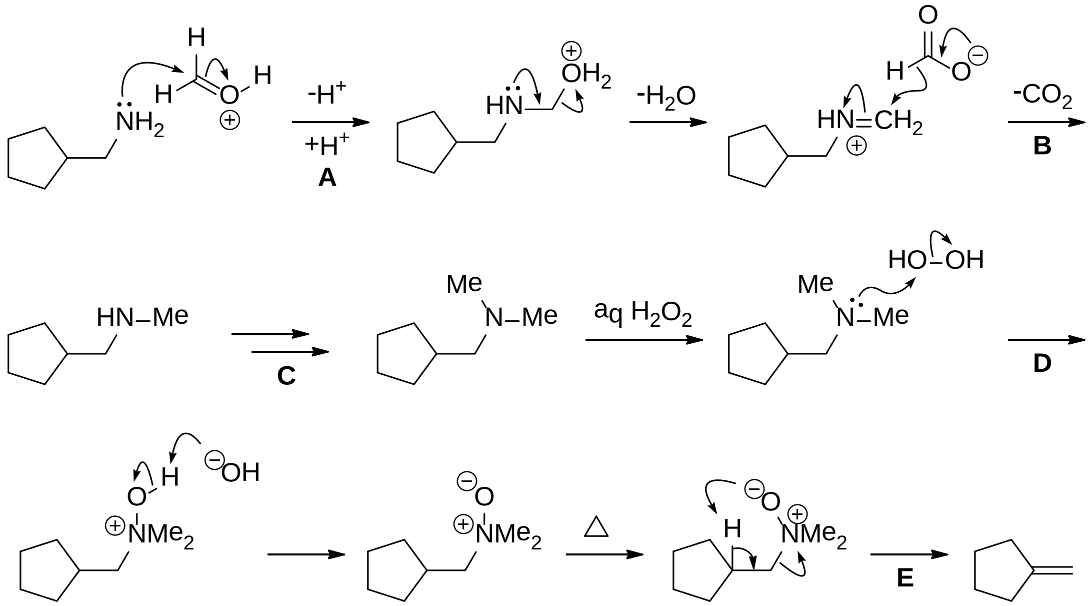




Manske, R. H. F. *Org. Synth., Coll*. Vol. II **1943**, 83.

Gabriel synthesis. **A**: pKa RCONHCOR = 9.6, HCO_3^- = 10.3. **B**: Alkylation, **C**: Addition of H_2NNH_2 to the imide to form a hydrazide. **D**: Intramolecular addition of the amino group of the hydrazide to the amide carbonyl to release benzylamine.

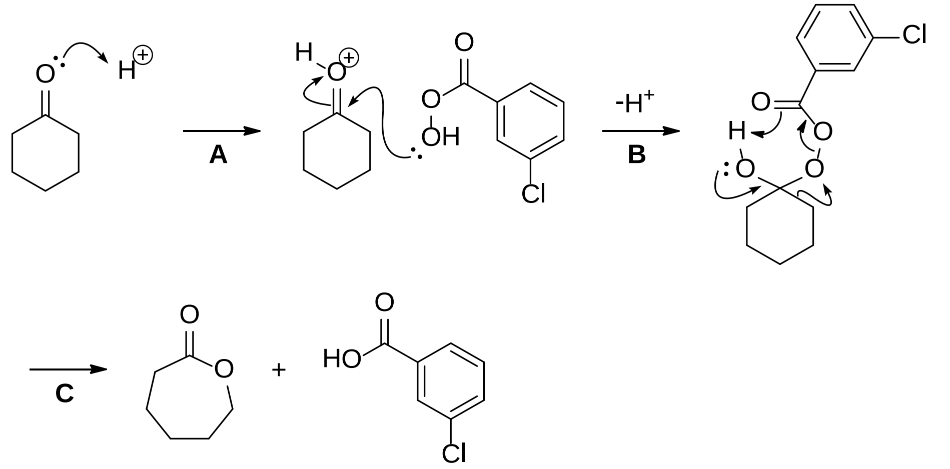
A053



Cope, A, C.; Bumgardner, C. L.; Schweizer. E. E. J. Am. Chem. Soc. **1957**, 79, 4729

Eschweiler-Clarke methylation (A-C)and Cope elimination (E). **A**: Addition of the amine to formaldehyde followed by dehydration to form an immium ion. **B**: Hydride transfer from a formate and to the iminium ion with generation of CO_2. **C**: Iteration of the same steps. **D**: Oxidation of the tertral amine to form an N-oxide. **E**: syn-Elimination.

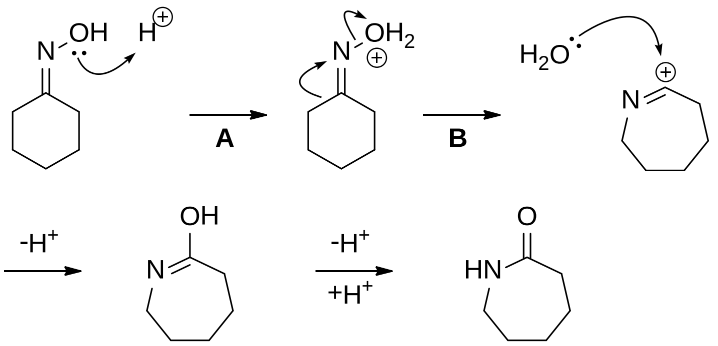
A054



Krow, G. R. *Org. React.* **1993**, 43, 251.

Baeyer-Villiger oxidation. **A**: Activation of the carbonyl group by protonation. **B**: Addition of mCPBA to the carbonyl group. **C**: 1,2-Alkyl shift helped by the oxygen tone-pair with cleavage of the peroxide to form a lactone.

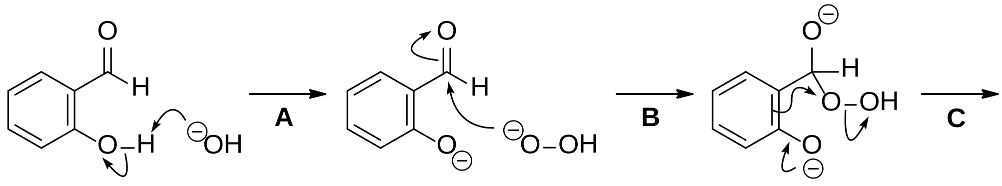
A055

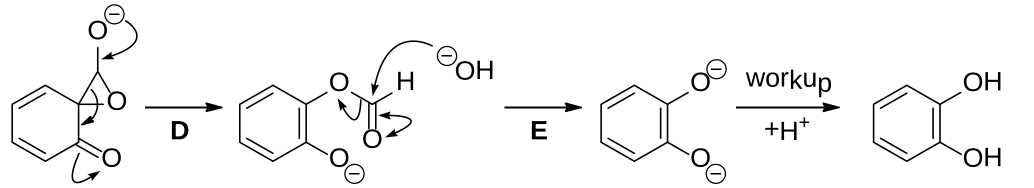


Eck, J. C.; Marvel, C. S. *Org. Synth., Coll*. Vol. Ⅱ **1943**, 76.

Beckmann rearrangement. **A**: Protonation of the oxime. **B**: Migration of the alkyl substituent with simultaneous cleavage of the N-O bond.

A056

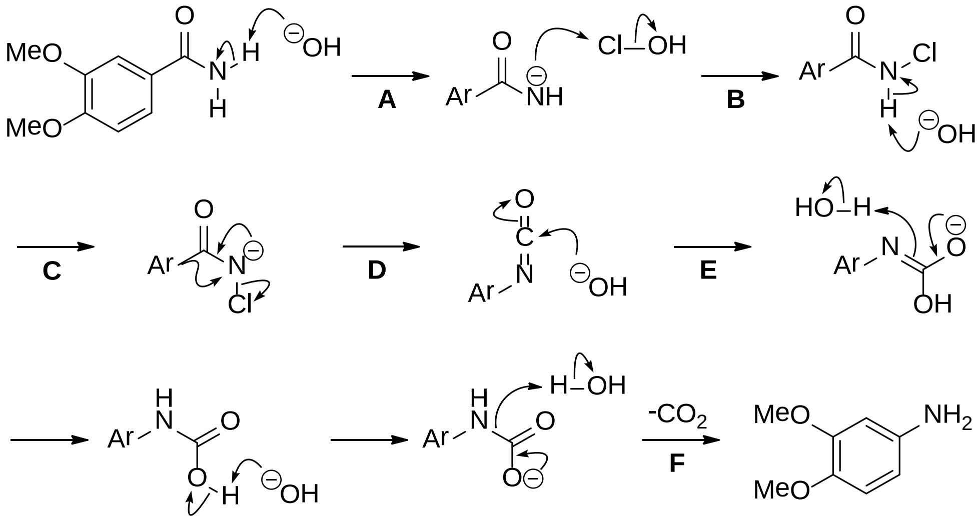




Dakin. H. D. *Org. Synth., Coll.* Vol. Ⅰ **1941**, 149.

Dakin reaction. **A**: Deprotonation of the phenol (pKa PhOH = 10, H_2O = 15.7). **B**: Addition of hydroperoxide ion to the carbonyl group. **C**: Attack of the electron-rich aromatic ring to the peroxide oxygen with cleavage of the O-O bond to form an epoxide. **D**: Cleavage of the epoxide to restore the aromaticity, **E**: Hydrolysis of the resulting formate.

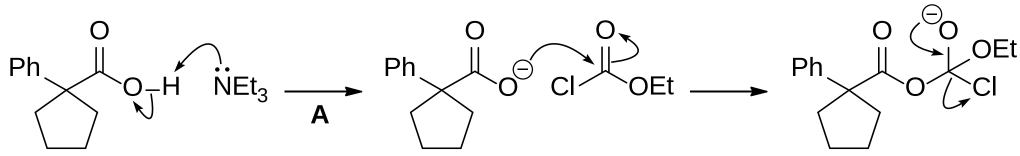
A057

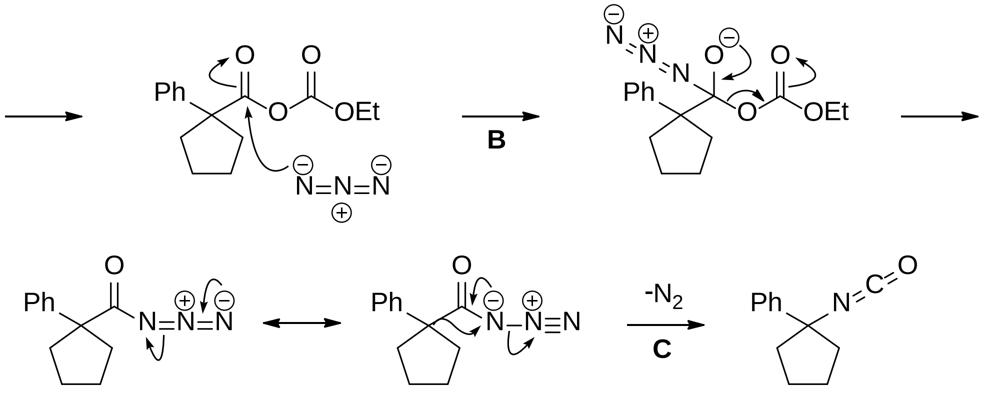


Buck. J. S.; Ide, W. S. *Org. Synth., Coll.* Vol. Ⅱ **1943**, 44

Hofmann rearrangement. **A**: pKa $RCONH_2$ = 17, H_2O = 15.7. **B**: Chlorination of the amide anion. **C**: Deprotonation. **D**: The anion on the nitrogen atom induces migration of the aromatic ring with cleavage of the N-Cl bond to form an isocyanate. **E**: Addition of hydroxide ion to the isocyanate. **F**: Decarboxylation.

A058

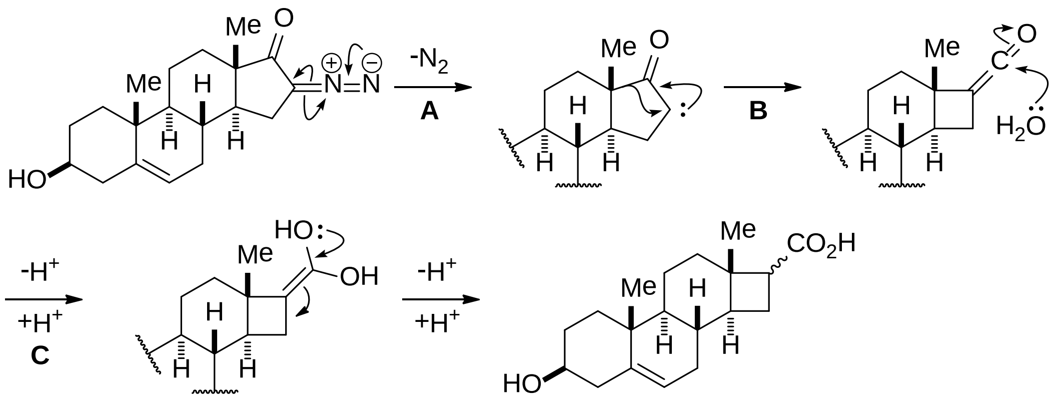




Kaiser, C.; Weinstock, J. *Org. Synth., Coll.* Vol Ⅵ **1988**, 910.

Curtius rearrangement. **A**: Formation of a mixed anhydride. **B**: Addition of azide ion to the mixed anhydride occurs at the more electron-deficient carbonyl group to form an acyl azide. **C**: Migration of the carbon atom to the nitrogen proceeds with retention of configuration as N_2, an extremely good leaving group, departs from the molecule.

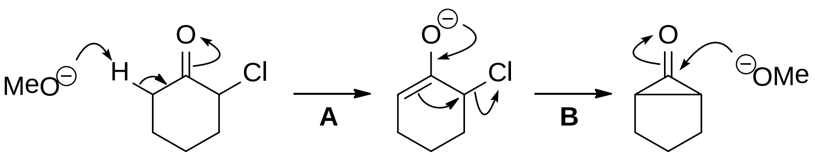
A059

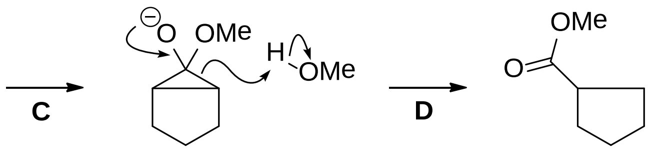


Wheeler, T. N.; Meinwald, J. *Org. Synth., Coll*. Vol. Ⅵ**1988**, 840.

Wolff rearrangement. **A**: Photo-induced generation of a carbene. **B**: Insertion of the carbene to the C-C bond results in a ring contraction to form a ketene. **C**: Addition of water to the ketene.

A060

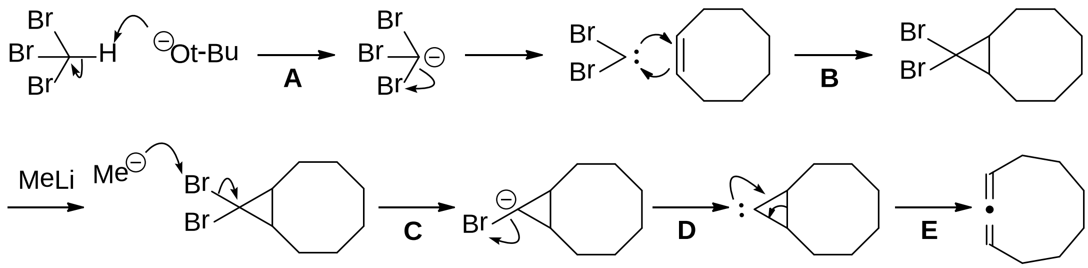




Goheen, D. W.; Vaughan, W. R. *Org. Synth., Coll*. Vol. Ⅳ **1963**, 594.

Favorskii rearrangement. **A**: Deprotonation to form an enolate. **B**: Formation of a cyclopropanone. **C**: Addition of methoxide ion to the carbonyl group. **D**: Cleavage of the cyclopropane ring with simultaneous protonation.

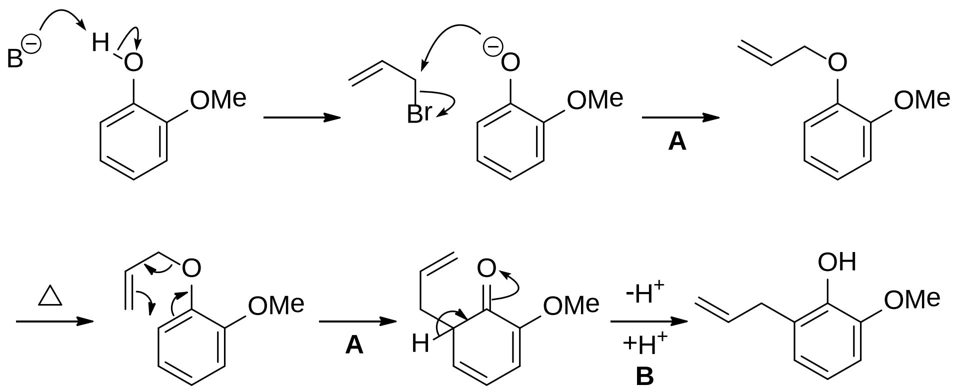
A061



Skattebel, L,; Solomon, S. *Org. Synth., Coll*. Vol. Ⅴ **1973**, 306,

A: Generation of a dibromocarbene via α-elimination of HBr, **B**: Insertion of the carbene to the olefin toform a cyclopropane. **C**: Halogen-lithium exchange. **D**: Generation of a carbene. **E**: Insertion of the carbene to the C-C bond to form an allene.

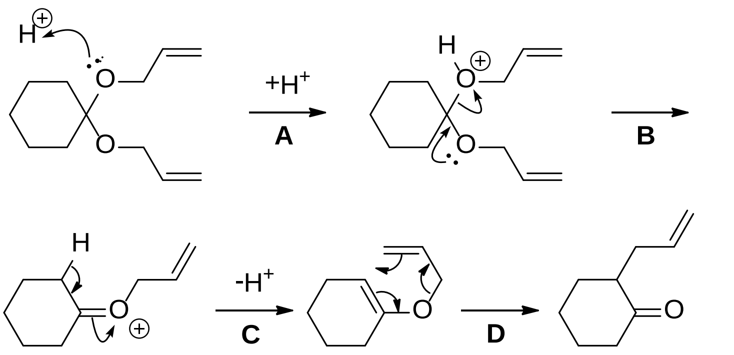
A062



Allen, C. F. H; Gates, J. W., Jr, *Org. Synth., Coll*. Vol. Ⅲ **1955**, 418

A: Allylation of the phenol. **B**: [3,3] Sigmatropic rearrangement (Claisen rearrangement). **C**: Aromatization.

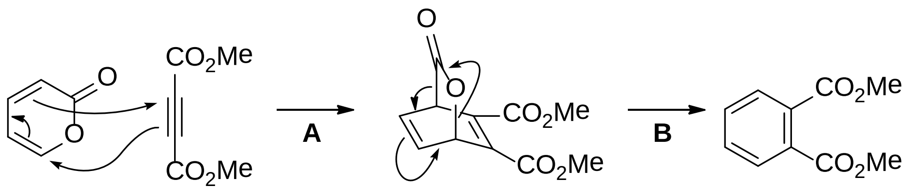
A063



Howard, W. L.; Lorette, N. B. *Org, Synth., Coll* Vol. Ⅴ **1973**.25

A: Protonation of an oxygen atom of the acetal. **B**: Elimination of allyl alcohol helped by the oxygen lone pair of the acetal. **C**: Deprotonation to form an enol ether. **D**: [3,3] Sigmatroplc rearrangement (Claisen rearrangement).

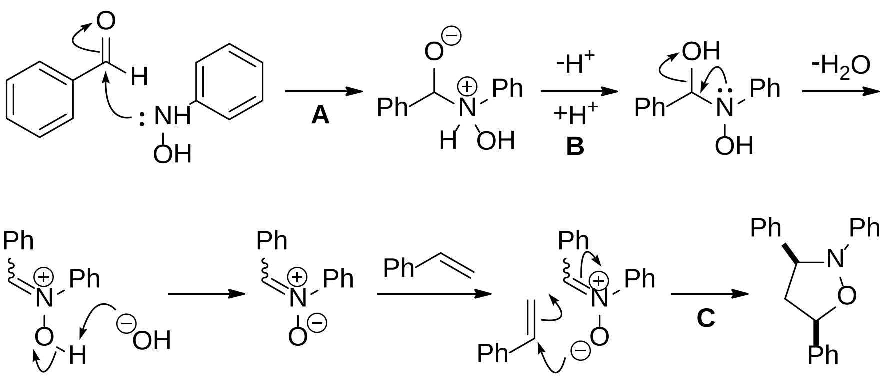
A064



Ziegler, T,; Layh, M.; Effenberger, F. *Chem. Ber.* **1987**, 120, 1347.

A: Diels-Alder reaction. **B**: Retro Diels-Alder reaction.

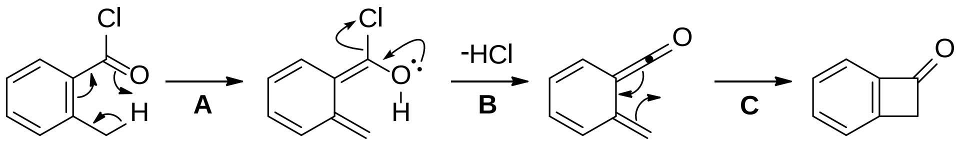
A065



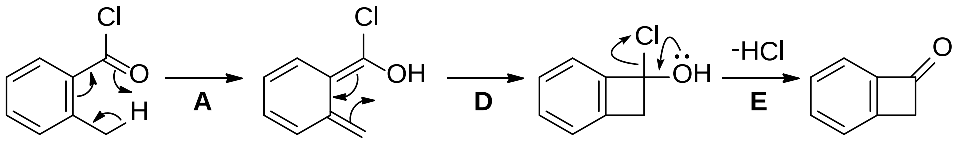
Brüning, I.; Grashey, R.; Hauck, H.; Huisgen, R.; Seidl, H, *Org. Synth., Coll*. Vol. Ⅴ **1973**, 1124

A: Addition of a hydroxylamine to the aldehyde. **B**: Proton transfer followed by elimination of water to form a nitrone **C**: 1,3-Dipolar cycloaddition of the nitrone to stvrene (electronically, [4+2] cycloaddition).

A066



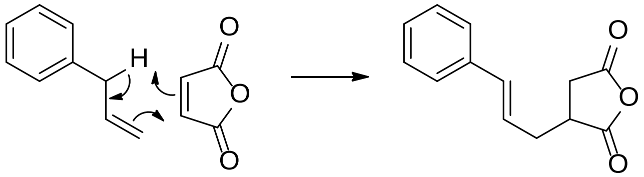
or



Schiess, P.; Barve, P. V.; Dussy, F E.; Pfiffner, A. *Org. Synth., Coll.* Vol. Ⅸ **1998**, 28.

A: Isoerization to form an o-quinodimethane. **B**: Elimination of HCl to form a ketene. **C**: 4e Elimination of hydrogen chloride to form a ketone.

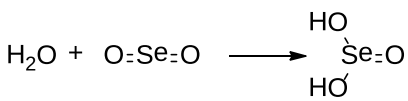
A067

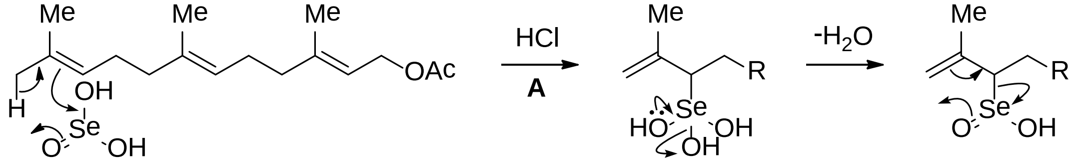


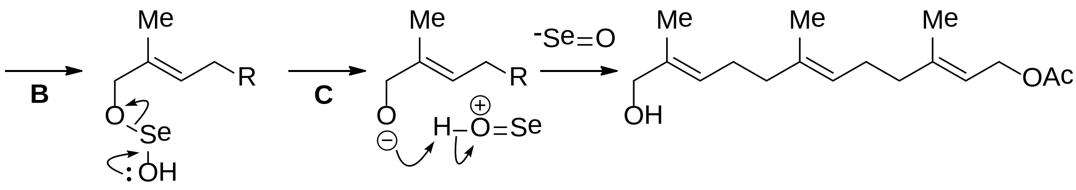
Rondestvedt, C. S., Jr. Org. Synth., Coll. Vol. /V 1963, 766

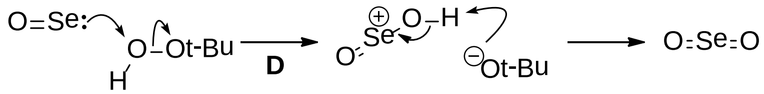
Ene reaction.

A068





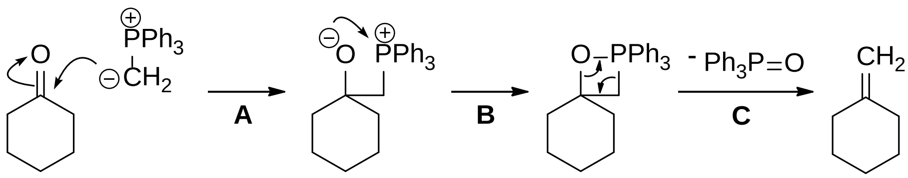




Umbreit, M. A.; Sharpless, K. B. *J. Am. Chem. Soc.* **1977**, 99, 5526.

A: Ene reaction occurs on the least hindered olefin. **B**: [2,3] Sigmatropic rearrangement. **C**: Elimination of the alcohol. **D**: Oxidation of SeO with TBHP to regenerate SeO_2.

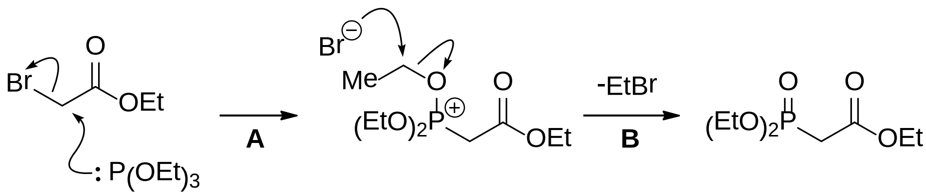
A069



Wittig, G.; Schoellkopf, U. Org. Synth., Coll. Vol. Ⅴ **1973**, 751.

Wittig reaction. **A**: Addition of the ylide to the carbonyl group to form a betaine. **B**: Attack of the alkoxide to the phosphonium cation to form an oxaphosphetane. **C**: Irreversible elimination of Ph_3PO.

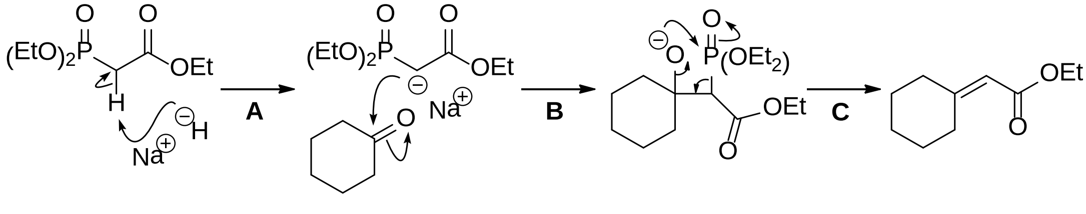
A070



van der Klei, A.; de Jong, R. L. P.; Lugtenburg, J.; Tielens, A. G. M. Eur. *J. Org. Chem*. **2002**, 3015.

Arbuzov reaction. **A**: Attack of $P(OEt)_3$ to the reactive bromoacetate to release bromide ion (S_N2 reaction). **B**: Attack of the resulting bromide ion to the ethyl group in an S_N2 fashion to form a phosphonate.

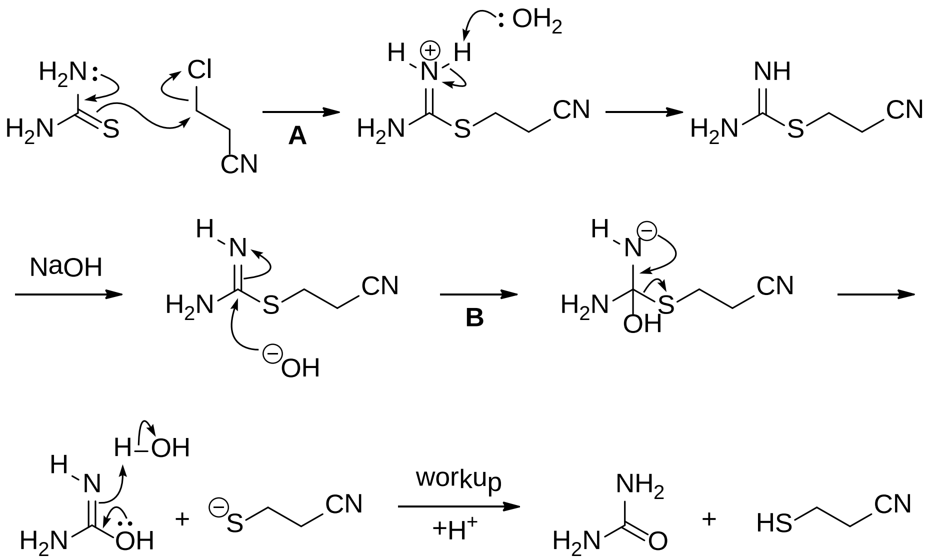
A071



Wadsworth, W. S., Jr.; Emmons, W. D. *Org. Synth., Coll*. Vol. Ⅴ **1973**, 547.

Horner-Wadsworth-Emmons reaction. **A**: Deprotonation of the phosphonate. **B**: Addition of the phosphonate ion to the ketone. **C**: Attack of the alkoxide to the phosphonate followed by elimination of a phosphate ion to form an olefin.

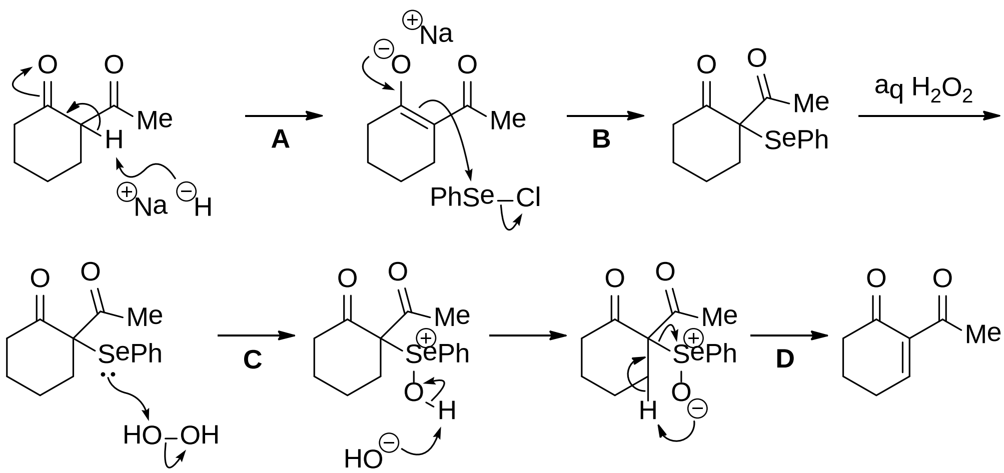
A072



Gerber, R, E.; Hasbun, C.; Dubenko, L. G.; King, M. F.; Bierer, D. E. *Org. Synth., Coll*. Vol. Ⅹ **2002**, 475

A: Attack of the more reactive sulfur atom of thiourea to the alkyl chloride to form an isothiourea (S_N2 reaction). **B**: Hydrolysis of the isothiourea.

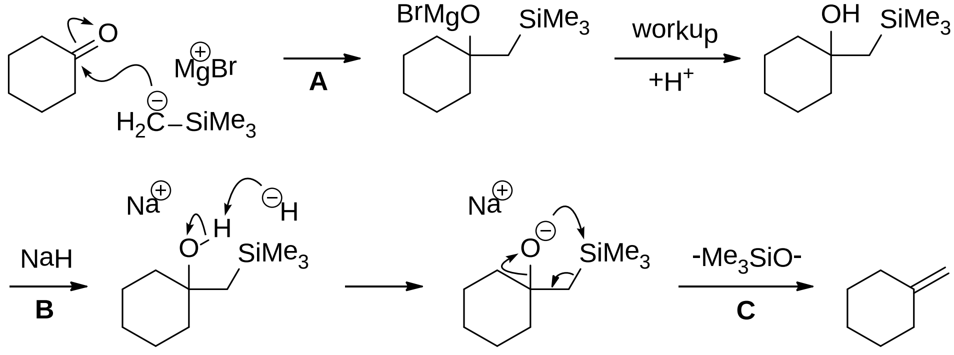
A073



Renga, J. M: Reich, H. J. *Org. Synth., Coll.* Vol. Ⅵ **1988**.23

A: Deprotonatien of the β-diketone (pKa RCOCH$_2$COR = 9, H$_2$ = 35). **B**: Selenylation at the α-position. **C**: Oxidation of the selenide to form a selenoxide. **D**: β-Elimination.

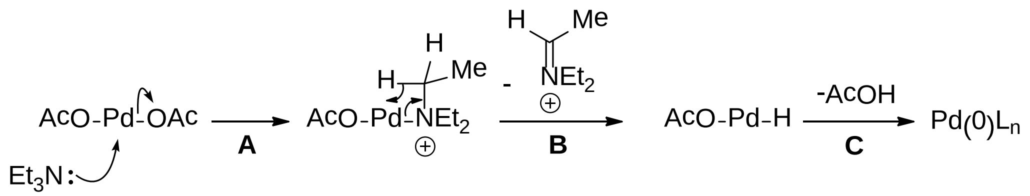
A074



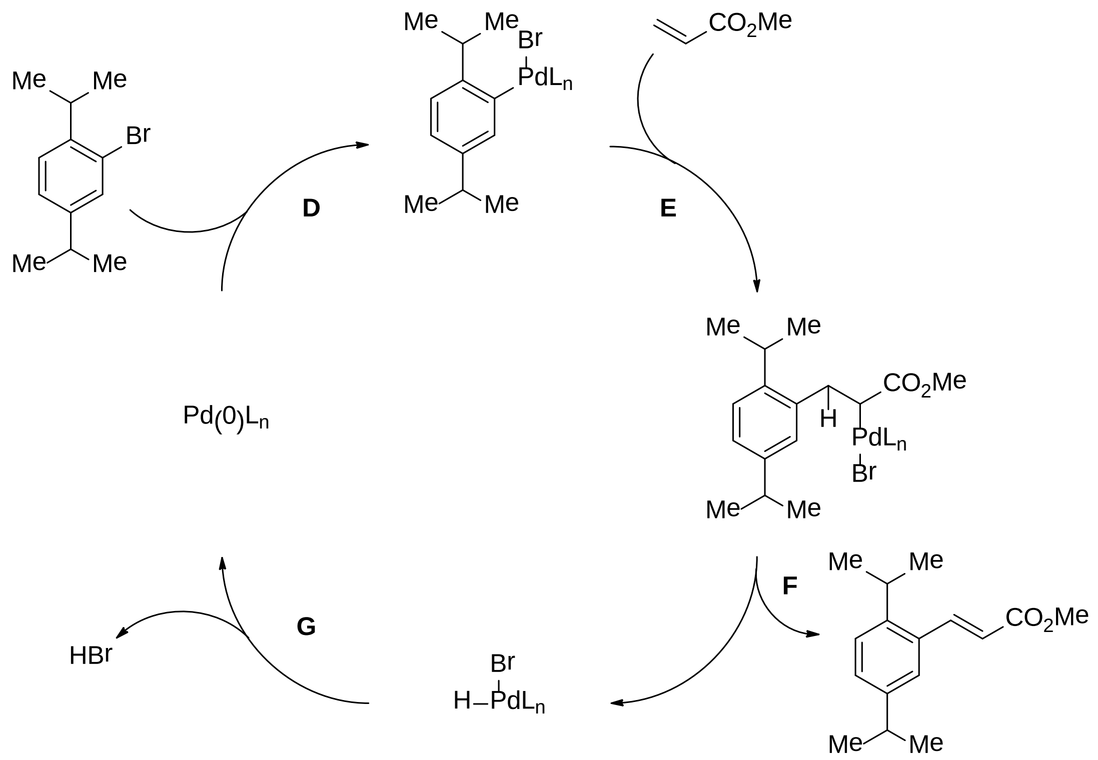
Ager, D. J. *Org. React.* **1990**, 38, 1.

Peterson olefination. **A**: Addition of Me3SiCH2MgBr to the ketone. **B**: Exchange of the counter cation from Mg to Na. **C**: Elimination of a silanol ion via a four-membered transition state.

A075



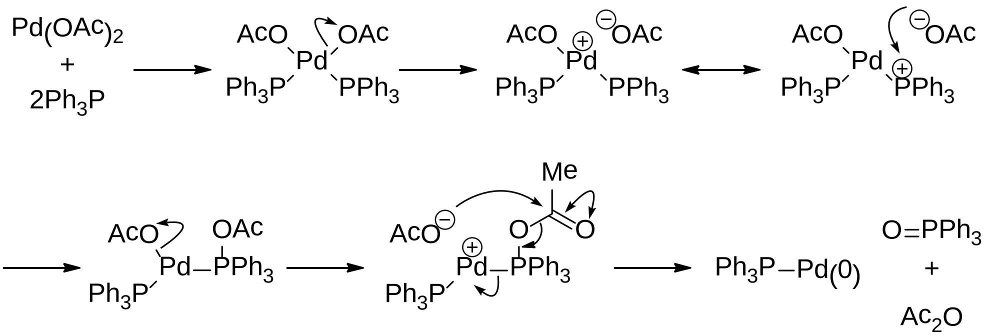
Reduction of $Pd(OAc)_2$ to Pd(0) using Et_3N. **A**: Ligand exchange. **B**: β-Elimination. **C**: Reductive elimination of AcOH.



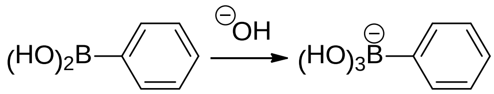
Patel, B. A.; Ziegler, C. B.; Cortese, N. A.; Plevyak, J. E.; Zebovitz, T. C. Terpko, M.; Heck, R. F. *J. Org. Chem*. **1977**, 42, 3903.

Heck reaction. **D**: Oxidative addition. **E**: Carbopalladation. **F**: β-Elimination to form the product. **G**: Reductive elimination of HBr.

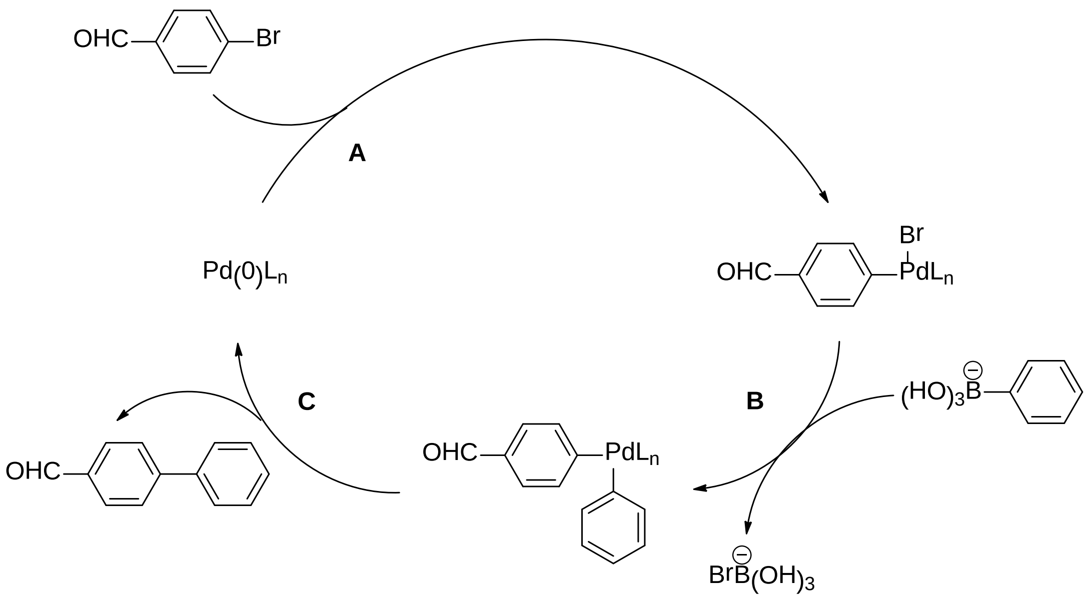
A076



Reduction of $Pd(OAc)_2$ to Pd(0) using Ph_3P.



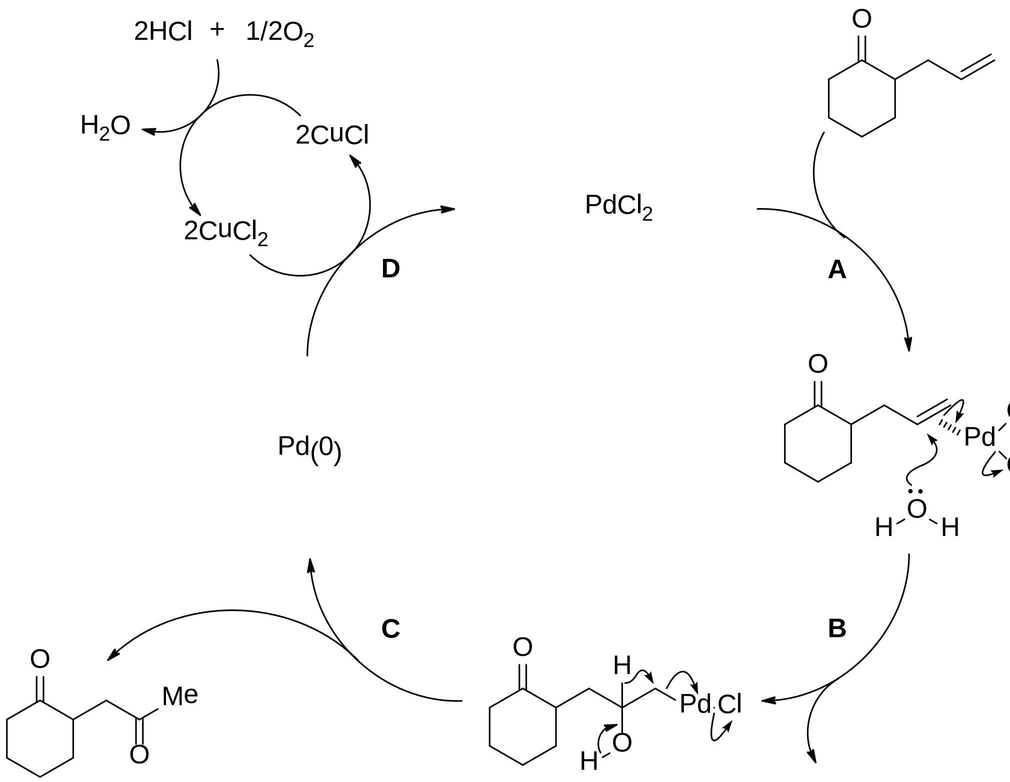
Activation of boronic acid,



Huff, B. E.; Koenig, T. M.; Mitchell, D.; Staszak, M. A. *Org. Synth., Coll* Vol. X **2002**, 122

Suzuki-Miyaura coupling. **A**: Oxidative addition. **B**: Transmetallation. **C**: Reductive elimination.

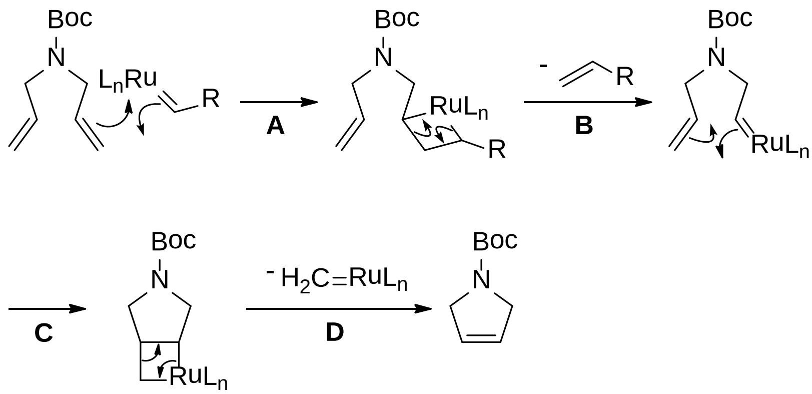
A077



Tsuji, J.; Shimizu, I.; Yamamoto, K. *Tetrahedron Lett.* **1976**, 34, 2975.

Wacker oxidation, **A**: Olefin complexation. **B**: Oxypalladation. **C**: Hydride shift. **D**: Oxidation of Pd(0) with $CuCl_2$ to regenerate $PdCl_2$. **E**: Oxidation of CuCl with O_2 to regenerate $CuCl_2$.

A078

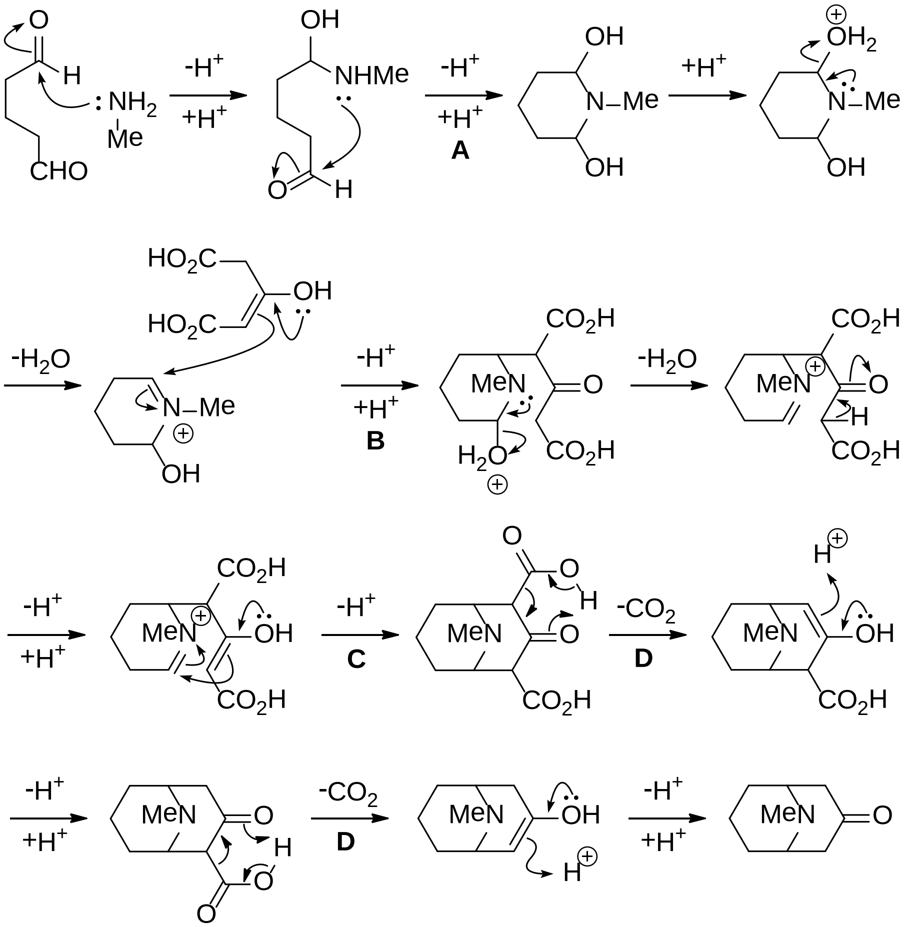


Ferguson, M. L.; O'Leary, D. J.; Grubbs, R. H. *Org. Synth*. **2002**, 80, 85.

Ring closing metathesis (RCM). **A**: Cycloaddition of a ruthenium carbene complex to the olefin to from a metallacyclobutane. **B**: Retro cycloaddition. **C**: Intramolecular cycloaddition of the ruthenium carbene complex. **D**: Retro cycloaddition to regenerate a ruthenium carbene complex.

解答 中级编

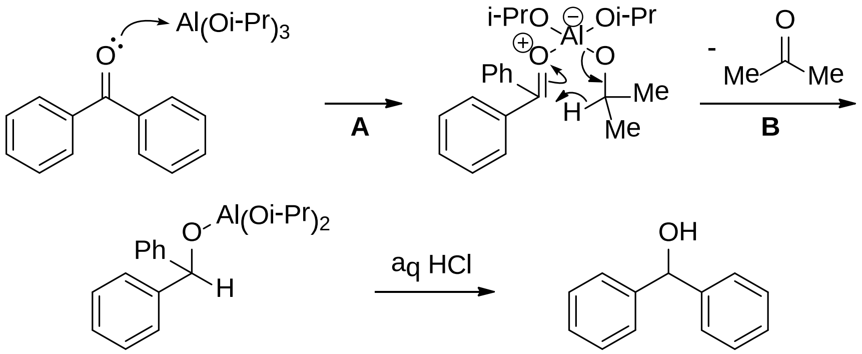
B001



Cope, A. C: Dryden, H. L.: Howell, C. F *Org. Synth., Coll*. Vol. Ⅳ **1963**, 816

Robinson-Schöpf reaction. **A**: Formation of a cyclic hemiaminal. **B**: Mannich reaction **C**: Intramolecular Mannich reaction. **D**: Decarboxylation through the six-membered transition state.

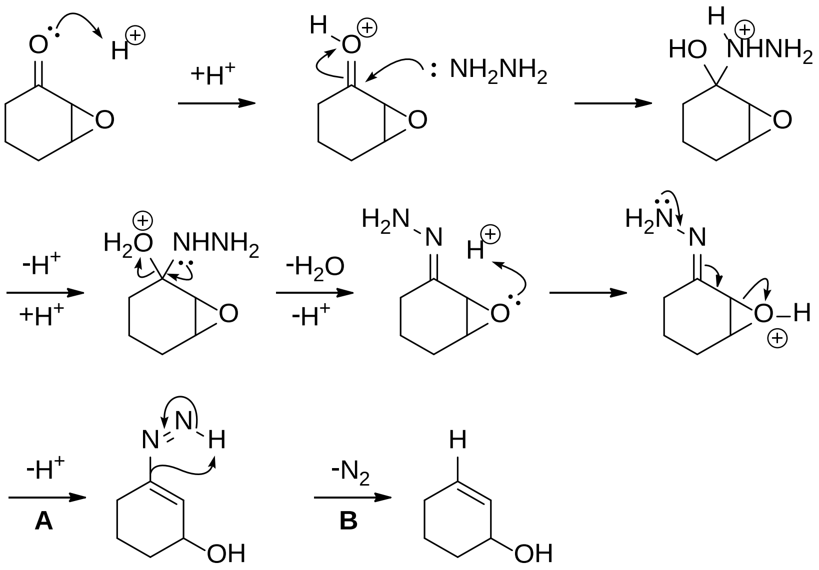
B002



Wilds, A. L. *Org. React.* **1944**, 2.

Meerwein-Ponndorf-Verley reduction. **A**: Formation of an ate complex. **B**: Hydride transfer via a six membered transition state with formation of acetone.

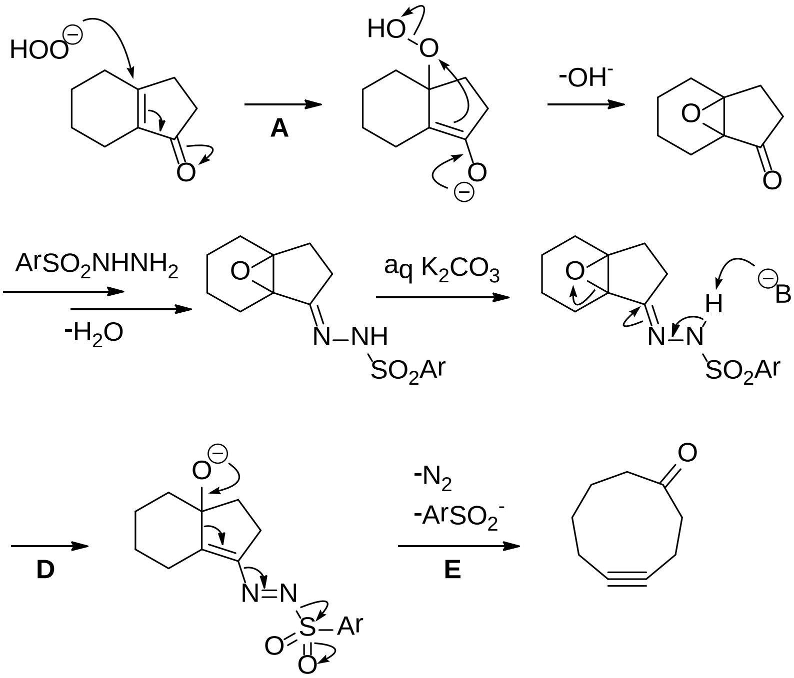
B003



Wharton, P. S.: Bohlen, D. H. *J. Org. Chem*. **1961**, 26, 3615.

Wharton rearrangement. **A**: Cleavage of the epoxide helped by the nitrogen lone pair of the hydrazone. **B**: Elimination of N_2 (an extremely good leaving group).

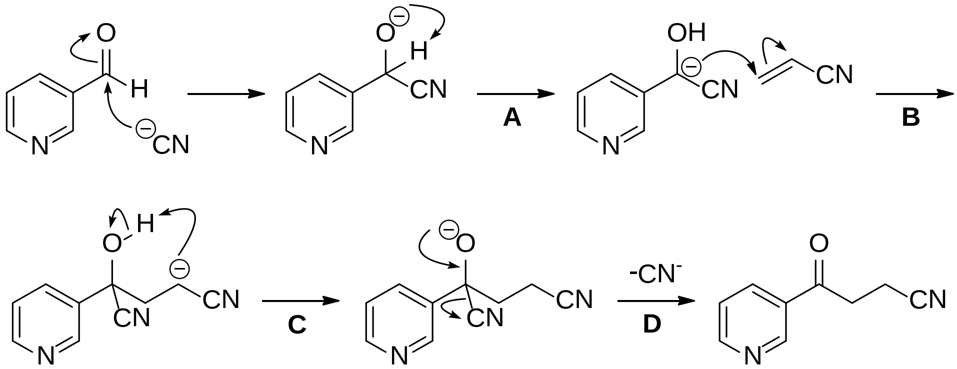
B004



Reese, C. B.; Sanders, H. P. *Synthesis* **1981**, 276.

Eschenmoser fragmentation. **A**: Michael addition. **B**: Formation of an epoxide (the O-O bond is activated). **C**: Formation of a hydrazone. **D**: pKa HCO_3^- = 10.3, $ArSO_2NH_2$ = 8.5. E: Fragmentation involving a loss of N2 and a sulfinate ion.

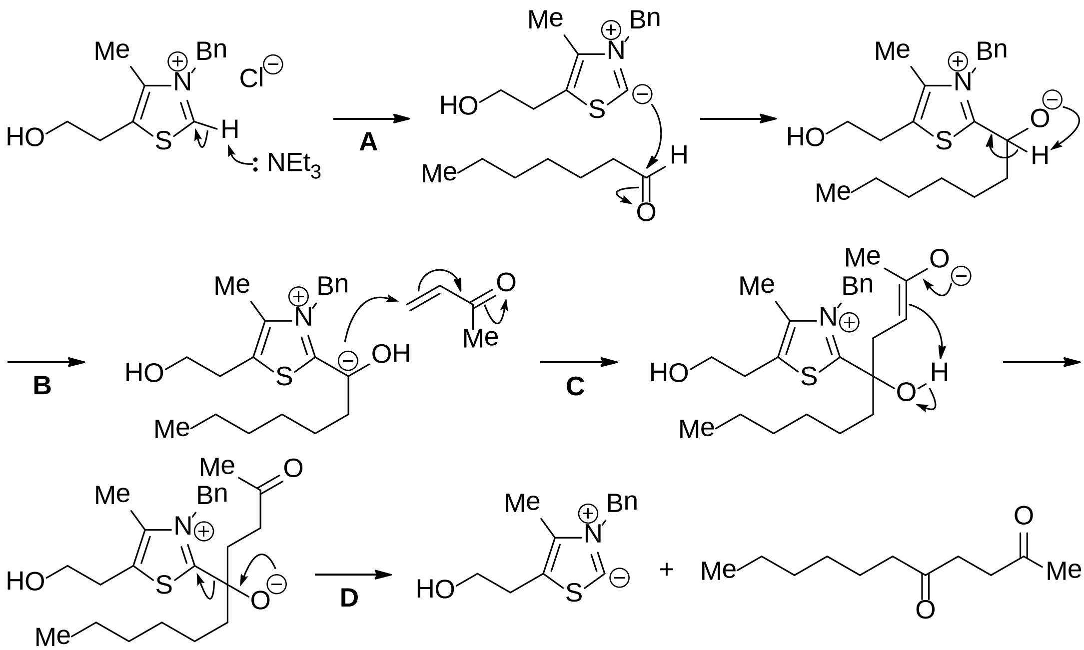
B005



Stetter, H.; Kuhlmann, H.; Lorenz, G. *Org. Synth., Coll* Vol. Ⅵ **1988**, 866

A: Formation of the less favored cyanohydrin carbanion. **B**: Michael addition. **C**: Regeneration of the cyanide ion (cyanohydrin is unstable under basic conditions).

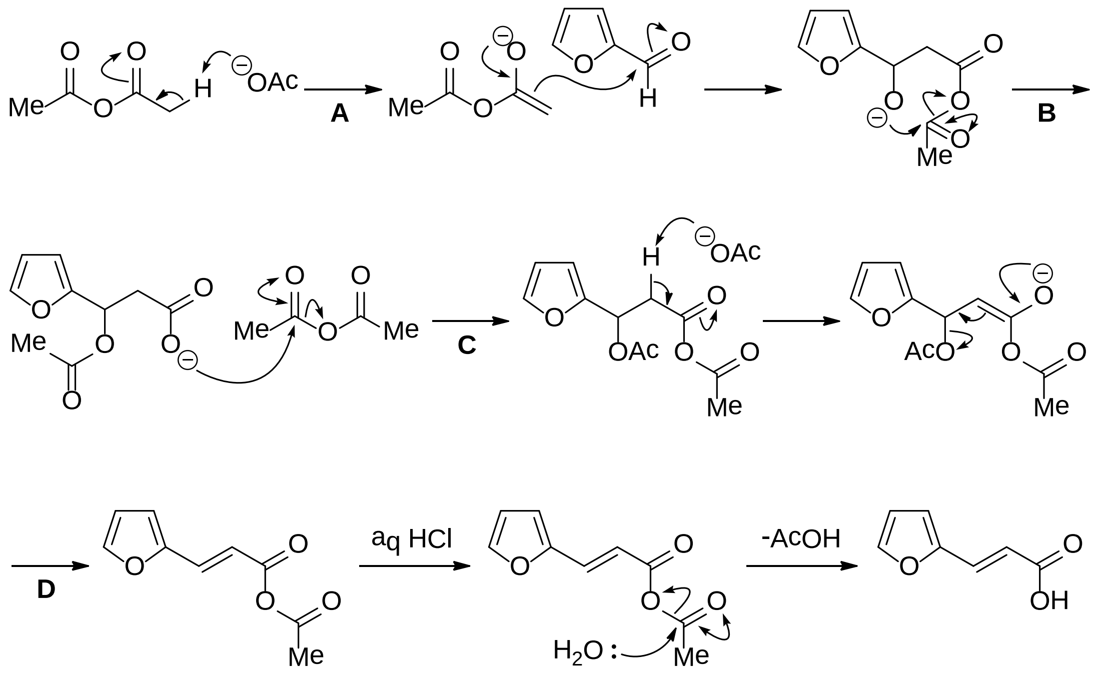
B006



Stetter, H.; Kuhlmann, H.; Haese, W. Org. Synth., Coll. Vol. Ⅷ 1993. 52

Stetter reaction. **A**: pKa thiazolinium ion = 10, $HNEt_3^+$ = 10.7. **B**: Generation of a stabilized carbanion (ref B005). **C**: Michael addition. **D**: Regeneration of the thiazolinium ion.

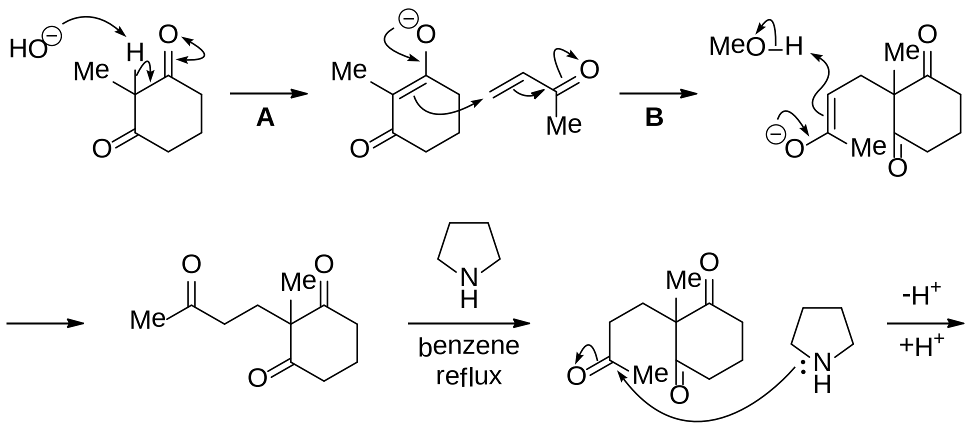
B007

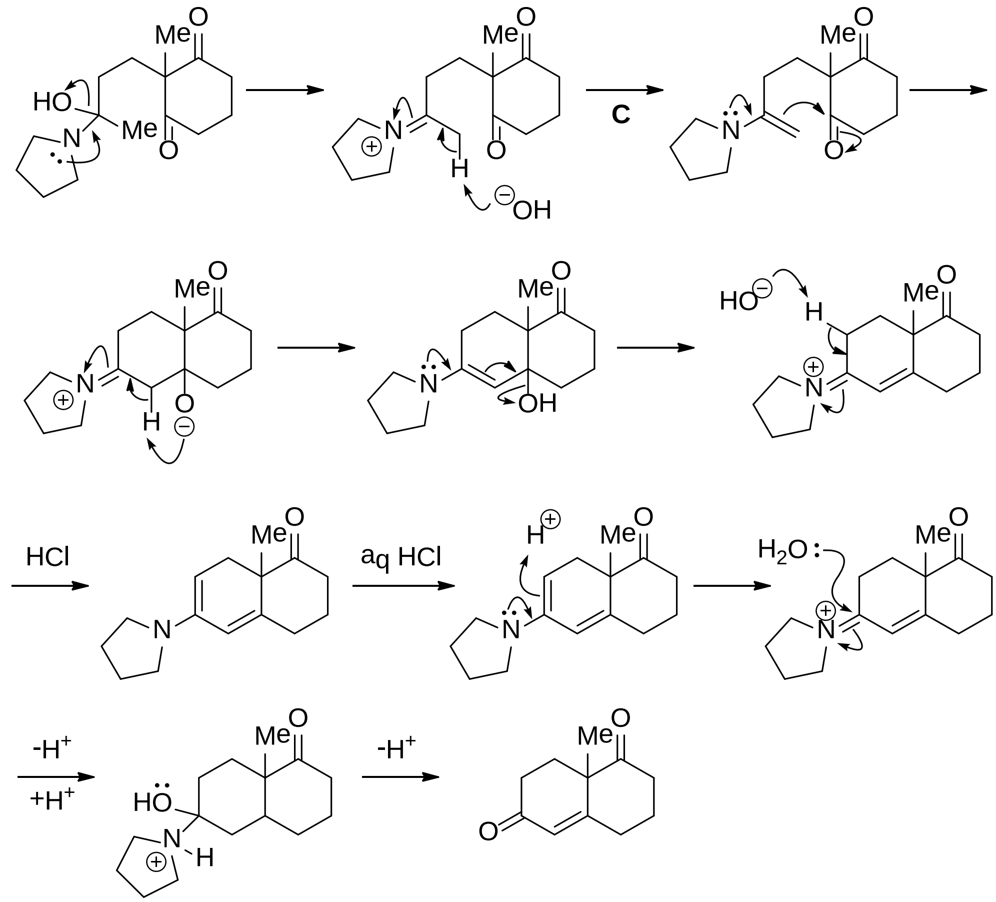


Rajagopalan, S.; Raman, P. V. A. *Org. Synth., Coll. Vol*. III **1955**, 425.

Perkin reaction. **A**: pKa $(CH_3CO)_2O$ = 13.5, AcOH = 4.8 (a small amount of the acetic anhydride anion can be formed). **B**: Intramolecular acyl transfer. **C**: Formation of a mixed anhydride. **D**: Base-catalyzed elimination of acetic acid.

B008

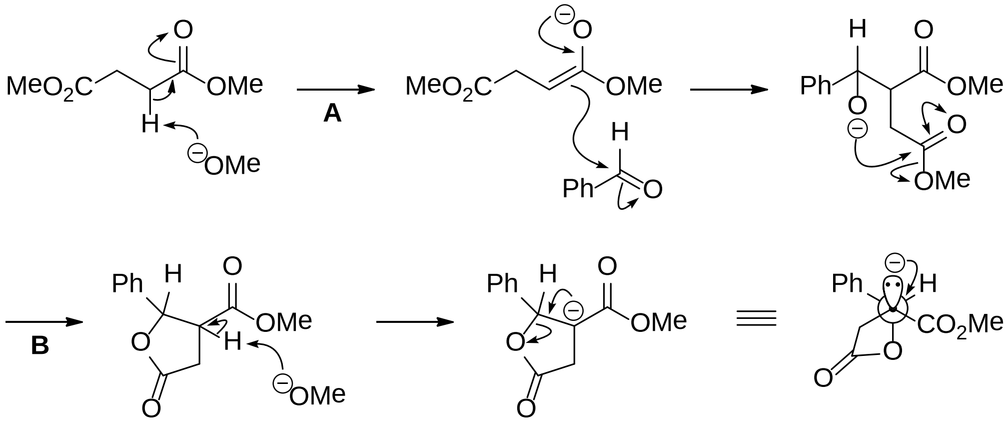


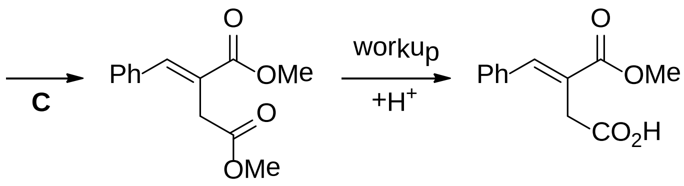


Ramachandran, S.; Newman, M. S. Org. Synth., *Coll. Vol*. V **1973**, 486

Robinson annulation. **A**: pKa $RCOCH_2COR$ = 9, H_2O = 15.7. **B**: Michael addition. **C**: Formation of an enamine followed by an intramolecular addition to the ketone.

B009

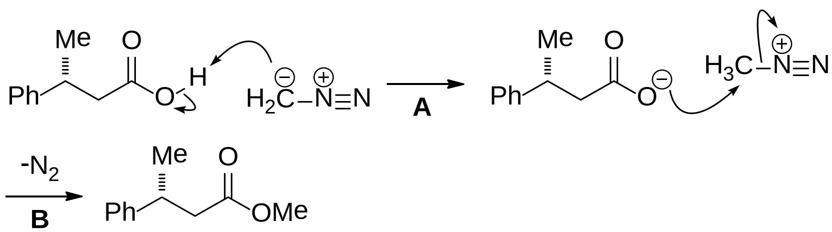




Johnson, W. S.; Daub, G. H. *Org. React.* **1951**. 6

Stobbe condensation. **A**: pKa CH_3CO_2R = 24, MeOH = 15.5. **B**: Formation of a five-membered lactone. **C**: Elimination of the carboxylate occurs by avoiding the steric repulsion between the phenyl and the methoxycarbonyl groups.

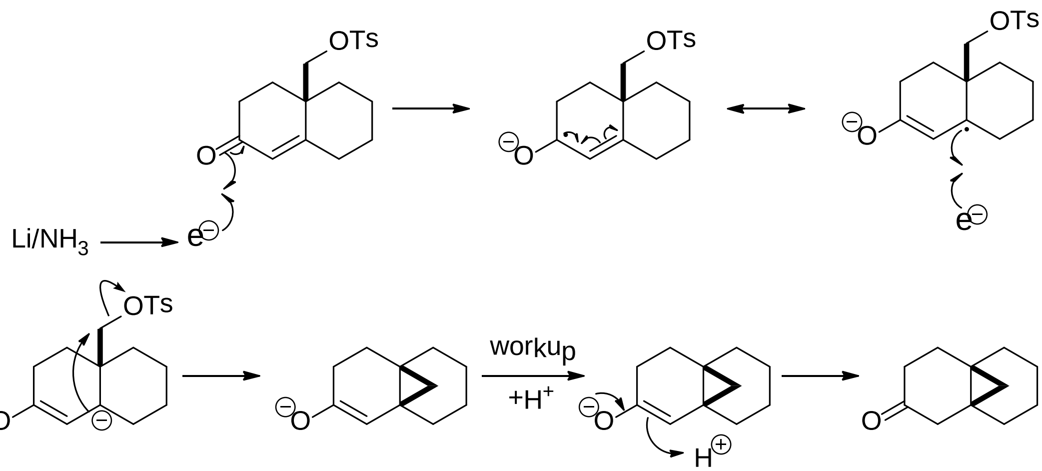
B010



Black, T. H. *Aldrichimica Acta* **1983**, 16, 3

A: pKa CH_3CO_2H = 4.8, CH_3N_2 = 10.2. **B**: The S_N2 reaction occurs in a solvent cage.

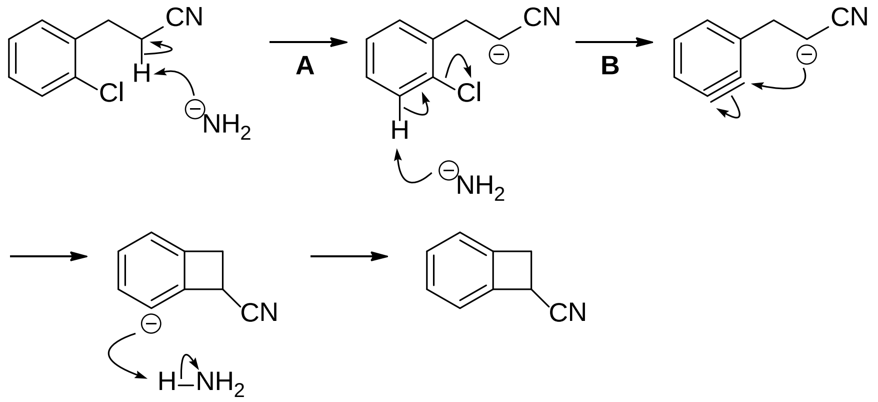
B011



Stork, G.; Tsuji, J. *J. Am. Chem. Soc.* **1961**, 83, 2783.

Two successive SET reactions followed by cyclopropane formation.

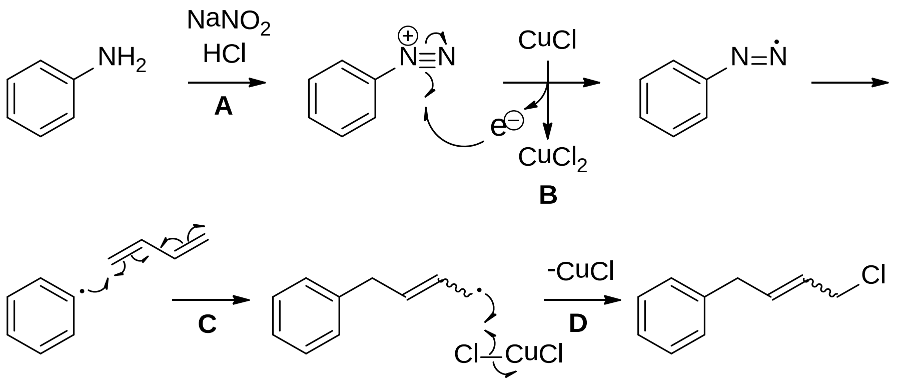
B012



Skorcz, J. A.; Kaminski, F. E. *Org. Synth., Coll*. Vol. Ⅴ **1973**.263

A: pKa CH_3CN = 25, NH_3 = 35. **B**: Formation of benzyne followed by an intramolecular nucleophilic addition.

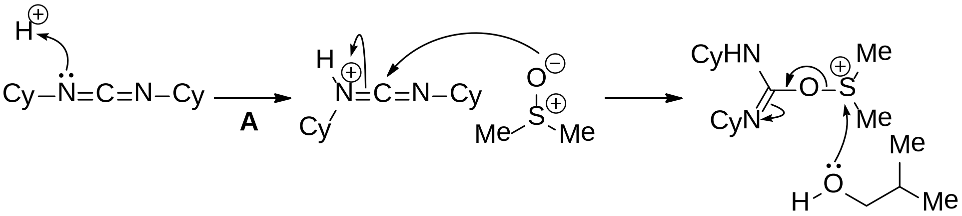
B013

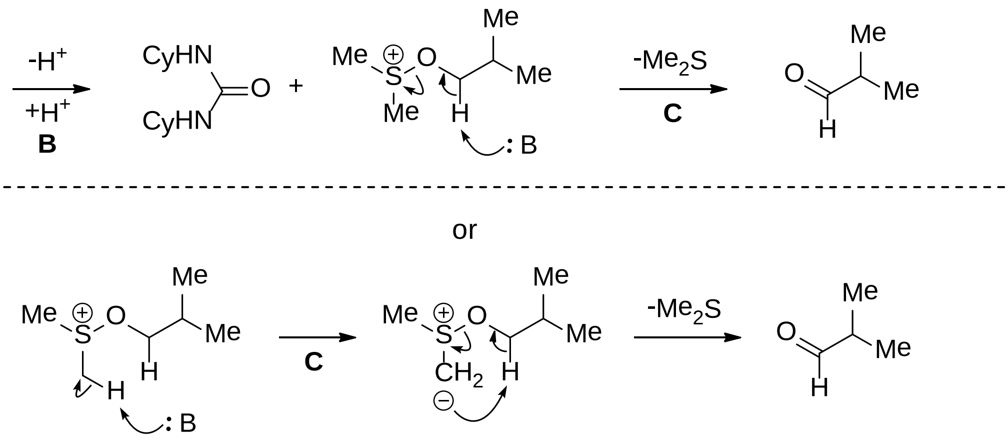


Ropp, G. A.; Coyner, E. C. *Org. Synth. Coll*, Vol. Ⅳ **1963**. 27

Meerwein arylation. **A**: Formation of a diazonium salt (ref A037). **B**: SET induces a loss of N_2 to form a phenyl radical. **C**: Addition of the phenyl radical to butadiene to form a stabilized radical. **D**: Recycle of CuCl to continue the radical chain reaction.

B014

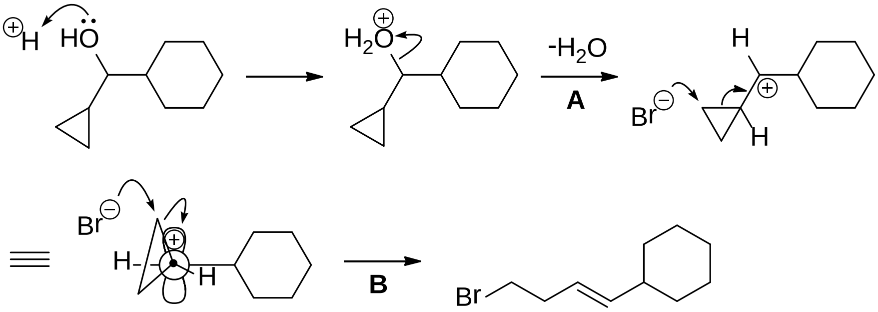




Tidwell, T. T. *Org. React.* **1990**, 39, 297.

Pfitzner-Moffatt oxidation. **A**: Activation of DCC by protonation. **B**: Nucleophilic substitution at the sulfur atom. **C**: β-Elimination of dimethyl sulfide might proceed either by 1) direct deprotonation with a base or 2) formation and collapse of a sulfur ylide.

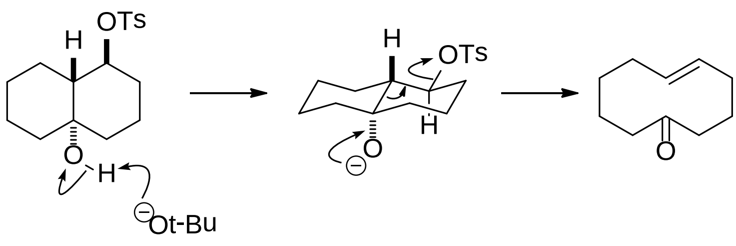
B015



Ferreri, C.; Ambrosone, M. *Syn. Commun.* **1995**, 25, 3351.

A: Generation of a carbocation stabilized by a cyclopropyl group. **B**: Cleavage of the cyclopropane ring occurs by avoiding the steric repulsion to form the trans-product.

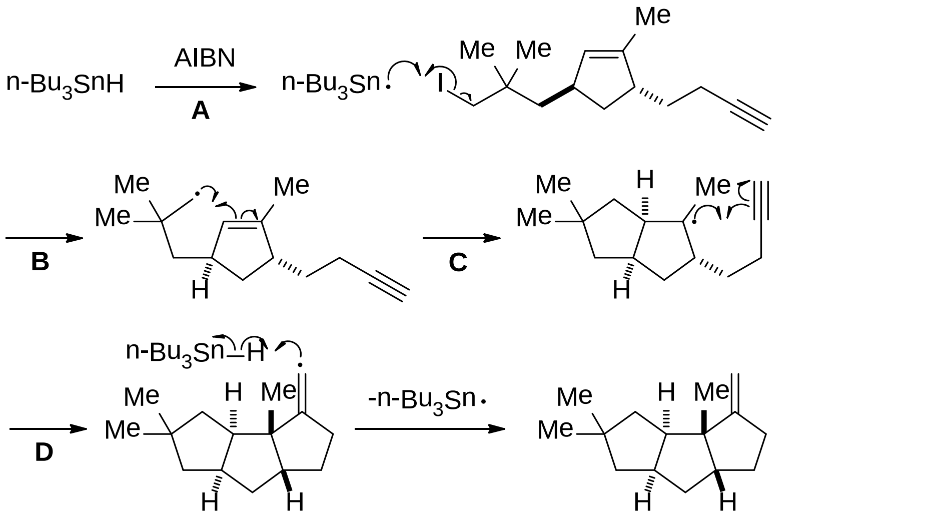
B016



Wharton, P. S.; Hiegel, G. A. *J. Org. Chem.* **1965**, 30, 3254.

Grob fragmentation. This Grob fragmentation can occur when the orbitals of the breaking C-C o-bond and C-OTs σ-bond overlap on the same plane (antiperiplanar interaction).

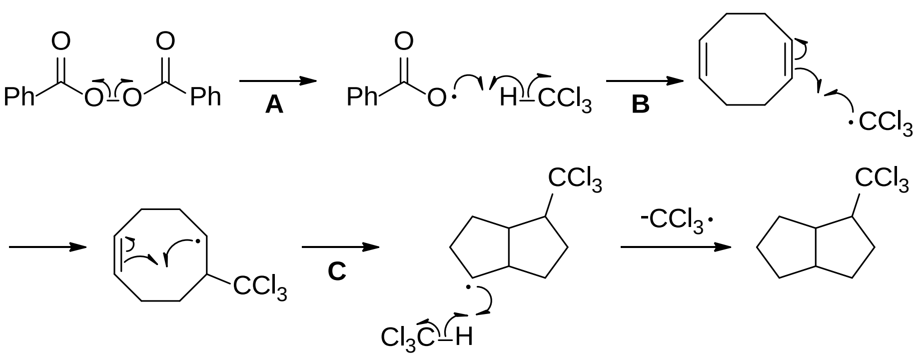
B017



Weinges, K.; Reichert, H.; Huber-Patz, U.; Irngartinger, H. *Liebigs Ann. Chem.* **1993**, 403.

A: Generation of a tin radical (ref A050). **B**: Attack on the iodide to initiate the radical chain reaction. **C**: 5-exo-trig Radical cyclization. **D**: 5-exo-dig Radical cyclization.

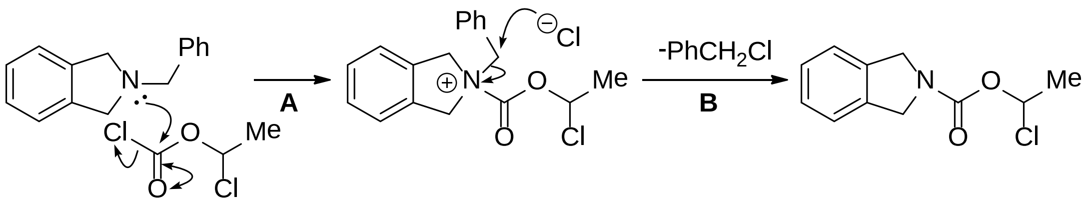
B018

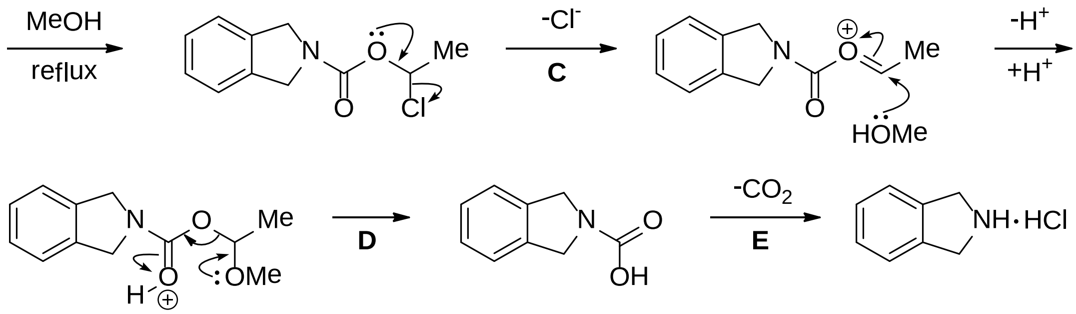


Dowbenko, R. *Org. Synth., Coll* Vol. Ⅴ **1973**, 93.

A: Homolytic cleavage of dibenzoyl peroxide. **B**: Generation of a trichloromethyl radical which then adds to 1,5-cyclooctadiene. **C**: Transannular radical cyclization.

B019

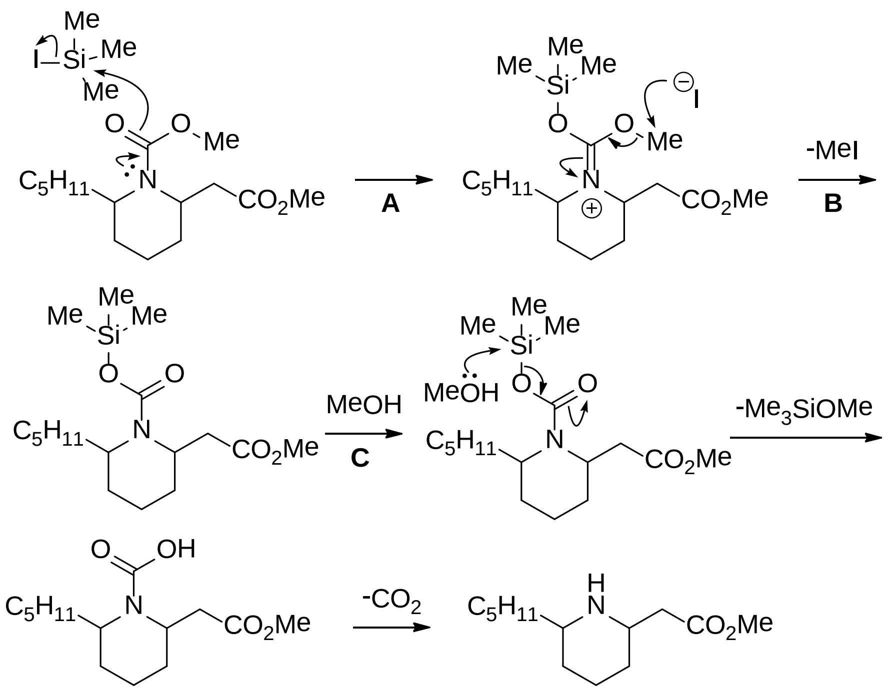




Yang, B. V.; O'Rourke, D.; Li, J. *Synlett.* **1993**, 195.

A: Acylation of a tertiary amine. **B**: Attack of chloride ion on the benzylic position. **C**: E1 elimination ofthe chloride followed by addition of methanol, **D**: Elimination of the carbamic acid helped by the oxygen lone pair of the methoxy group. **E**: Decarboxylation.

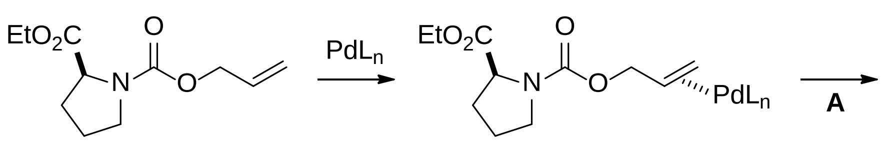
B020

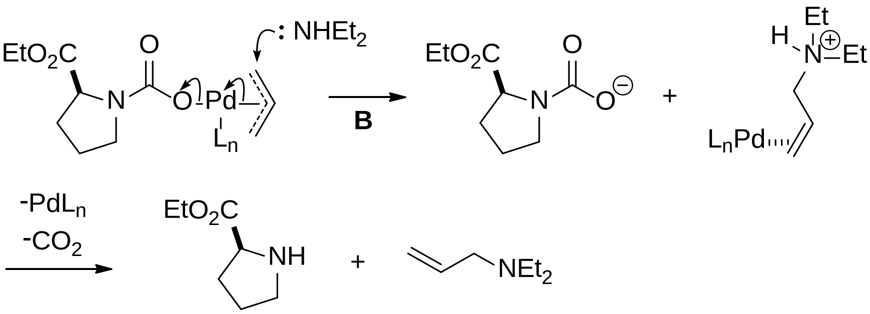


Laurent, P.; Braekman, J.-C.; Daloze, D. Eur. *J. Org. Chem*. **2000**, 2057.

A: Silylation of the electron-rich oxygen of the carbamate. **B**: Demethylation by S_N2 reaction. **C**: Methanolysis of the silyl carbamate.

B021

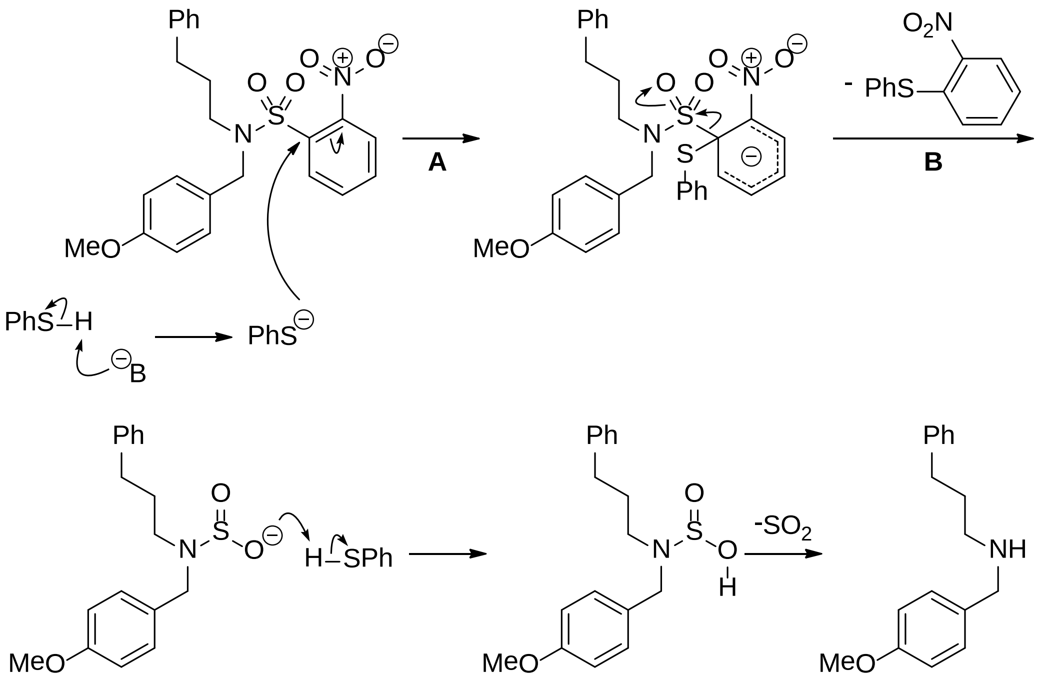




Genet, J. P.; Blart, E.; Savignac, M.; Lemeune, S.; Lemaire-Audoire, S.; Bernard, J. M. *Synlett* **1993**, 680.

A: Formation of a π-allylpalladium complex. **B**: Attack of Et_2NH to the π-allylcomplex.

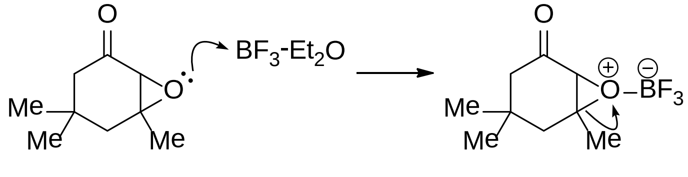
B022

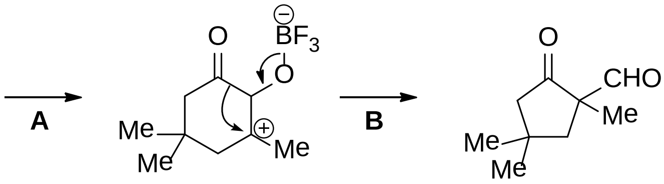


Kurosawa, W.; Kan, T.; Fukuyama, T. *Org. Synth., Coll*. Vol. X **2004**, 482.

A: Addition of a thiolate ion to the electron deficient aromatic ring to form a Meisenheimer complex. **B**: Elimination of an amidosulfurous acid anion which, upon protonation and extrusion of SO_2, gives an amine.

B023

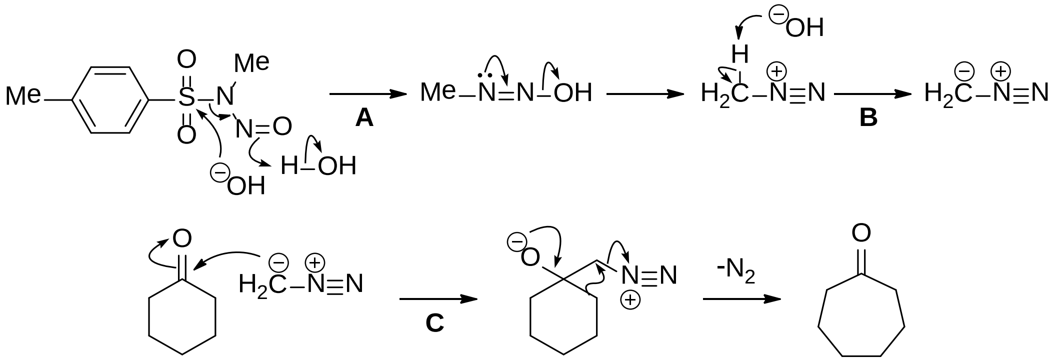




Ryerson, G. D.; Wasson, R. L.; House, H. O. *Org. Synth., Coll* Vol. Ⅳ **1963**, 957.

A: Cleavage of the epoxide to form the more stable tertiary carbecation (formation of a carbocation next to a carbonyl group is unusually difficult). **B**: Wagner-Meerwein-type rearrangement.

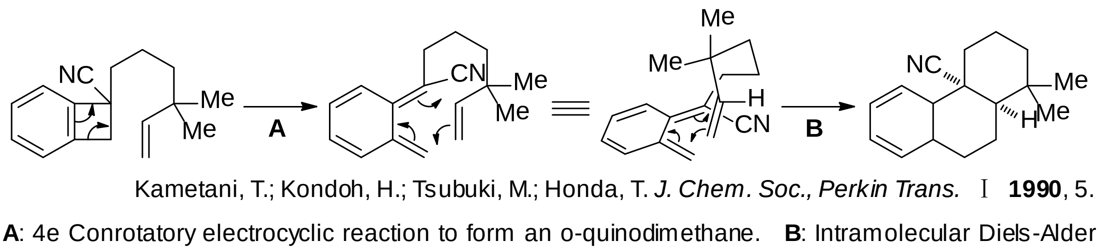
B024



de Boer, T. J.; Backer, H. J. *Org. Synth., Coll* Vol. Ⅳ **1963**, 225.

A: Hydrolysis of N-methyl-N-nitrososulfonamide. **B**: Formation of diazomethane. pKa CH_3N_2 = 10.2, H_2O = 15.7. **C**: Addition of diazomethane to a ketone followed by ring expansion (cf. Tiffeneau-Demjanov rearrangement).

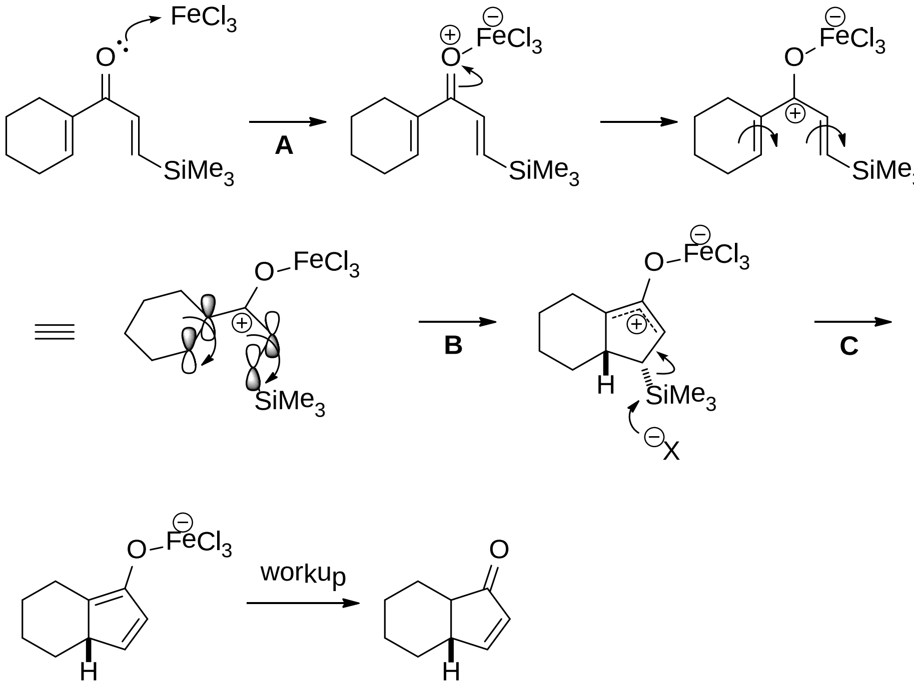
B025



Kametani, T.; Kondoh, H.; Tsubuki, M.; Honda, T. *J. Chem. Soc., Perkin Trans.* Ⅰ **1990**, 5.

A: 4e Conrotatory electrocyclic reaction to form an o-quinodimethane. **B**: Intramolecular Diels-Alder reaction.

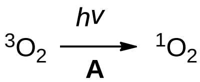
B026

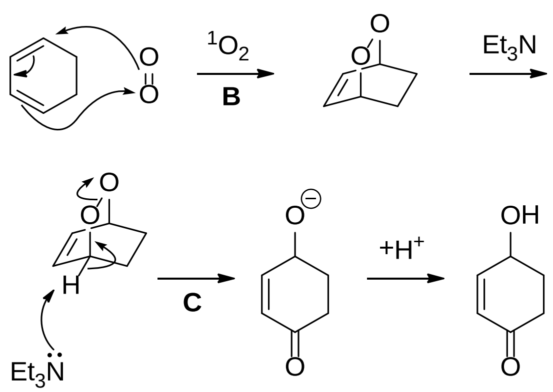


Jones, T. K.; Denmark, S. E. *Helv. Chim. Acta* 1983, 66, 2397.

Silicon-directed Nazarov reaction. **A**: Activation of the carbonyl group with $FeCl_3$, a Lewis acid. **B**: 4e Conrotatory electrocyclic reaction. **C**: Desilylation to form the olefin regioselectively.

B034



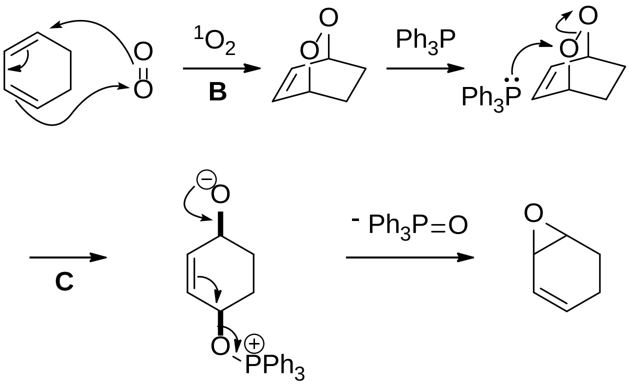


Balci, M. Chem. Rev. 1981, 81, 91.

A: Generation of singlet oxygen. B: Diels-Alder reaction. C: Base-induced cleavage of the endoperoxide.

B035

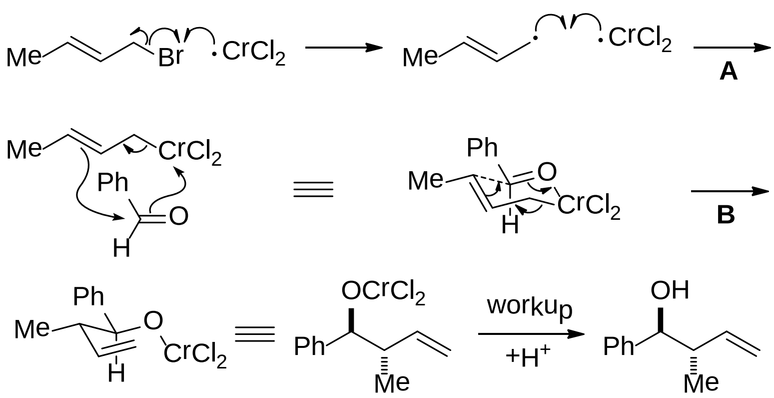
$$^3O_2 \xrightarrow[\textbf{A}]{h\nu} {}^1O_2$$



Balci, M. *Chem. Rev.* **1981**, 81, 91

A: Generation of singlet oxygen. **B**: Diels-Alder reaction. **C**: Reductive cleavage of the endoperoxide with triphenylphosphine. **D**: Formation of an epoxide via S_N2' reaction with elimination of triphenylphosphine oxide.

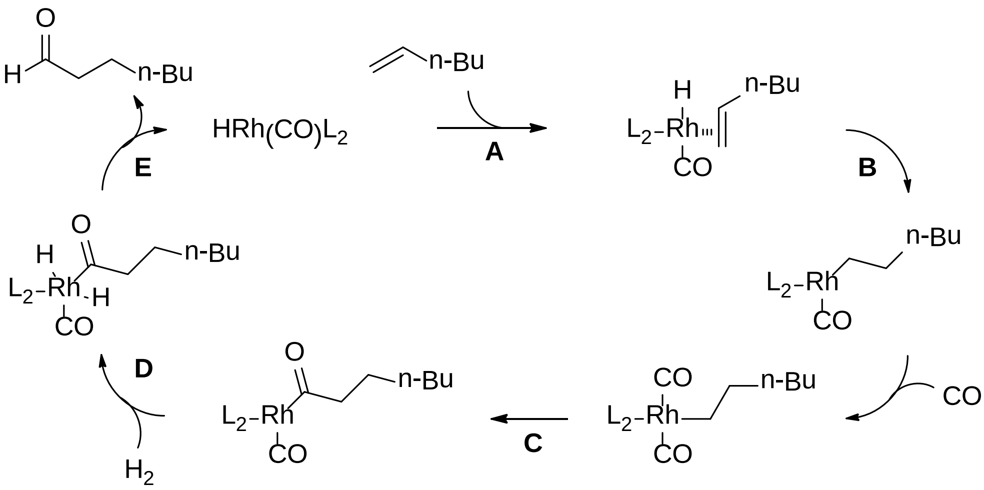
B041



Okude, Y.; Hirano, S.; Hiyama, T.; Nozaki, H. J. Am. Chem. Soc. **1977**, 99, 3179.

A: Since $CrCl_2$ is a single electron reductant, two molecules of $CrCl_2$ are needed to convert an alkyl bromide to the corresponding organochromium species. **B**: Addition to an aldehyde via a chair-like six-membered transition state.

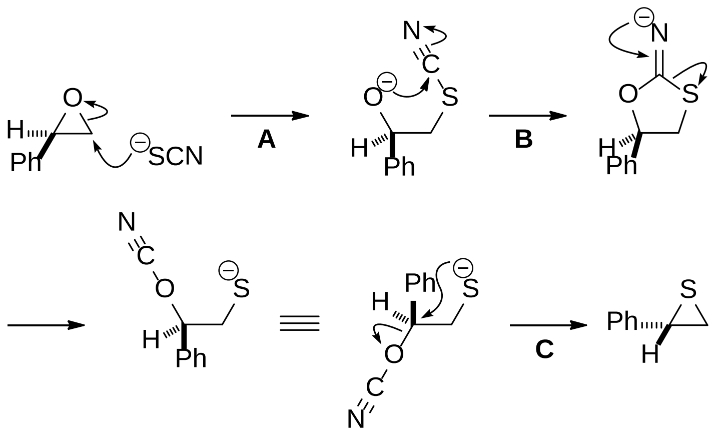
B042



Hallman, P. S.; McGarvey, B. R.; Wilkinson, G. *J. Chem. Soc. (A)* **1968**, 3143.

Hydroformylation. **A**: Complexation of the catalyst with an olefin. **B**: Hydrometallation. **C**: Insertion

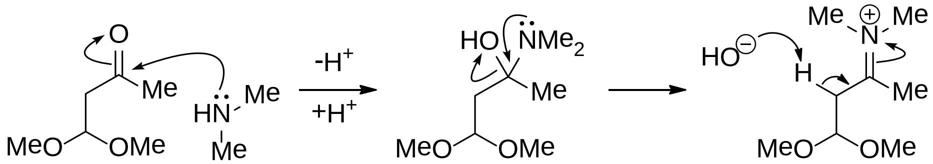
B045

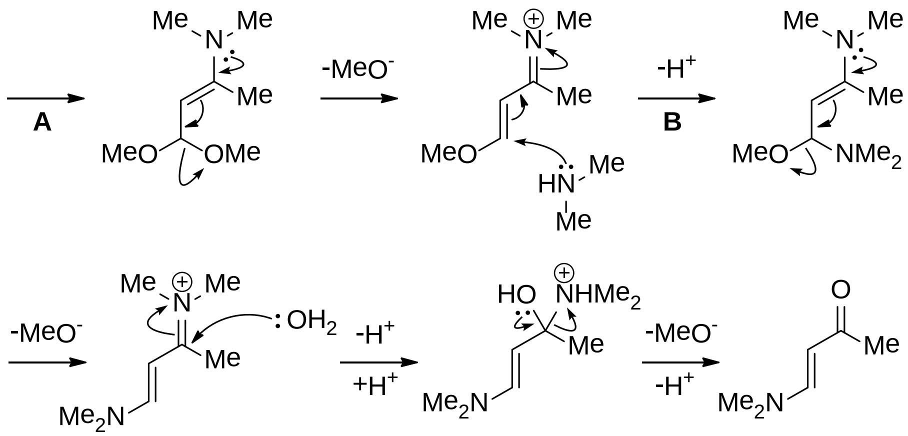


Guss, C. O.; Chamberlain, D. L., Jr. *J. Am. Chem. Soc.* **1952**, 74, 1342.

A: Cleavage of the epoxide by S_N2 reaction at the less hindered position. **B**: Migration of the cyano group. **C**: Intramolecular S_N2 reaction with inversion of configuration.

B046

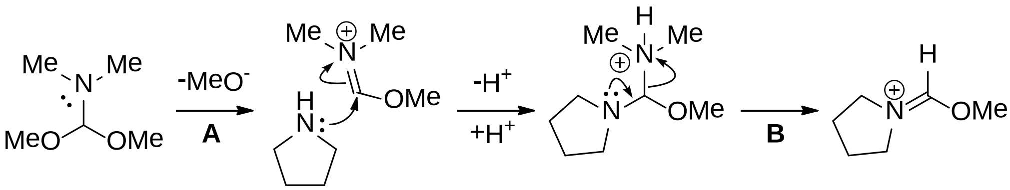


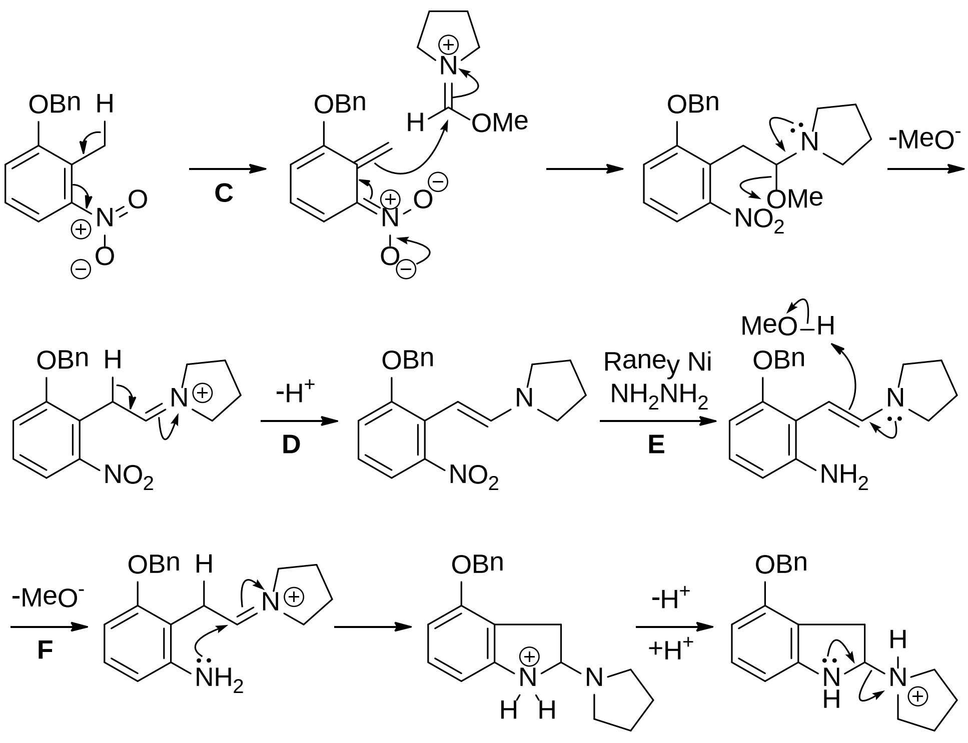


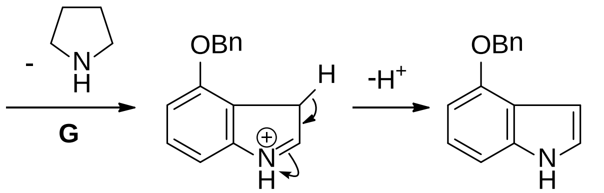
Kozmin, S. A.' He, S.; Rawal, V. H. *Org. Synth., Coll*. Vol. Ⅹ **2004**, 301.

A: Formation of an enamine to eliminate methoxide ion. **B**: Conjugate addition of dimethylamine to the α,β-unsaturated iminium ion.

B047



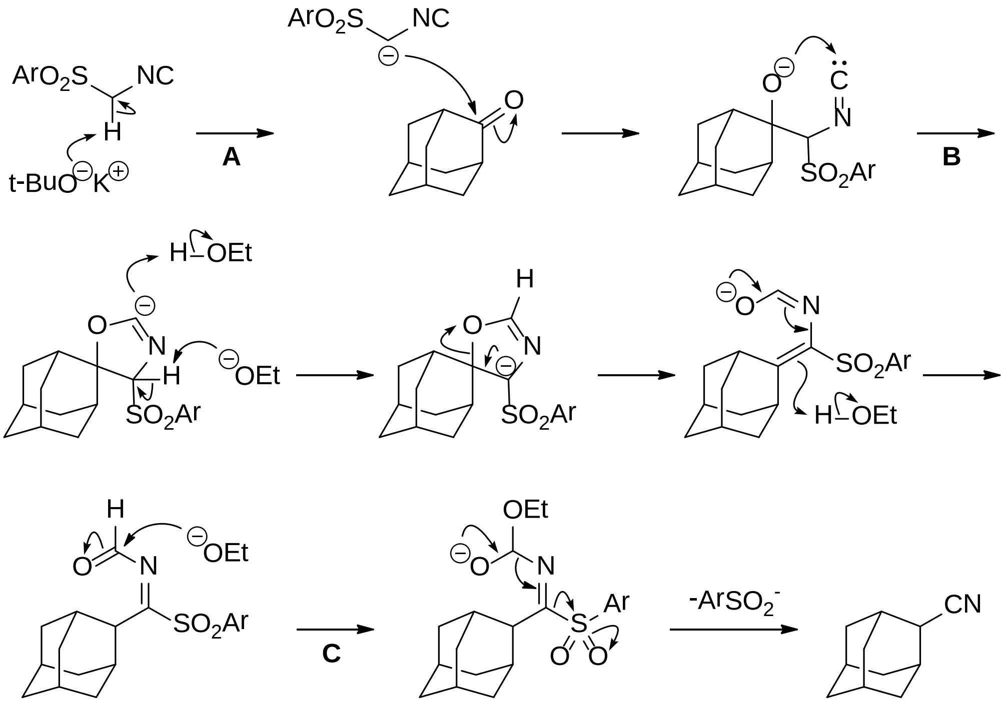




Batcho, A. D.; Leimgruber, W. *Org. Synth., Coll*. Vol. Ⅶ **1990**

Leimgruber-Batcho indole synthesis. **A**: Generation of an iminium ion under thermal conditions. **B**: Replacement of dimethylamine with pyrrolidine. **C**: Generation of a benzylic carbanion stabilized by o-nitro group. **D**: Formation of an enamine. **E**: Reduction of the nitro group. **F**: Protonation of the enamine to form the reactive iminium ion. **G**: Elimination of pyrrolidine helped by the nitrogen lone pair.

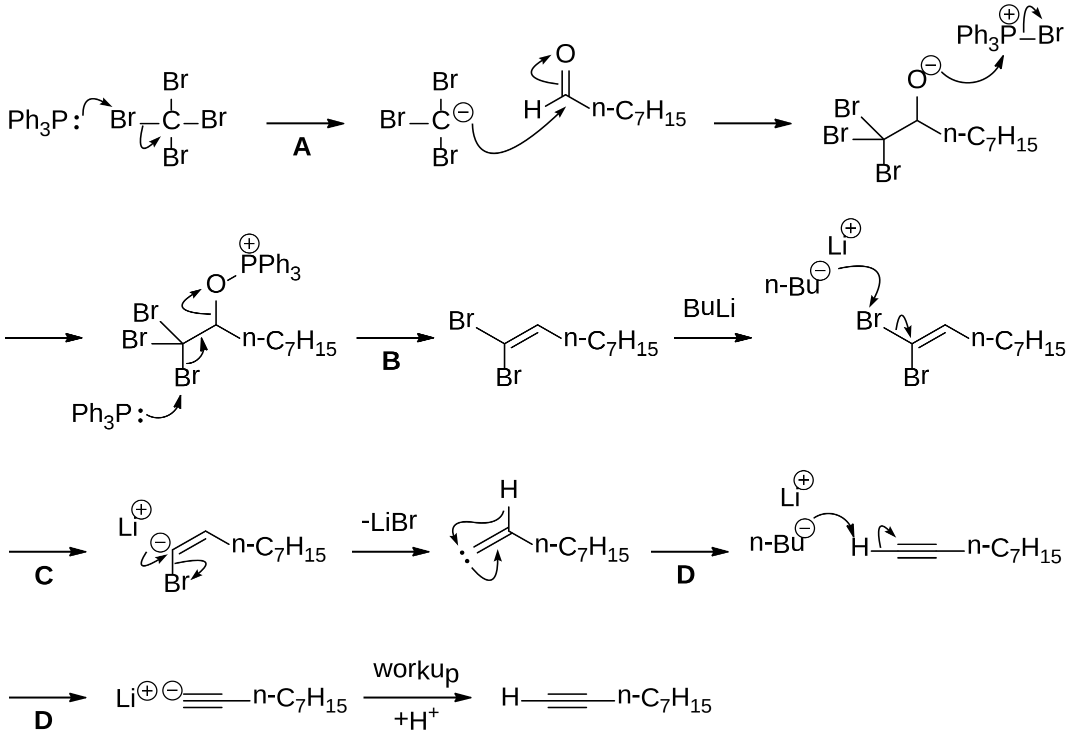
B048



Oldenziel, O. H.; Wildeman, J; van Leusen, A. M. *Org. Synth., Coll*. Vol Ⅵ **1988**, 41.

TosMIC (p-toluenesulfonylmethyl isocyanide). **A**: Deprotonation of an active methylene compound. **B**: Intramolecular addition to the isocyanide to form an oxazoline anion. **C**: Loss of the activated formyl group with a concomitant elimination of a toluenesulfinate ion (pKa $PhSO_2H$ = 1.5).

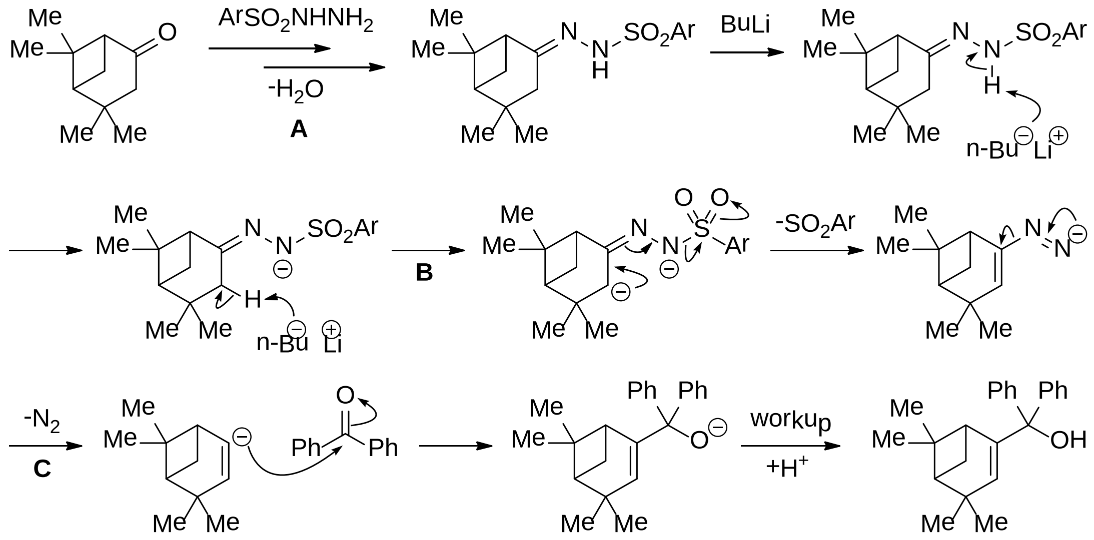
B049



Corey, E. J.; Fuchs, P. L. *Tetrahedron Lett.* **1972**, 13, 3769

Corey-Fuchs reaction. **A**: Generation of a stable carbanion (cf. pKa $CHCl_3$ = 13.6). **B**: E2 elimination (triphenylphosphine oxide is an extremely good leaving group). **C**: Halogen-lithium exchange follow by α-elimination to generate an alkylidene carbene. **D**: C-H insertion of the carbene. **E**: pKa n-Bu$^-$ = 50, RC≡CH = 25.

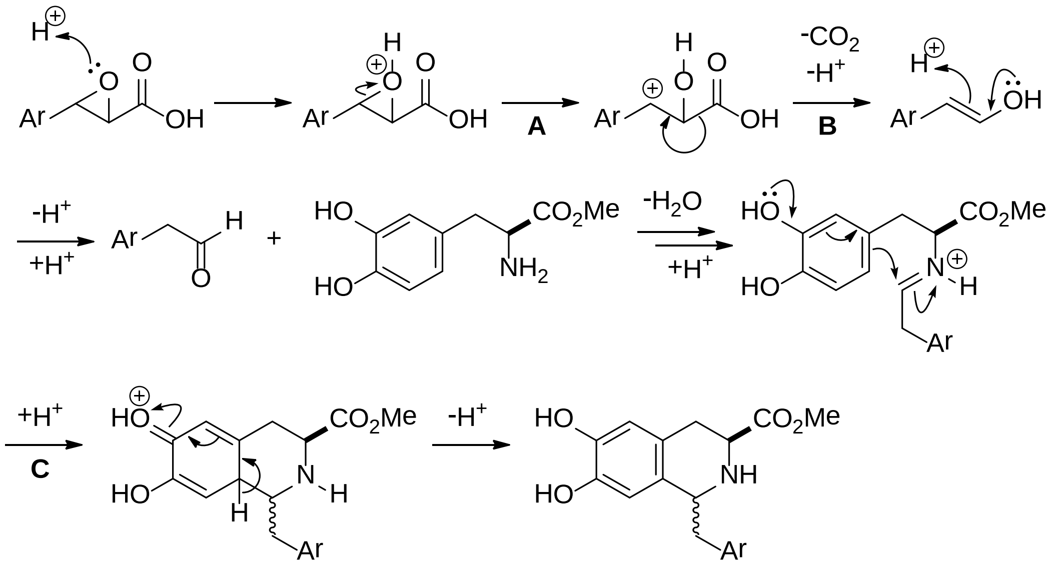
B050



Rupert, K. C.; Liu, C. C.; Nguyen, T. T.; Whitener, M. A.; Sowa, J. R.. J, *Organometallics* **2002**, 21,144

Shapiro reaction. **A**: Formation of a hydrazone. **B**: Deprotonation of the α-position of the hydrazone anion. **C**: Elimination of a sulfinate ion (pKa RSO_2H = 1.5). **D**: Loss of N_2 to form an alkenyl anion.

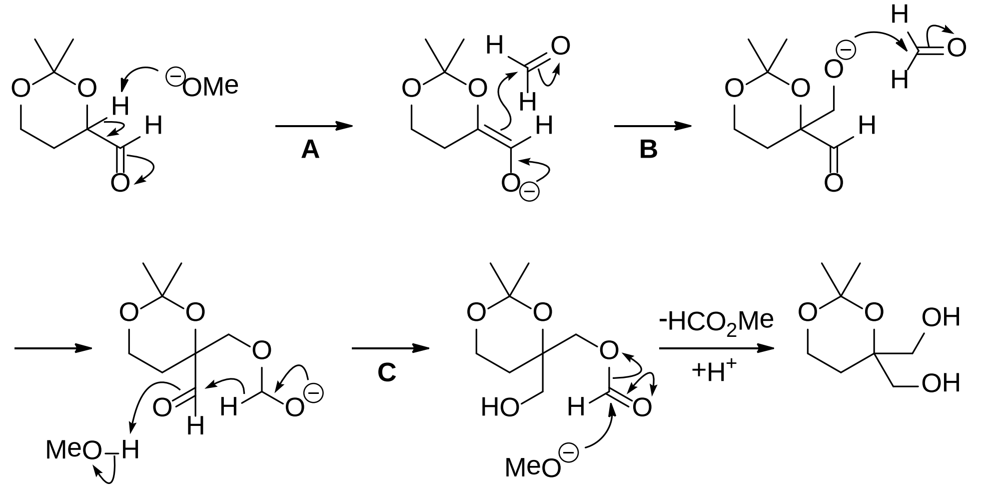
B051



Konda, M.; Shioiri, T.; Yamada, S. *Chem. Pharm. Bull.* **1975**, 23, 1025

A: Generation of a stabilized benzyl cation. **B**: Decarboxylation to form an enol, an aldehyde equivalent. **C**: Pictet-Spengler reaction (ref A033).

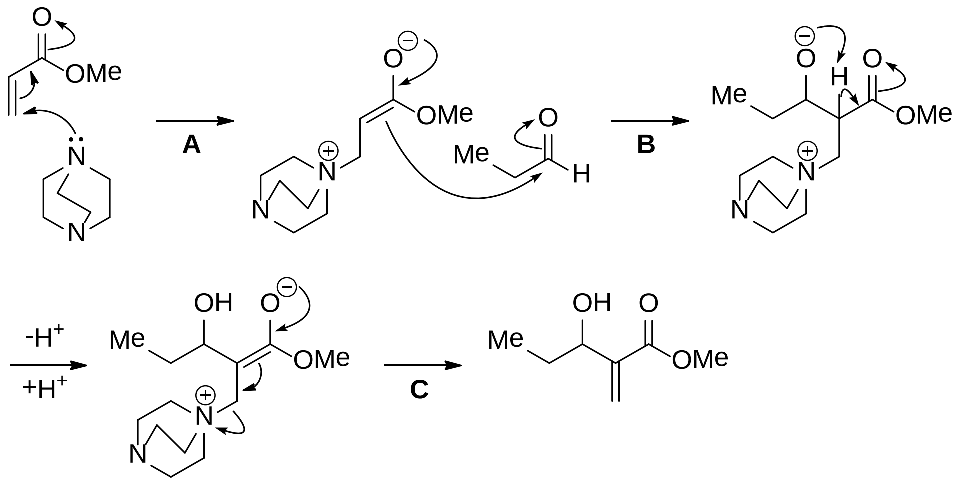
B052



Shimada, K.; Kaburagi, Y.; Fukuyama, T. *J. Am. Chem. Soc.* **2003**, 125, 4048.

A: pKa MeOH = 15.5, CH_3CHO = 16.7. **B**: Aldol reaction. **C**: Intramolecular hydride transfer (Cannizzaro-type reaction).

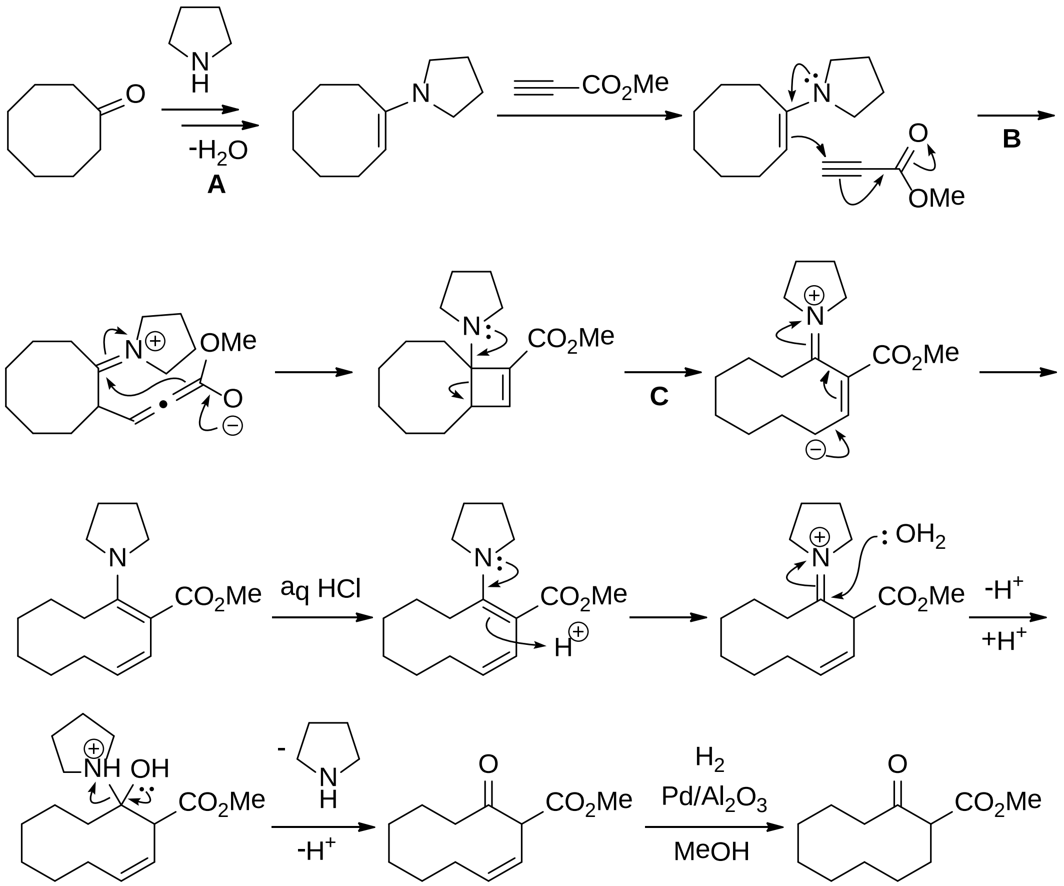
B053



Brown, J. M.; Evans, P. L.; James, A. P. *Org. Synth., Coll.* Vol. Ⅷ **1993**, 420.

Morita-Baylis-Hillman reaction. **A**: Michael addition of DABCO. **B**: Aldol reaction. **C**: Elimination of DABCO.

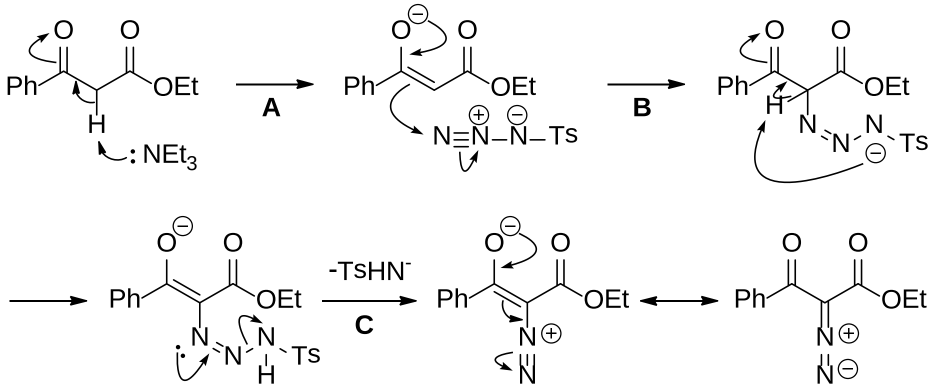
B054



Burpitt, R. D.; Thweatt, J. G. *Org. Synth., Coll.* Vol. V **1973**, 277.

A: Formation of an enamine. **B**: A stepwise formation of the four-membered ring by means of Michael addition. **C**: Cleavage of the cyclobutene to release the ring strain.

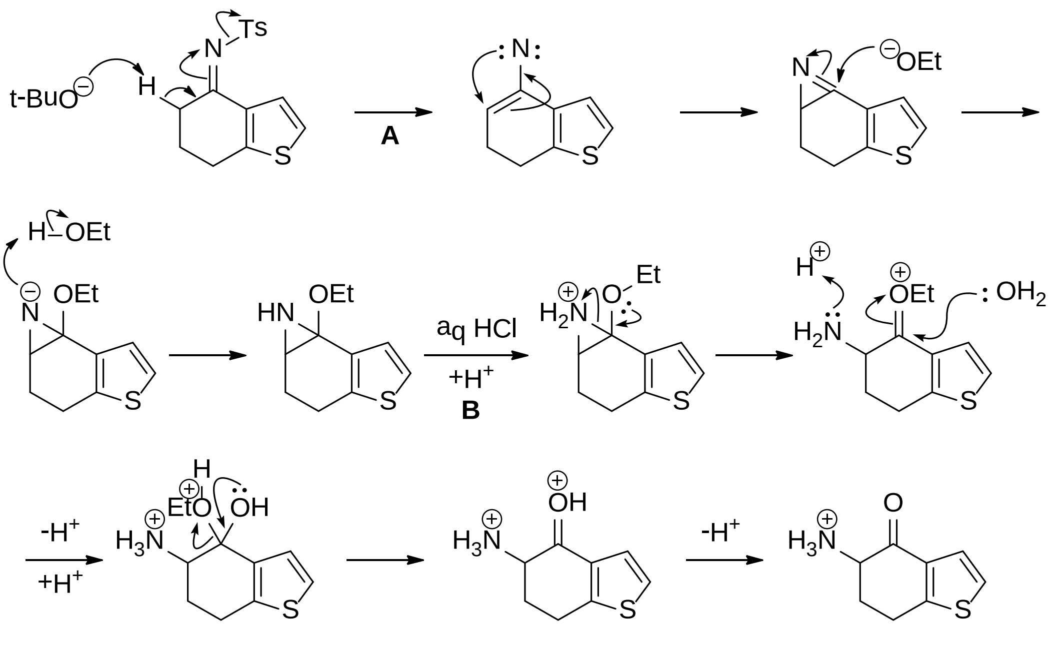
B055



Lall, M. S.; Ramtohul, Y. K.; James, M. N. G.; Vederas, J. C. *J. Org. Chem*. **2002**, 67, 1536.

Regiz Diazo transfer reaction. **A**: pKa $RCOCH_2CO_2R$ = 11, $HNEt_3^+$ = 10.7. **B**: Attack on the less hindered, electrophilic nitrogen. **C**: pKa $PhSO_2NH_2$ = 8.5:

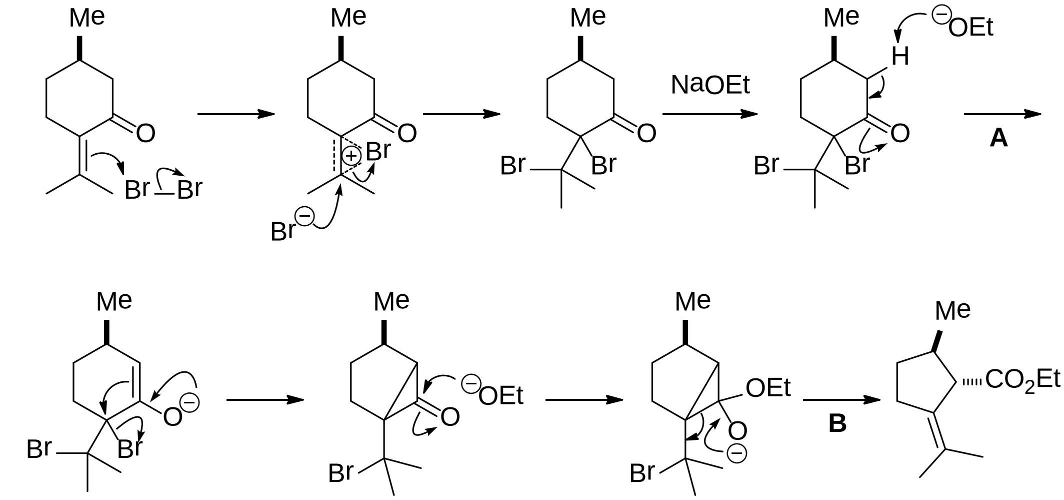
B056



Dijkstra, D.; Rodenhuis, N.; Vermeulen, E. S.; Pugsley, T. A.; Wise, L. D.; Wikstrm, H. V. *J. Med. Chem.* **2002**, 45, 3022.

Neber rearrangement. **A**: Generation of a nitrene to form the azirine, which then undergoes addition of ethanol. **B**: Acidic hydrolysis of the ethoxyaziridine.

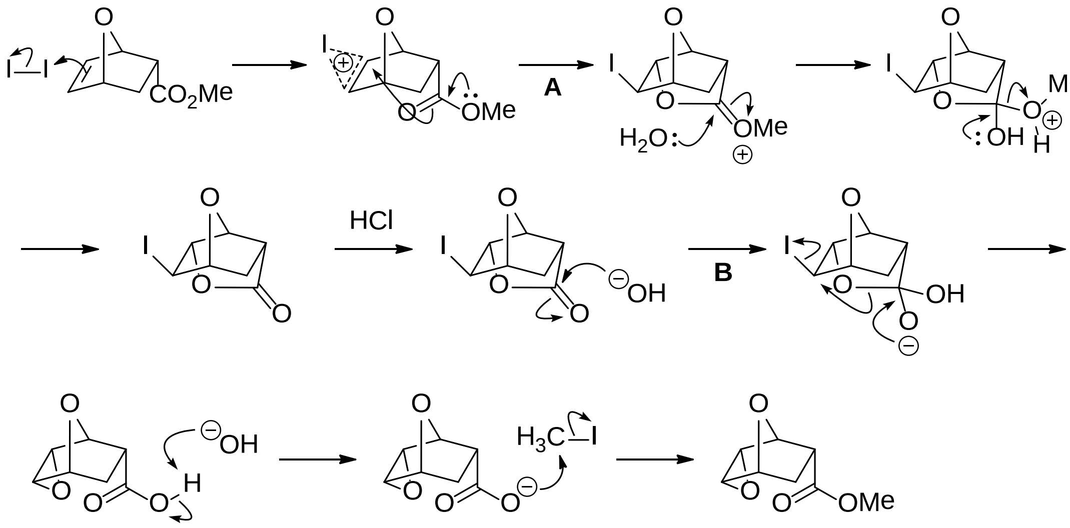
B057



Marx, J. N.; Norman, L. R. *J. Org. Chem*. **1975**, 40, 1602.

A: Favorskii rearrangement (ref A069). **B**: Cleavage of the strained cyclopropanone with a concurrent elimination of the bromide (formation of the thermodynamically more stable trans-ester).

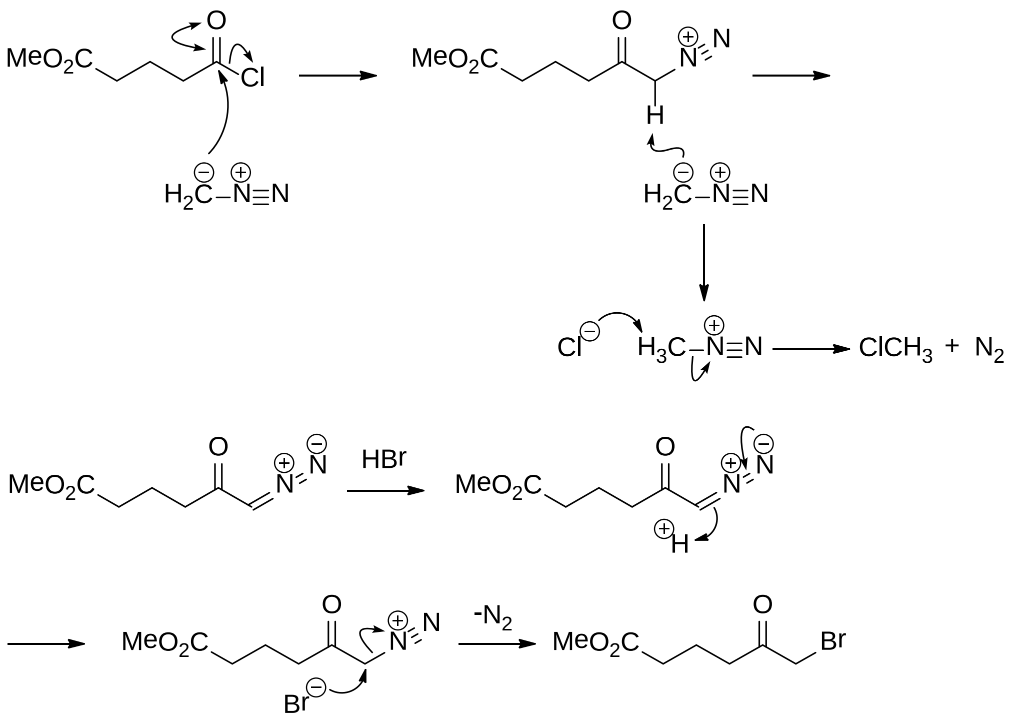
B058



Shoji, M.; Yamaguchi, J.; Kakeya, H.; Osada, H.; Hayashi, Y. *Angew. Chem. Int. Ed*. **2002**, 41,319;

A: Iodolactonization. **B**: Hydrolysis of the lactone followed by formation of the epoxide.

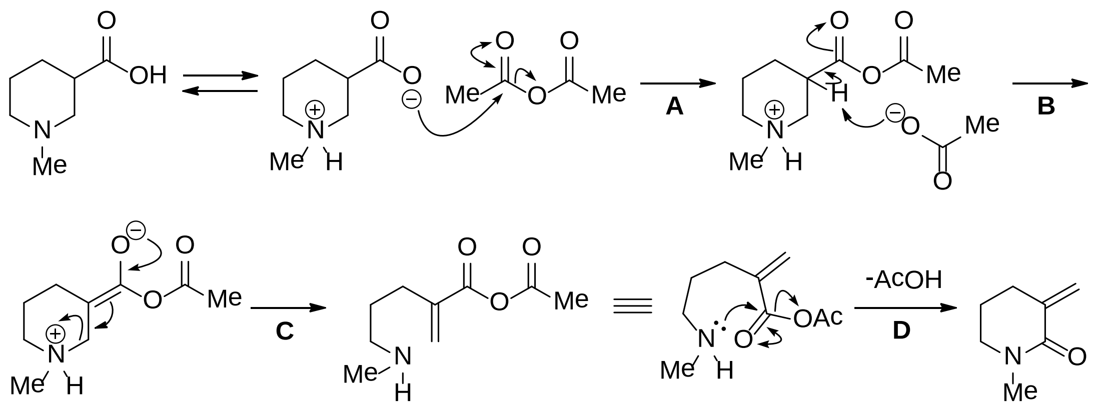
B059



Nair, V.; Jahnke, T. S. *Tetrahedron* **1987**, 43 4257.

Excess diazomethane is needed to scavenge HCl.

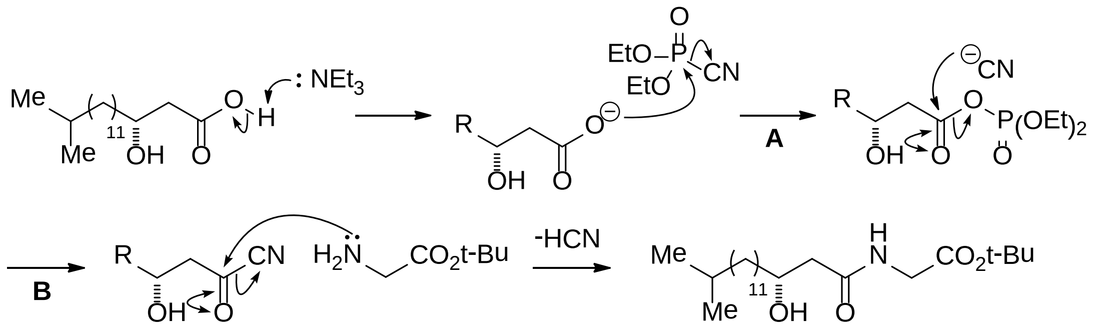
B060



Rueppel, M. L.; Rapoport, H. *J. Am. Chem. Soc.* **1978**, 92, 5781.

A: Formation of a mixed anhydride. **B**: pKa $(CH_3CO)_2O$ = 13.5. **C**: β-Elimination. **D**: Intramolecular acylation is faster than intermolecular one.

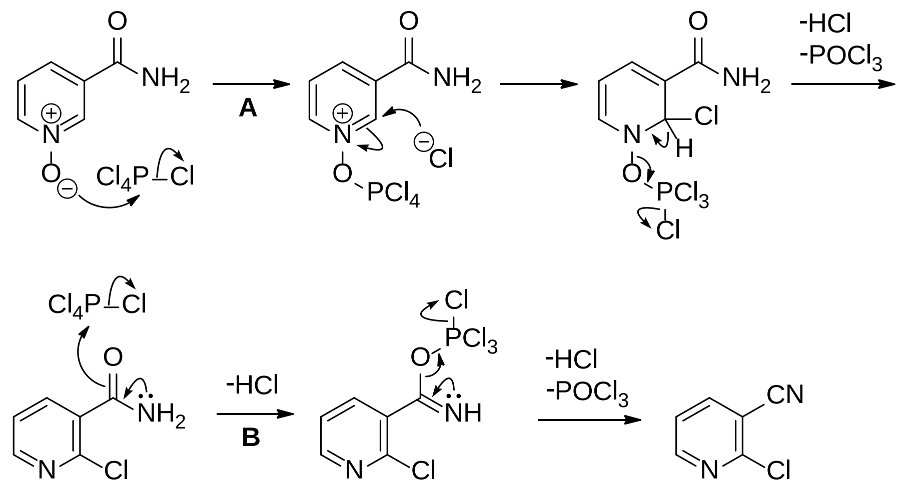
B061



Shioiri, T.; Terao, Y.; Irako, N.; Aoyama, T. *Tetrahedron* **1998**, 54, 15701.

A: Formation of a mixed anhydride. **B**: Formation of the reactive acyl cyanide.

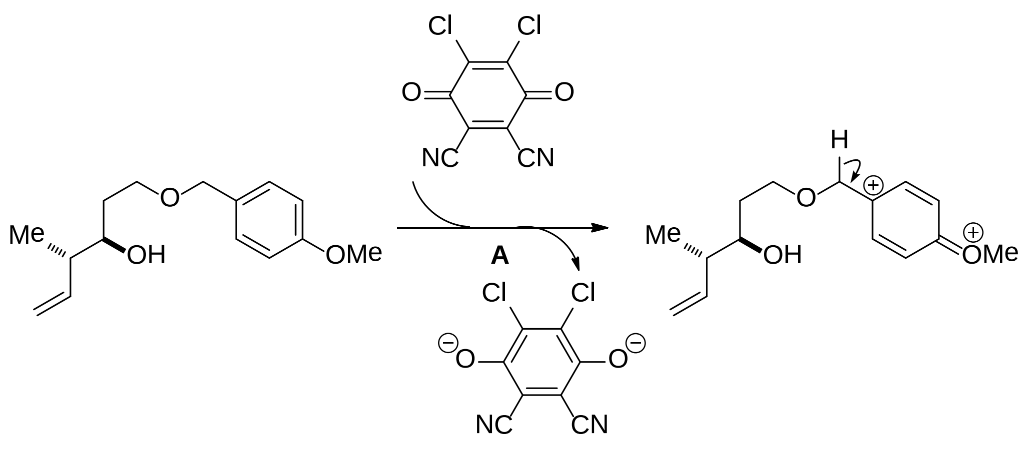
B062

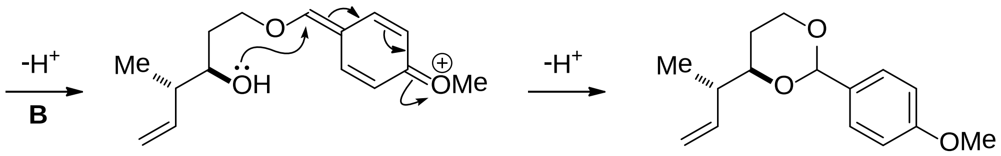


Taylor, E. C., Jr.; Crovetti, A. J. *Org. Synth., Coll.* Vol. Ⅳ **1963**, 166.

A: Activation of the N-oxide with PCl_5. **B**: Dehydration of the amide.

B063



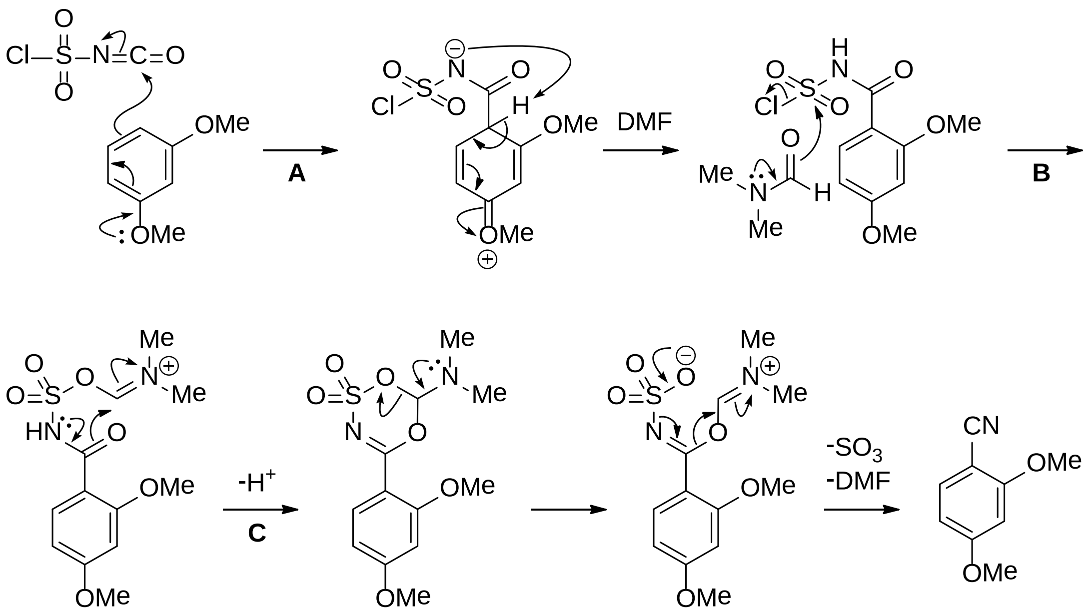


Crimmins, M. T.; Siliphaivanh, P. *Org. Lett.* **2003**, 5, 4641.

A: Transfer of two electrons from the starting material to DDQ by forming a charge-transfer complex.

B: Deprotonation to form a p-quinonemethide-type intermediate.

B064

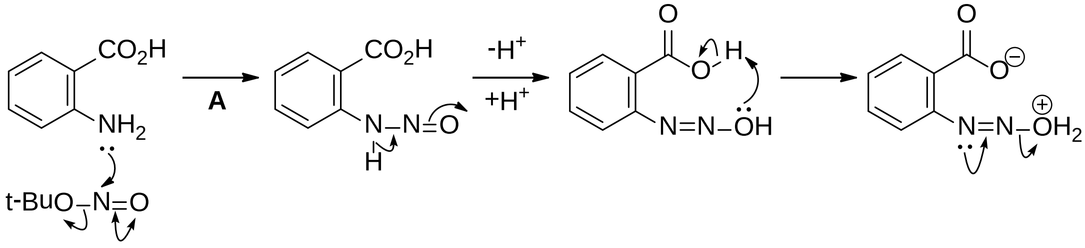


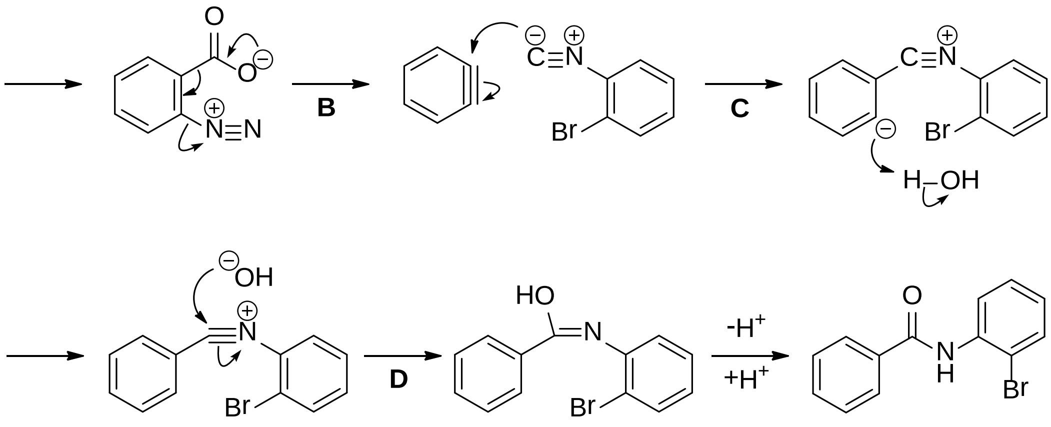
Lohaus, G. *Chem. Ber.* **1967**, 100, 2719.

A: Electrophilic substitution of an electron-rich aromatic compound. **B**: Attack on the oxygen of DMF.

C: Cyclization followed by fragmentation to form the nitrile.

B065



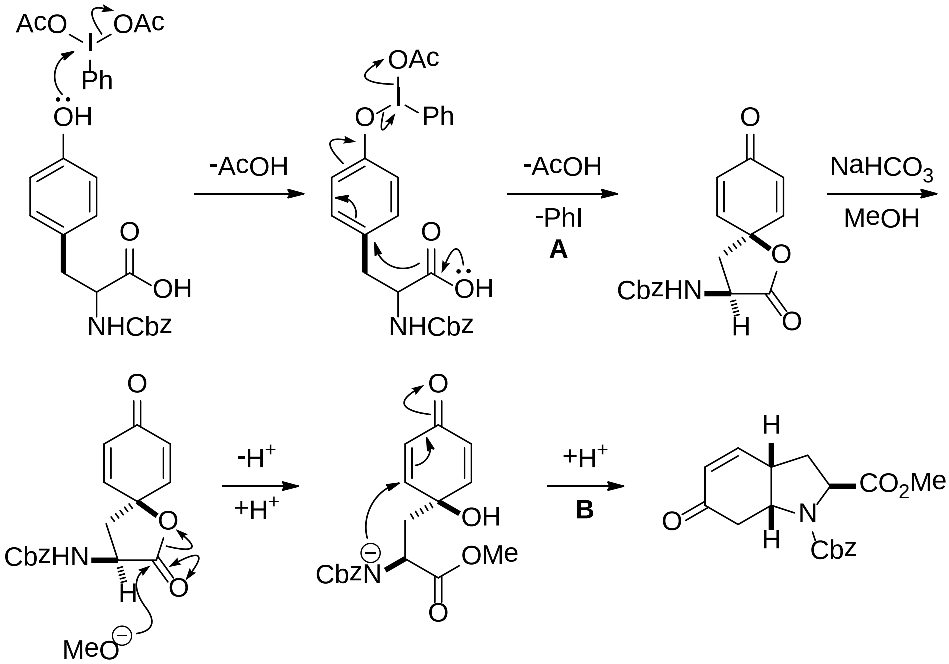


Rigby, J. H.; Laurent, S. *J. Org. Chem*. **1998**, 63, 6742.

A: Formation of a diazonium salt (ref A037). **B**: Formation of a benzyne with a loss of CO_2 and N_2.

C: Nucleophilic addition of the isocyanide. **D**: Addition of water to the nitrilium ion.

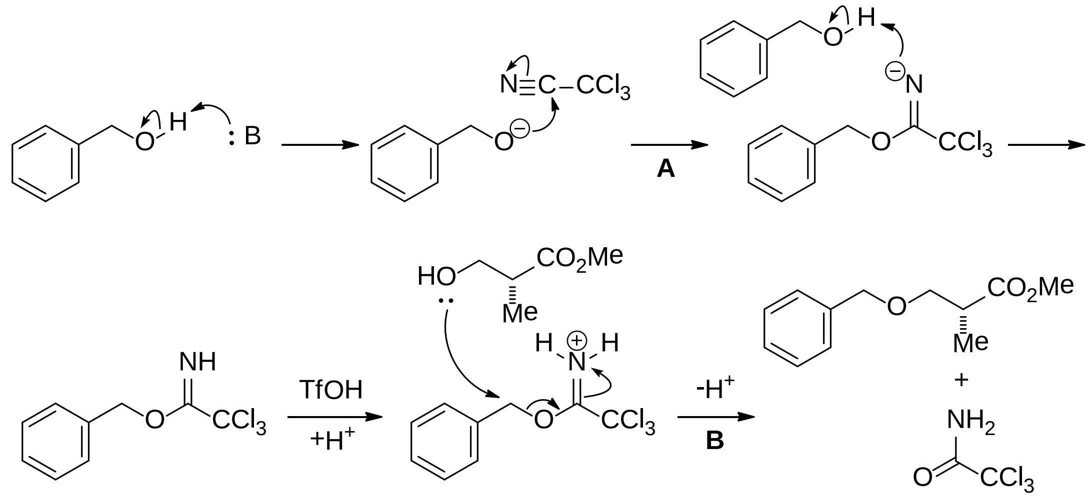
B066



Wipf, P.; Li, W. *J. Org. Chem*. **1999**, 64, 4576.

A: Oxidative lactonization of N-Cbz tyrosine. **B**: Intramolecular Michael addition to the cross-conjugated dienone.

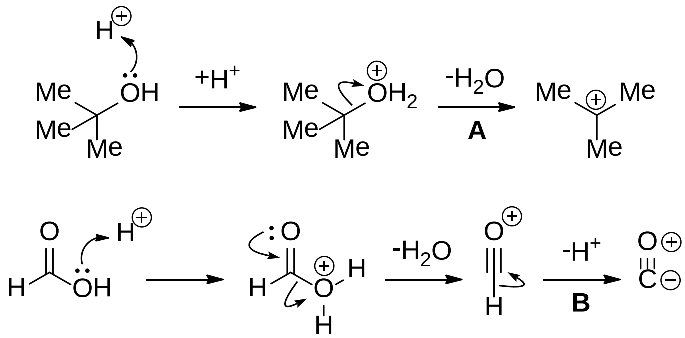
B067

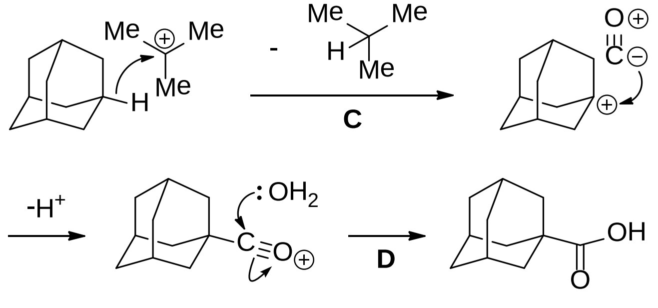


White, J. D.; Reddy, G. N.; Spessard, G. O. *J. Am. Chem. Soc.* **1988**, 110, 1624.

A: Addition of benzyl alcohol to electron-deficient Cl_3CCN with a help of catalytic amount of base. **B**: Ftherification of alcohols under acidic conditions.

B068

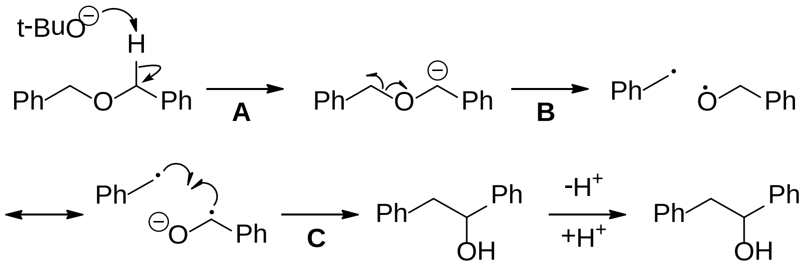




Koch, H.; Haaf, W. *Org. Synth., Coll*. Vol. V **1973**, 20.

A: Formation of a stable t-butyl cation. **B**: Generation of CO by dehydration of fomic acid. **C**: Hydride abstraction from the bridgehead of adamantane. **D**: Addition of CO to form an acylium ion.

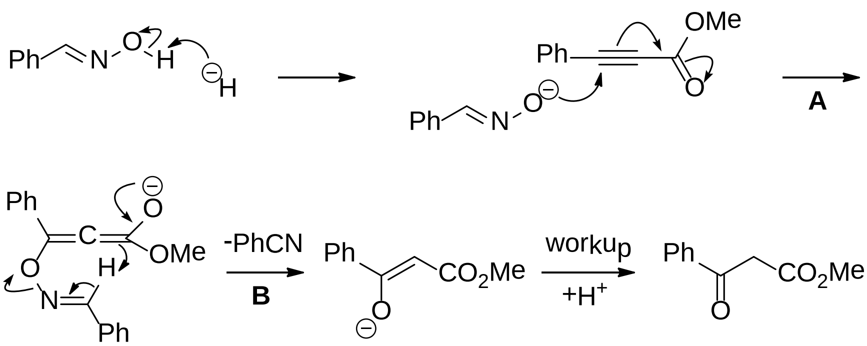
B069



Hauser, C. R.; Kantor, S. W. *J. Am. Chem. Soc.* **1951**, 73, 1437.

[1,2] Wittig rearrangement. **A**: pKa $PhCH_3$ = 41, n-BuH = 50. **B**: Homolytic cleavage to form a radical anion. **C**: A facile radical recombination in a solvent cage.

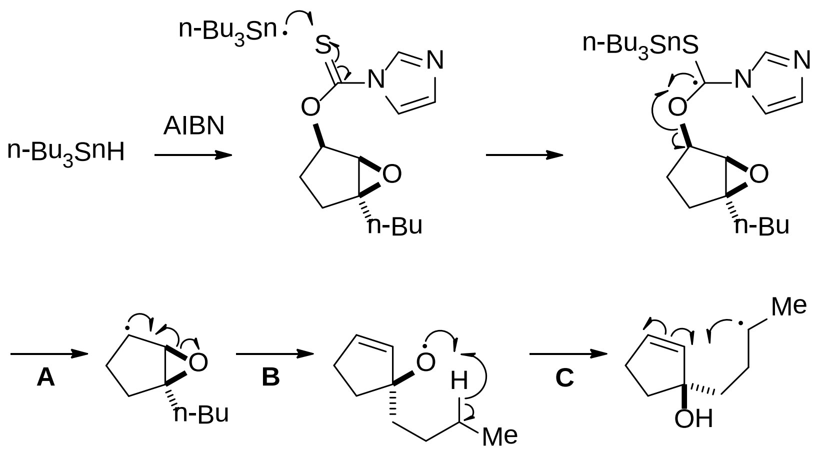
B070

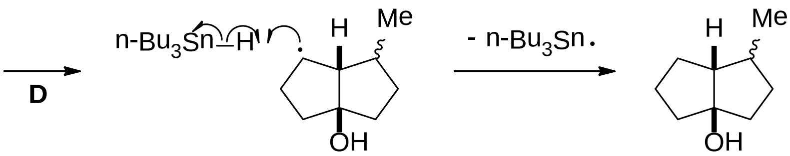


Gómez, V.; Perez-Medrano, A.; Muchowski, J. M. *J. Org. Chem.* **1994**, 59, 1219

A: Michael addition of an oxime anion. **B**: Intramolecular deprotonation to cause fragmentation.

B071

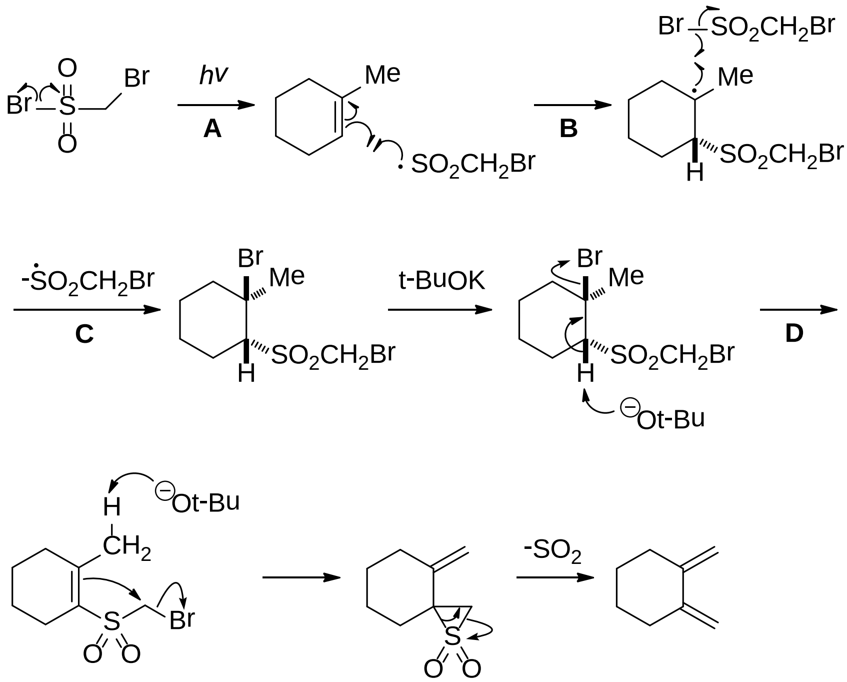




Rawal, V. H.; Newton, R. C.; Krishnamurthy, V. *J. Org. Chem*. **1990**, 55, 5181.

A: Barton-McCombie deoxygenation (ref A051). **B**: Cleavage of the strained epoxide ring. **C**: Intramolecular abstraction of a hydrogen via a six-membered transition state. **D**: 5-exo-trig Radical cyclization.

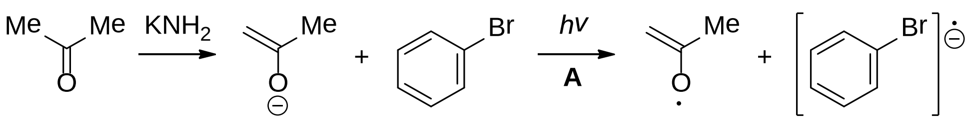
B072

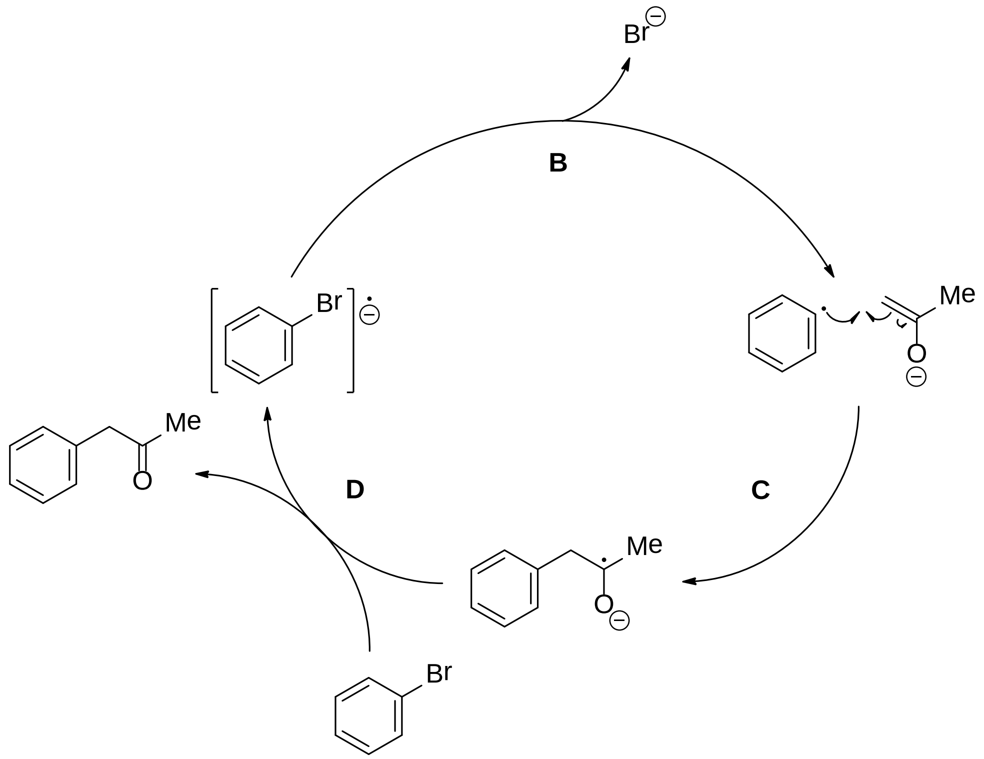


Block, E.; Aslam, M. *Org. Synth., Coll*. Vol. Ⅷ **1993**, 212.

A: Photo-induced homolytic cleavage to form a sulfinyl radical. **B**: Addition to the olefin to form a stable tertiary radical. **C**: Attack on the bromide of the reagent (radical chain reaction). **D**: Elimination of HBr followed by vinylogous Ramberg-Bäcklund reaction.

B073

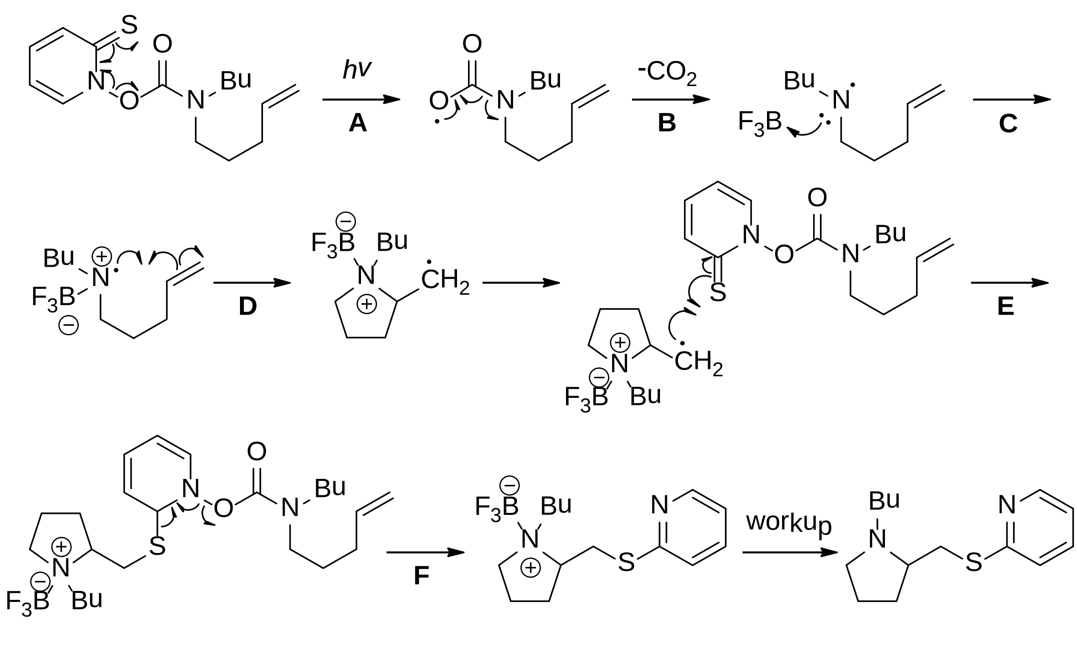




Rossi, R. A.; Bunnett, J. F. *J. Org. Chem*. **1973**, 38, 3020.

$S_{RN}1$ reaction. **A**: SET to bromobenzene to form a radical anion. **B**: Fragmentation of the radical anion to form a phenyl radical. **C**: Addition to enolate to form a radical anion. **D**: SET to continue the radical chain reaction.

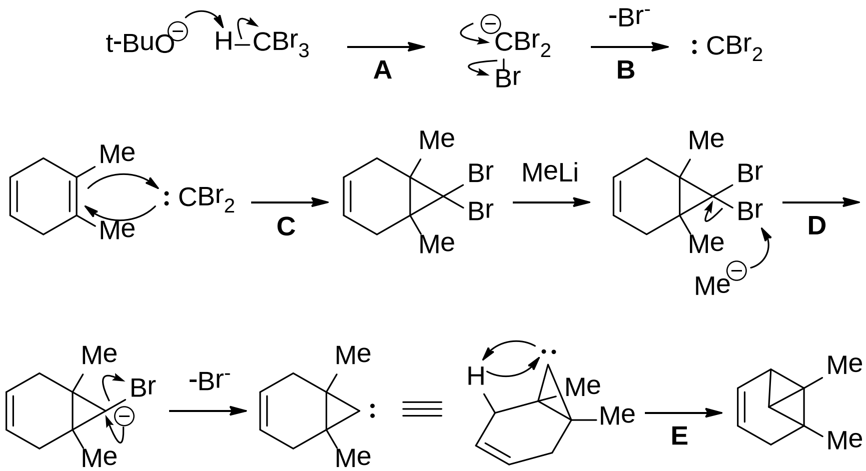
B074



Newcomb, M. Ha, C. *Tetrahedron Lett.* **1991**, 32, 6493.

A: Photo-induced homolytic cleavage. **B**: Decarboxylation to form an aminyl radical. **C**: Activation of the aminyl radical by Lewis acid. **D**: Kinetically favored 5-exo-trig radical cyclization. **E**: Group transfer reaction.

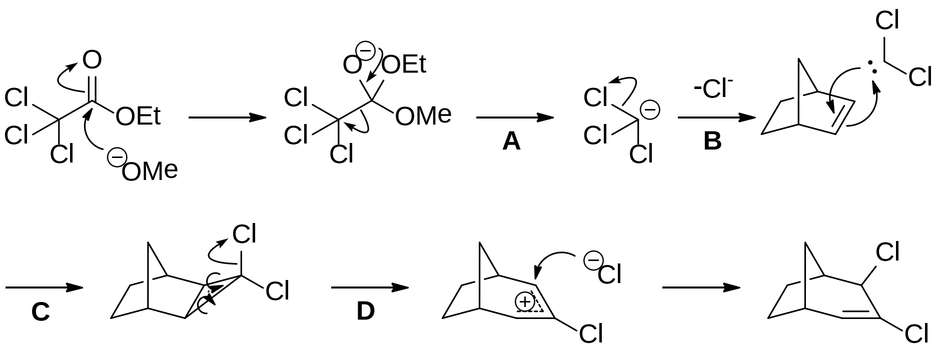
B075



Taylor, R. T.; Paquette, L. A. *Org. Synth., Coll.* Vol. Ⅷ **1990**, 200.

A: pKa $CHCl_3$ = 13.6. **B**: α-Elimination to form dibromocarbene. **C**: Cyclopropanation of the more electron-rich, tetrasubstituted olefin. **D**: Halogen-lithium exchange and subsequent α-elimination to form a carbene. **E**: C-H insertion of the carbene (the corresponding allene cannot be formed due to the excessive ring strain. ref A061).

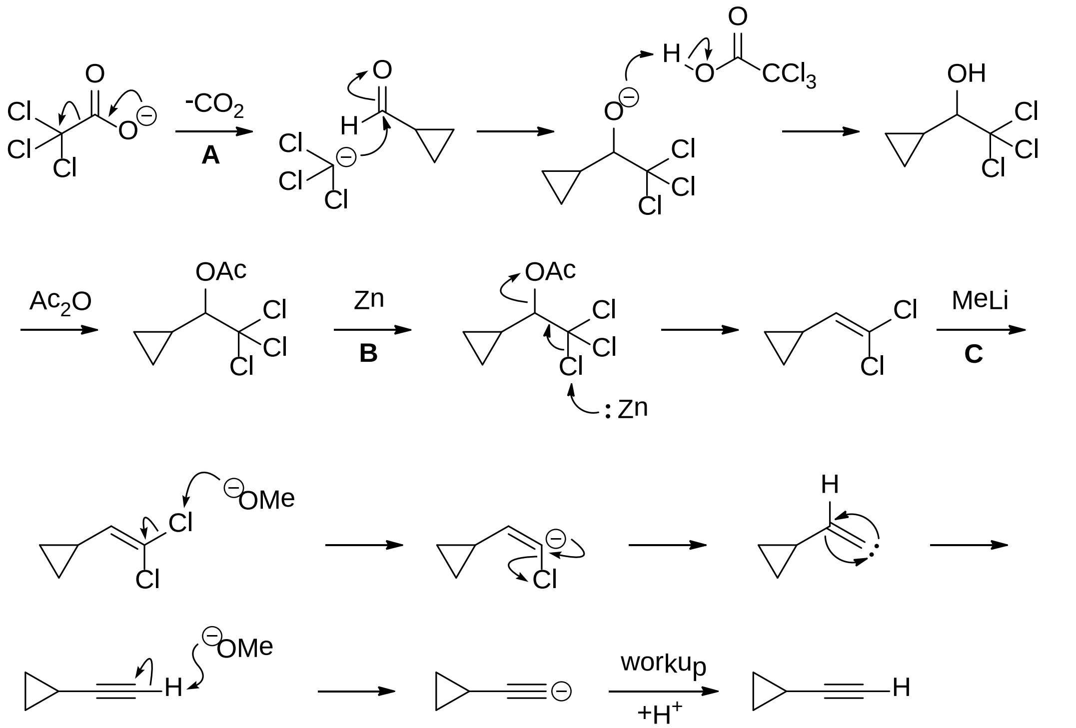
B076



Jefford, C. W.; Gunsher, J.; Hill, D. T.; Brun, P.; Gras, J. L.; Waegelt, B.
Org. Synth., Coll Vol. Ⅵ 1988, 142.

A: pKa $CHCl_3$ = 13.6. **B**: Generation of dichlorocarbene. **C**: Cyclopropanation from the sterically less hindered exo-side. **D**: 2e Disrotatory electrocyclic reaction to form an allyl cation.

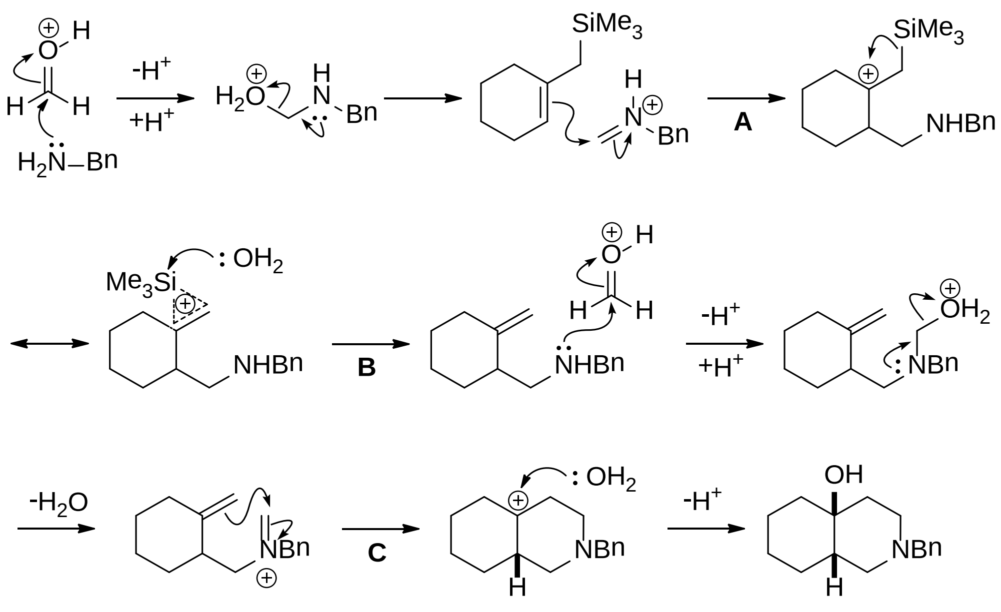
B077



Wang, Z.; Campagna, S.; Xu, G.; Pierce, M. E.; Fortunak, J. M.; Confalone, P. N. *Tetrahedron Lett.* **2000**, 41, 4007.

A: pKa $CHCl_3$ = 13.6. **B**: Reduction with Zn to form a gem-dichloroolefin. **C**: Corey-Fuchs-type alkynylation (ref B049).

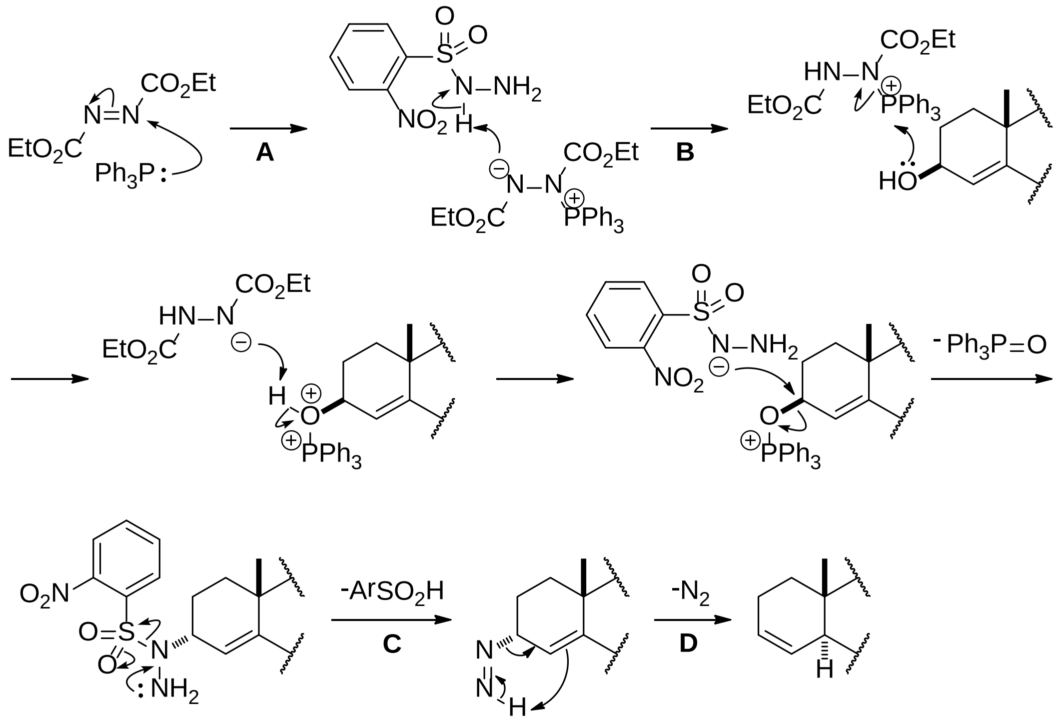
B078



Larsen, S. D.; Grieco, P. A.; Fobare, W. E *J. Am. Chem. Soc.* **1986**, 108, 3512.

A: Addition of an allylsilane to the iminium ion (a silyl group can stabilize the β-carbocation). **B**: Desilylation to form an olefin. **C**: Olefin-iminium ion cyclization to form a stable tertiary carbocation.

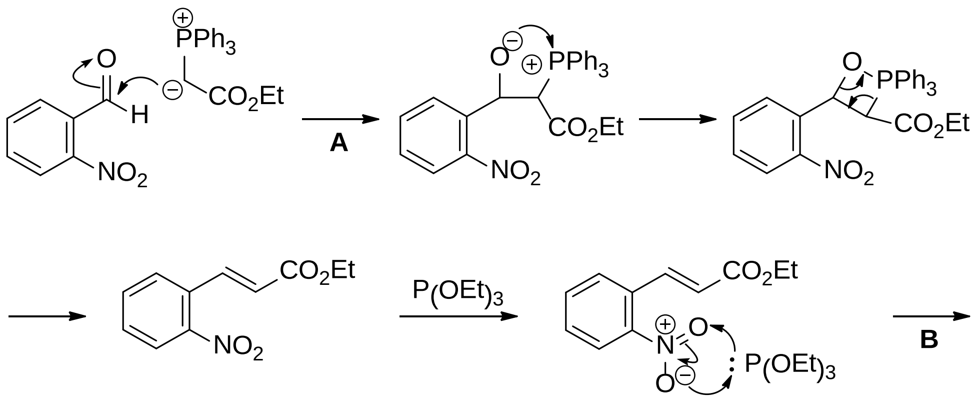
B079

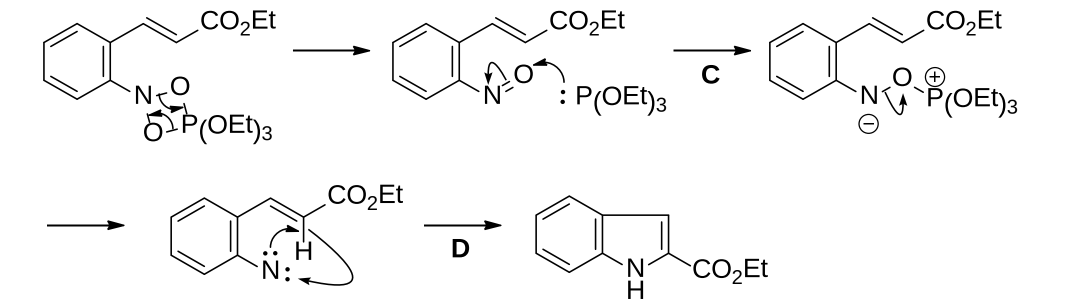


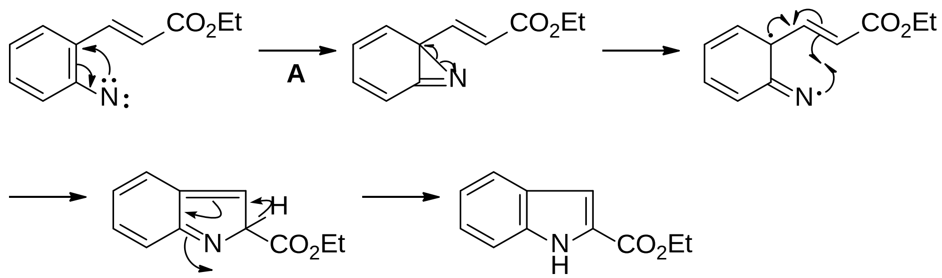
Myers, A. G.; Zheng, B. *Tetrahedron Lett.* **1996**, 37, 4841.

A: Mitsunobu reaction (ref A045). **B**: Deprotonation of the more acidic proton. **C**: Elimination of a sutfinate ion. **D**: Elimination of N_2 via a concerted mechanism.

B080



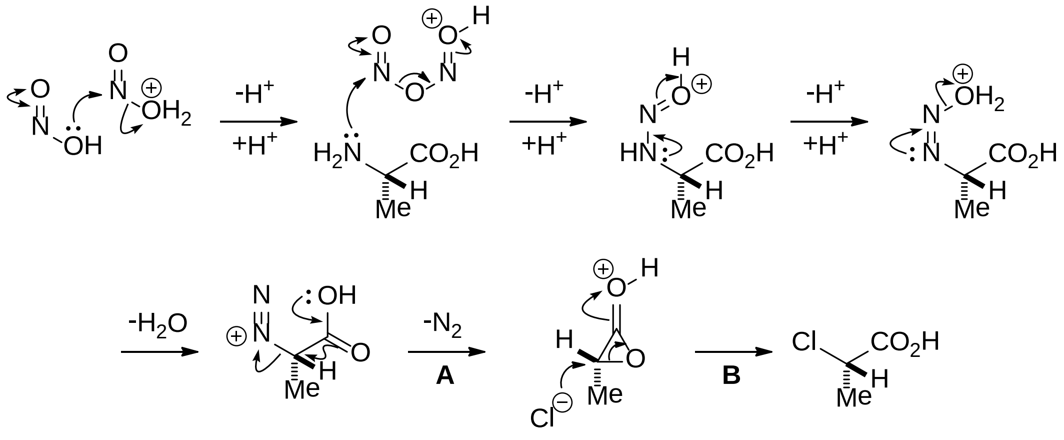




Mali, R. S.; Yadav, V. J. *Synthesis* **1984**, 862.

A: Wittig reaction. **B**: [4+2] Cheletropic reaction and elimination of a phosphate to form a nitroso intermediate. **C**: Deoxygenation of the nitroso compound to form a nitrene. **D**: Formation of the indole could be interpreted as a result of either 1) a direct C-H insertion or 2) formation of the azirine followed by homolytic cleavage and recombination of the resulting diradical.

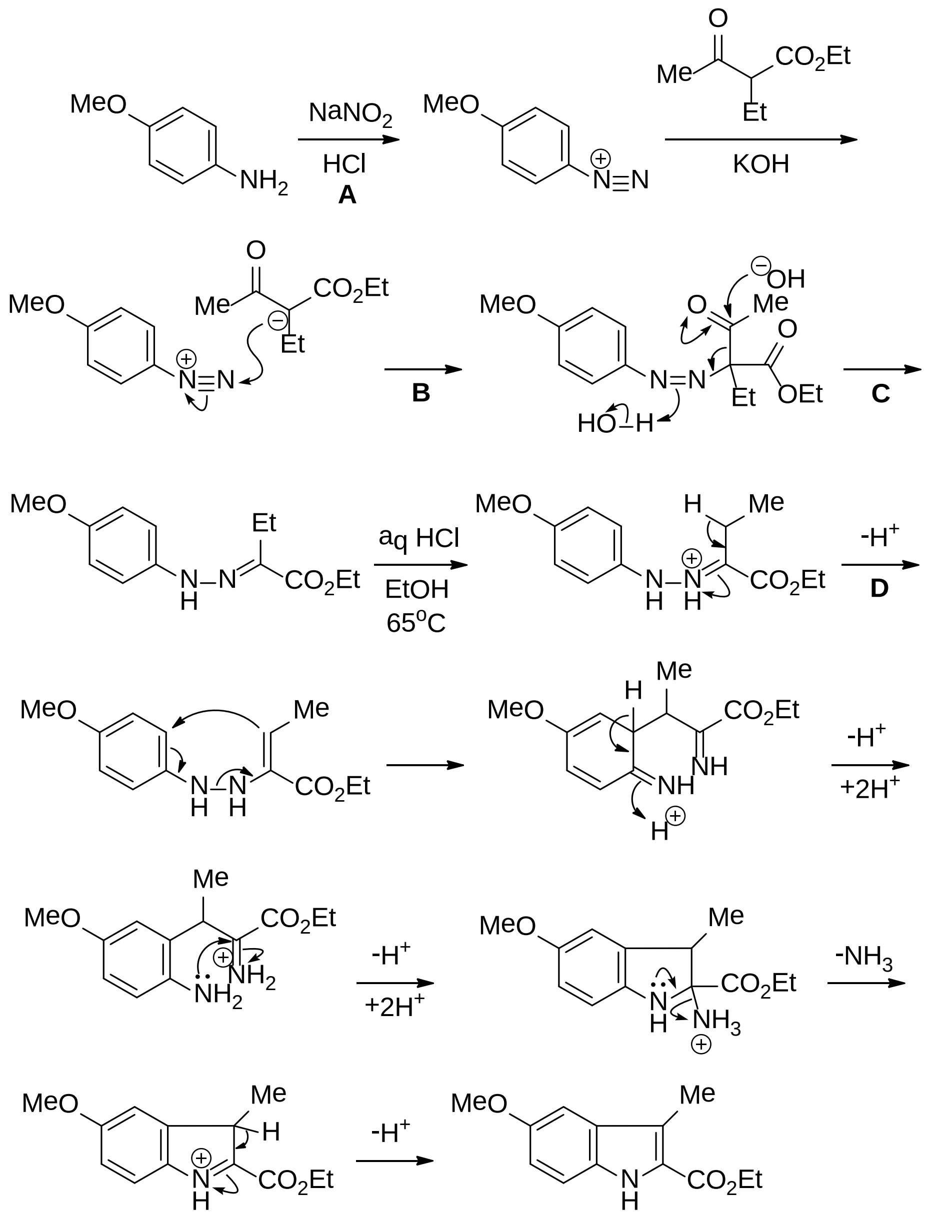
B081



Koppenhoefer, B.; Schurig, V. *Org. Synth., Coll.* Vol. Ⅷ **1993**. 119

A: Formation of a very reactive α-lactone via a diazonium salt. **B**: Cleavage of the α-lactone with chloride ion. The stereochemistry of the α-position is retained as a result of the double inversion.

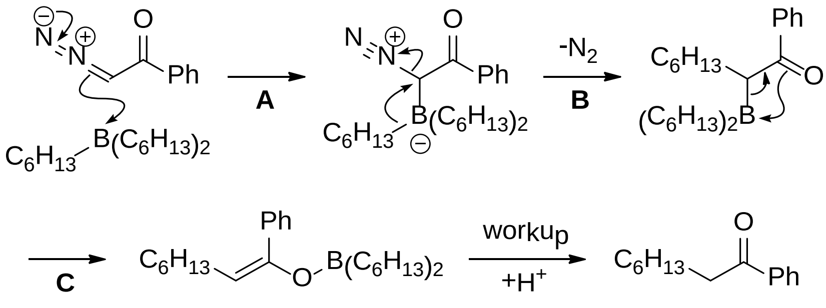
B082



Zhao, S.; Liao, X.; Wang, T.; Flippen-Anderson, J.; Cook, J. M. *J. Org. Chem*. **2003**, 68, 6279.

Japp-Klingemann reaction and Fischer indole synthesis. **A**: Formation of a diazonium salt. **B**: Addition of the enolate to the diazonium salt. **C**: Ketone cleavage of β-ketoester to form a hydrazone. **D**: Fischer indole synthesis (ref B031).

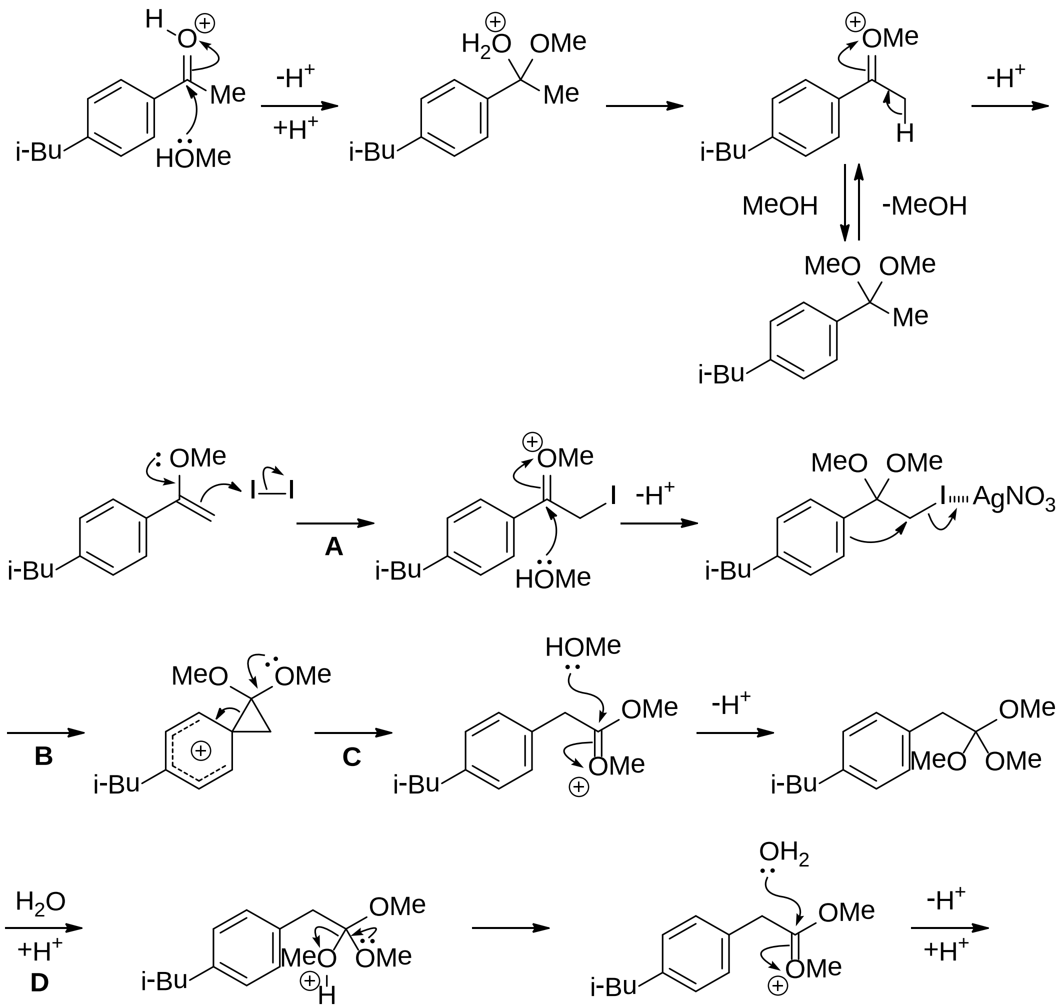
B083

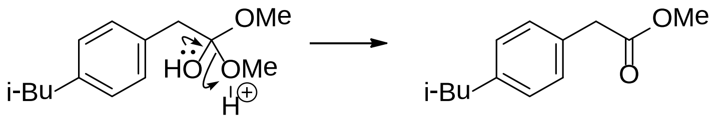


Kono, H.; Hooz, J. *Org. Synth., Coll*. Vol. Ⅵ **1988**, 919.

A: Attack of a diazoketone to B(n-hexyl)$_3$ to form an ate complex. **B**: Elimination of N_2 with a simultaneous migration of n-hexyl group. **C**: Formation of a boron enolate.

B084

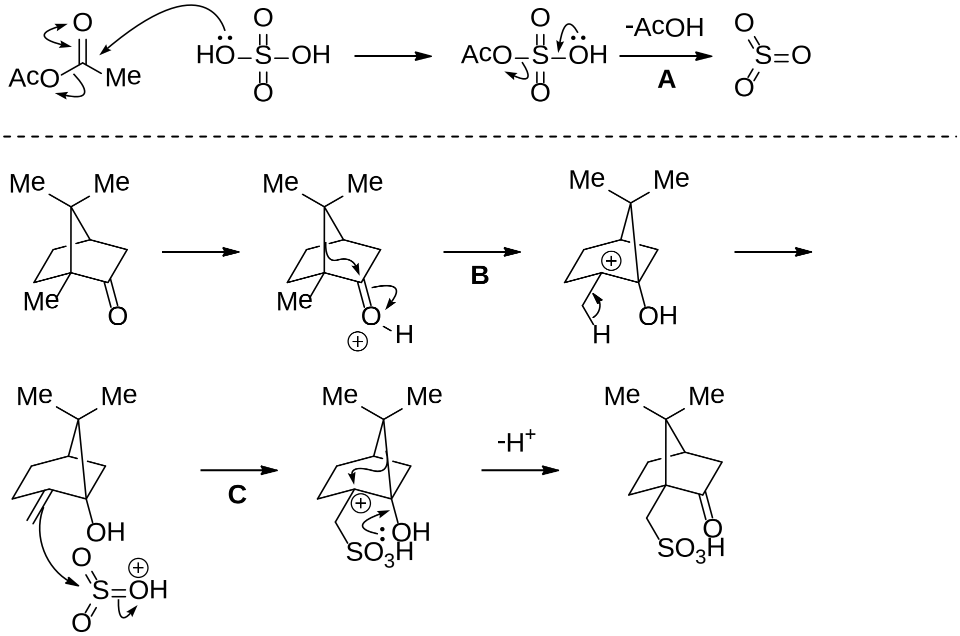




Oppolzer, W.; Rosset, S.; Brabander, J. D. *Tetrahedron Lett.* **1997**, 38, 1539.

A: Iodination of the enol ether with concomitant formation of a dimethyl acetal. **B**: Activation of the iodide with a silver ion to form a phenonium ion. **C**: Restoration of the aromaticity causes a cleavage of the electron-rich cyclopropane ring. **D**: The orthoester thus formed undergoes a facile hydrolysis to give the ester.

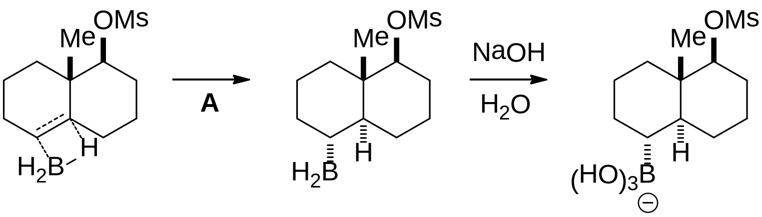
B085

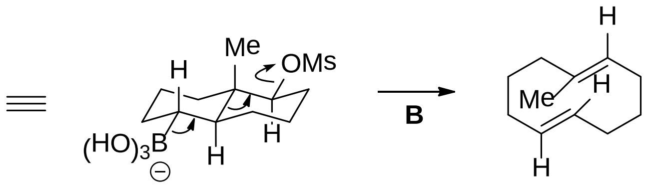


Bartlett, P. D.; Knox, L. H. *Org. Synth., Coll* Vol Ⅴ **1973**, 194.

A: Generation of SO_3. **B**: Wagner-Meerwein-type rearrangement. **C**: Sulfonation of the olefin to form a stable tertiary carbocation.

B086

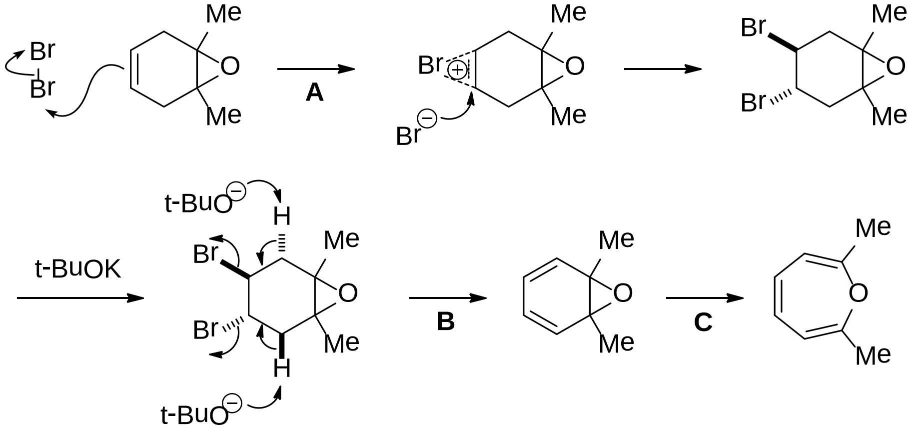




Marshall, J. A.; Bundy, G. L. *J. Am. Chem. Soc.* **1966**, 88, 4291.

A: Hydroboration from the less hindered side. **B**: Grob fragmentation ref B016).

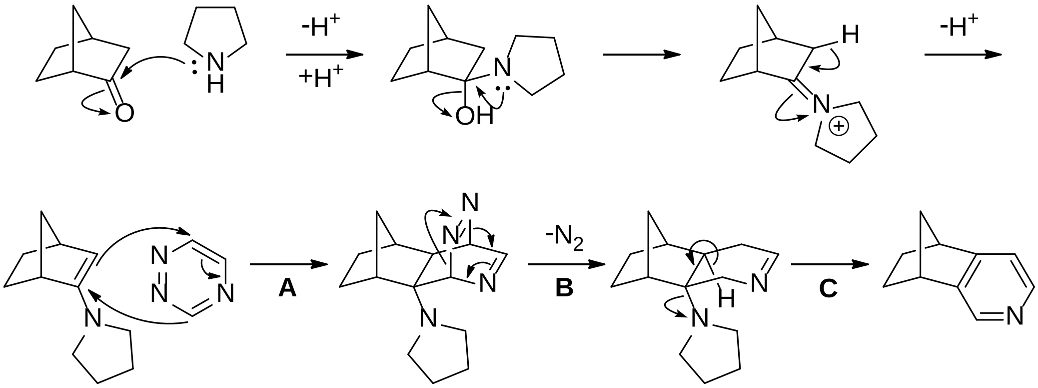
B087



Paquette, L. A.; Barrett, J. H. *Org. Synth., Coll.* Vol. V **1973**, 467.

A: Bromination of the olefin. **B**: Dehydrobromination to form a diene. **C**: 6e Disrotatory electrocyclic reaction (valence isomerism).

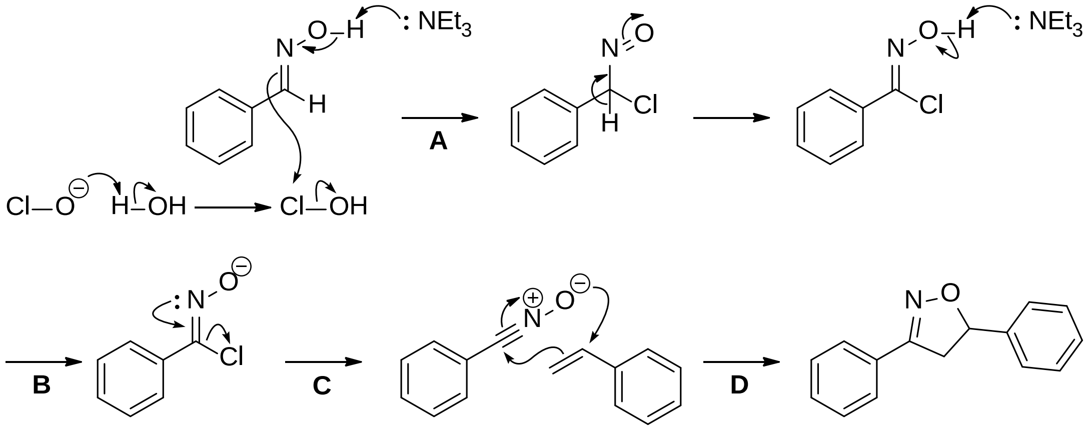
B088



Golka, A.; Keyte, P. J.; Paddon-Row, M. N. *Tetrahedron* **1992**, 48, 7663.

A: Inverse electron demand Diels-Alder reaction. **B**: Retro Diels-Alder reaction. **C**: Aromatization.

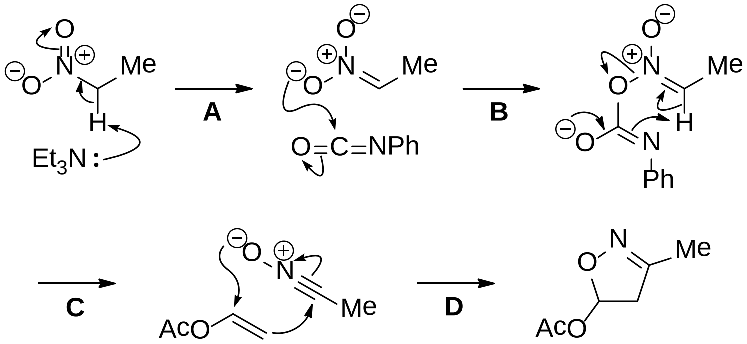
B089



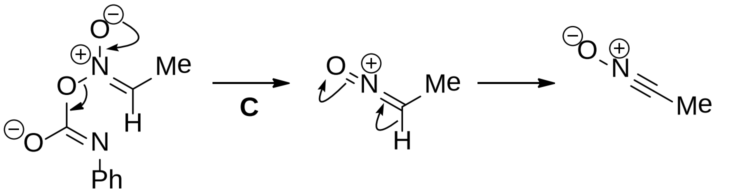
Lee, G. A. *Synthesis* **1982**, 508.

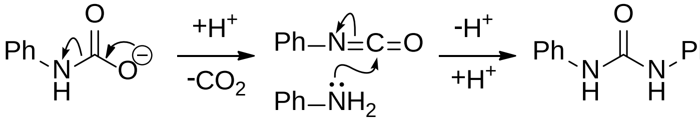
A: Chlorination of an oxime. **B**: Elimination of chloride ion is facilitated by the formation of an oxime anion. **C**: Generation of a nitrile oxide. **D**: 1,3-Dipolar cycloaddition.

B090



or

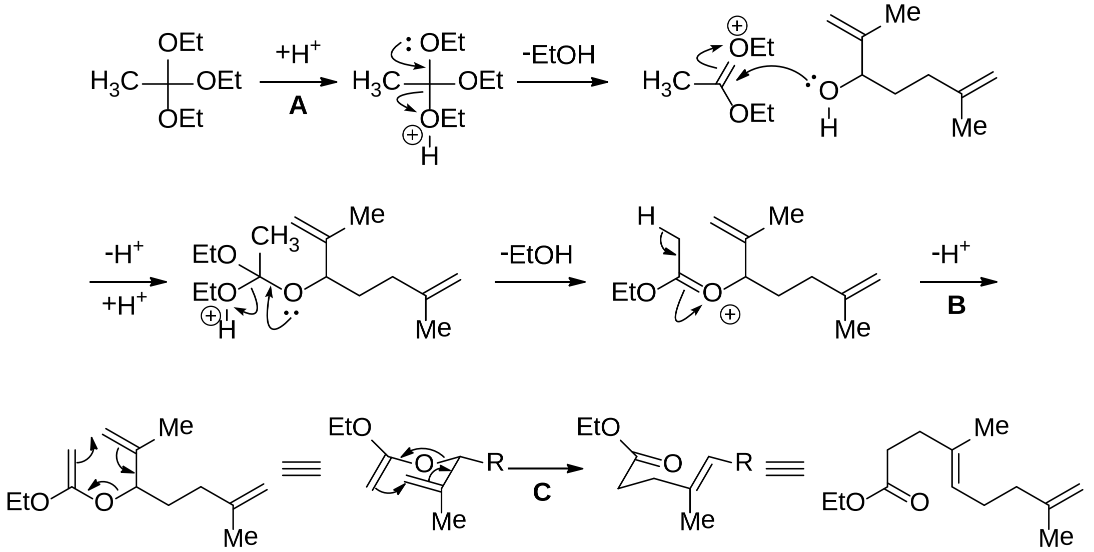




Mukaiyama, T.; Hoshino, T. *J. Am. Chem. Soc.* **1960**, 82, 5339.

A: pKa CH_3NO_2 = 10.2, $HNEt_3^+$ = 10.7. **B**: Addition of the nitronate to PhNCO. **C**: Formation of the nitrile oxide might proceed either by 1) syn-elimination of the carbamate ion or 2) elimination of the carbamate ion followed by deprotonation. **D**: 1,3-Dipolar cycloaddition.

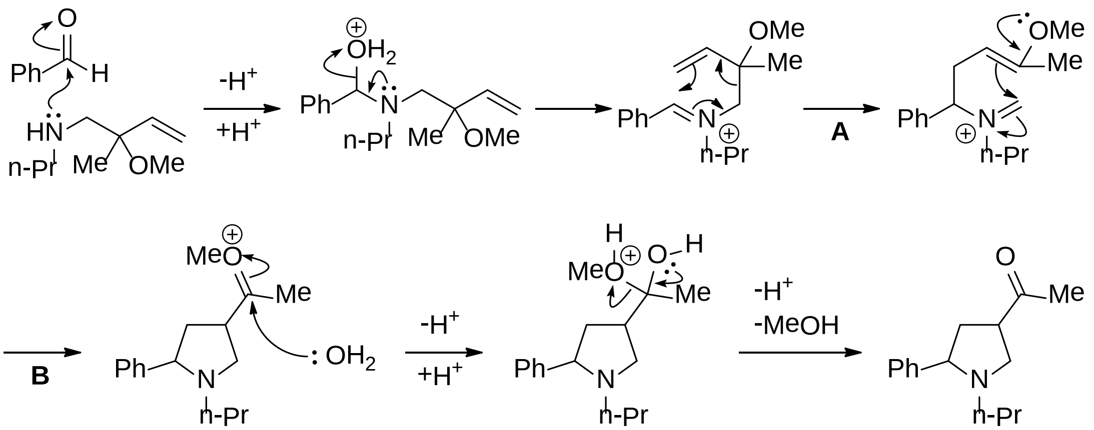
B091



Johnson, W. S.; Werthemann, L.; Bartlett, W. R.; Brocksom, T. J,; Li, T.-t.
J. Am. Chem. Soc. **1970**, 92, 741.

Claisen-Johnson rearrangement. **A**: Acid-catalyzed ether exchange of the orthoester. **B**: Formation of the mixed ketene acetal is effected by removal of ethanol from the reaction system by distillation. **C**: [3,3] Sigmatropic rearrangement via a chair-like transition state to form an (E)-olefin.

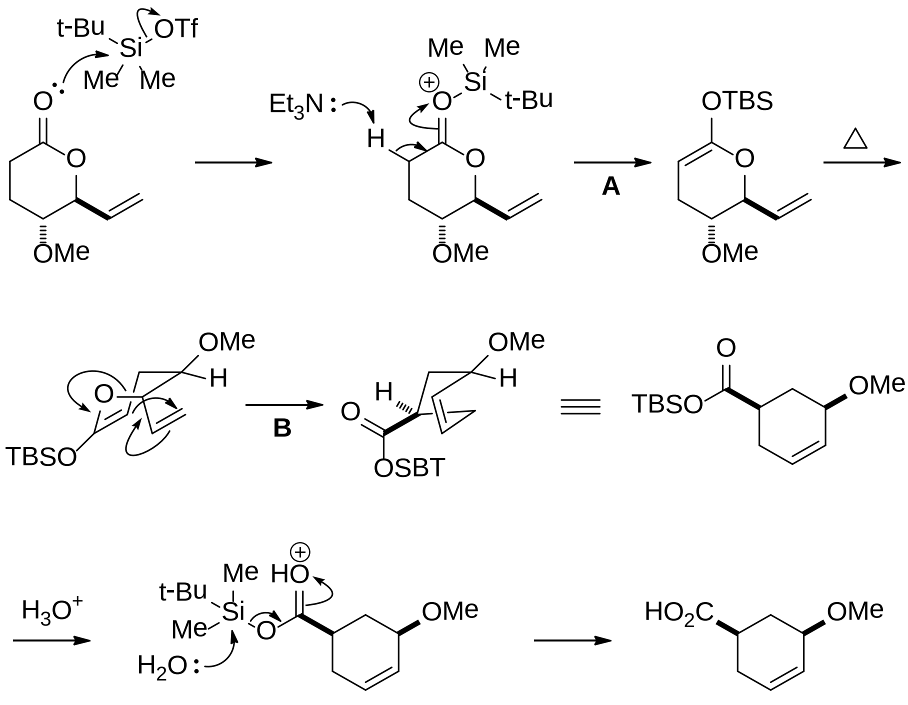
B092



Overman, L. E.; Kakimoto, M.; Okazaki, M. E.; Meier, G. P.
J. Am. Chem. Soc. **1983**, 105, 6622.

A: Aza-Cope rearrangement. **B**: Intramolecular Mannich reaction.

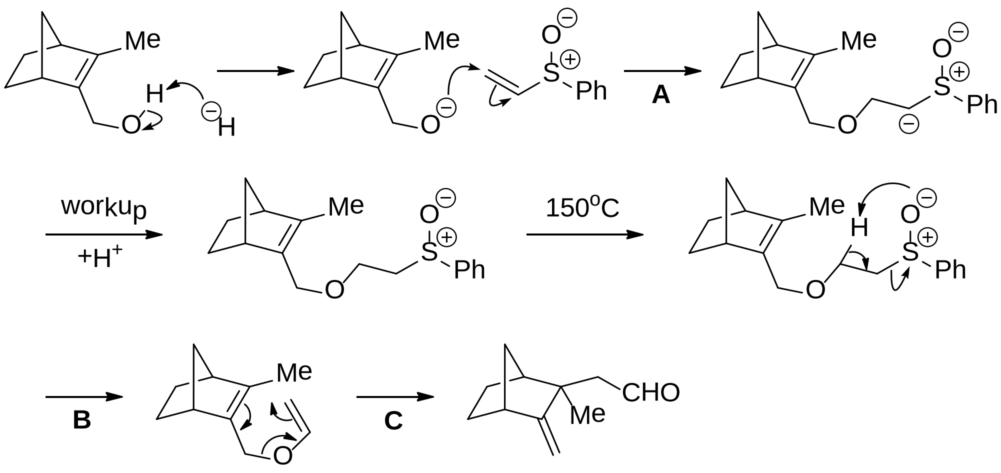
B093



Nakatsuka, M.; Ragan, J. A.; Sammakia, T.; Smith, D. B.; Uehling, D. E.; Schreiber, S. L. *J. Am. Chem. Soc.* **1990**, 112, 5583.

Claisen-Ireland rearrangement. **A**: Formation of a ketene silyl acetal. **B**: [3,3] Sigmatropic rearrangement via a boat-like transition state.

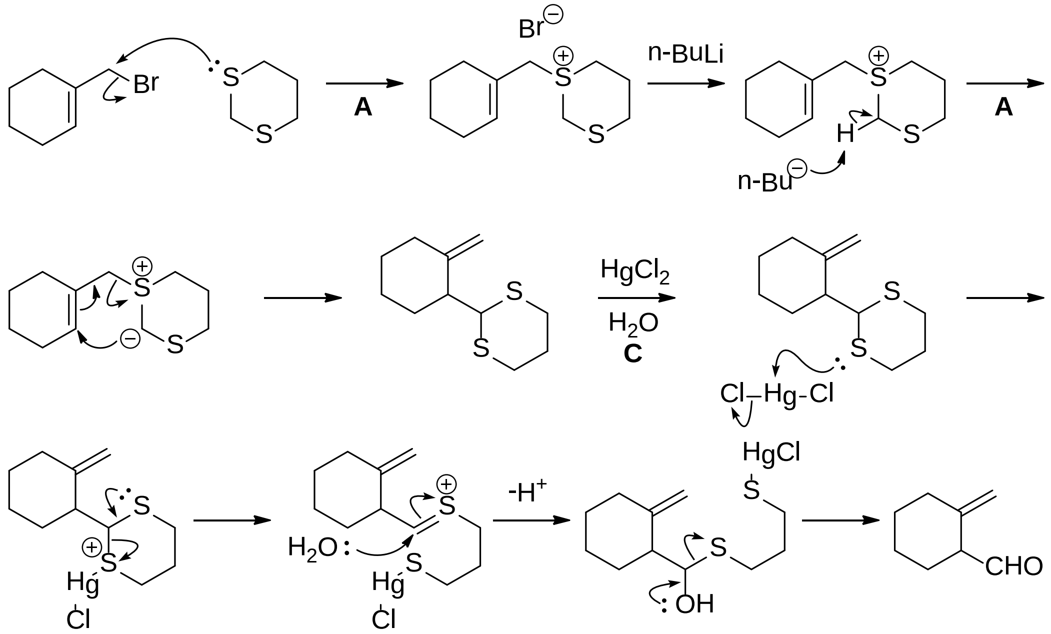
B094



Saito, M.; Kawamura, M.; Ogasawara, K. *Tetrahedron Lett.* **1995**, 36, 9003.

A: Conjugate addition to the vinyl sulfoxide. **B**: syn-Elimination. **C**: Claisen rearrangement.

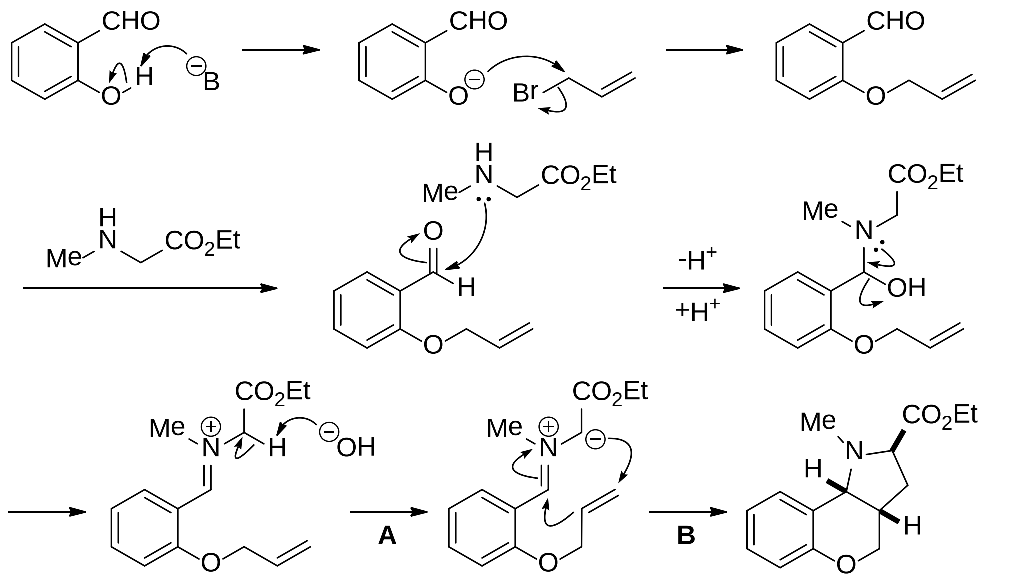
B095



Hunt, E.; Lythgoe, B. *J. Chem. Soc., Chem. Commun.* **1972**, 13, 757.

A: Formation of a sulfonium ion. **B**: Deprotonation to form a sulfur ylide, which undergoes [2,3] sigmatropic rearrangement. **C**: Hydrolysis of the thioacetal.

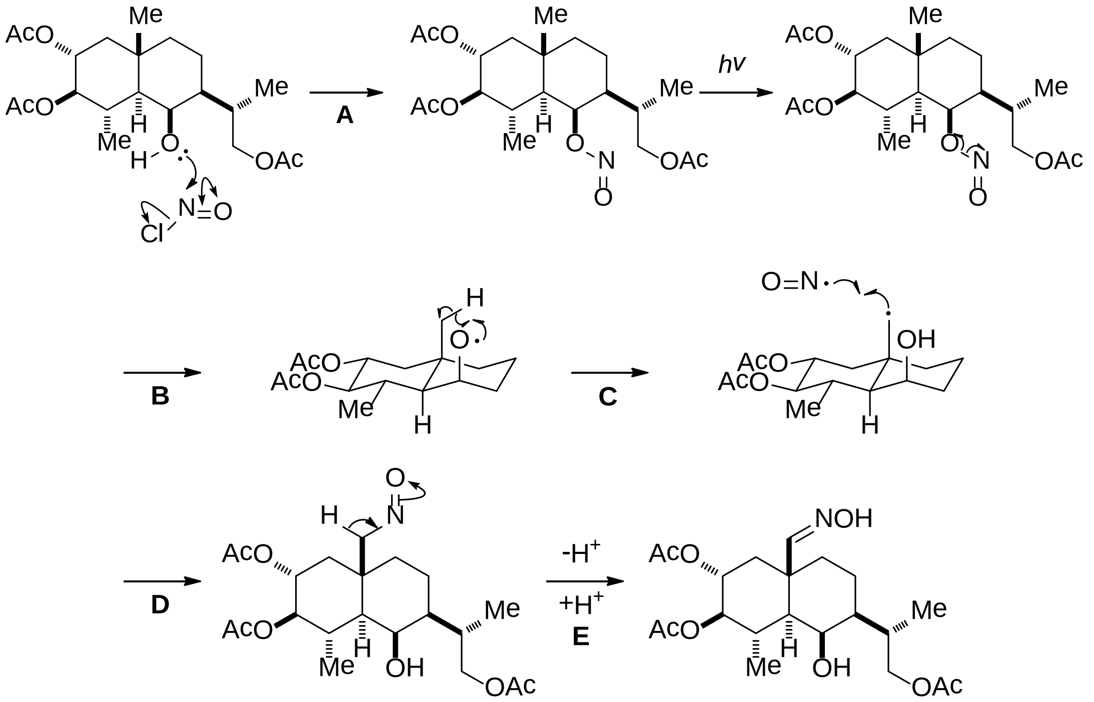
B096



Bashiardes, G.; Safir, I.; Mohamed, A. S.; Barbot, E; Laduranty, J. *Org. Lett.* **2003**, 5, 4915.

A: Formation of an azomethine ylide. **B**: Intramolecular 1,3-dipolar cycloaddition.

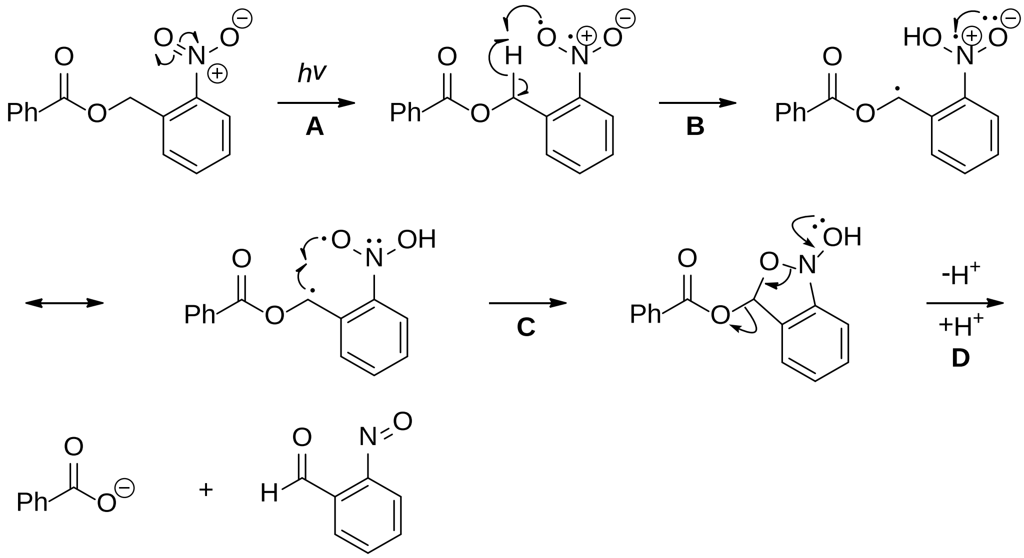
B097



Murai, A.; Nishizakura, K.; Katsui, N.; Masamune, T. *Tetrahedron Lett.* **1975**, 16, 4399.

Barton reaction. **A**: Formation of a nitrite. **B**: Homolytic cleavage. **C**: Abstraction of a hydrogen atom via a six-membered transition state. **D**: Recombination of ,NO with the resulting radical. **E**: Tautomerization.

B098

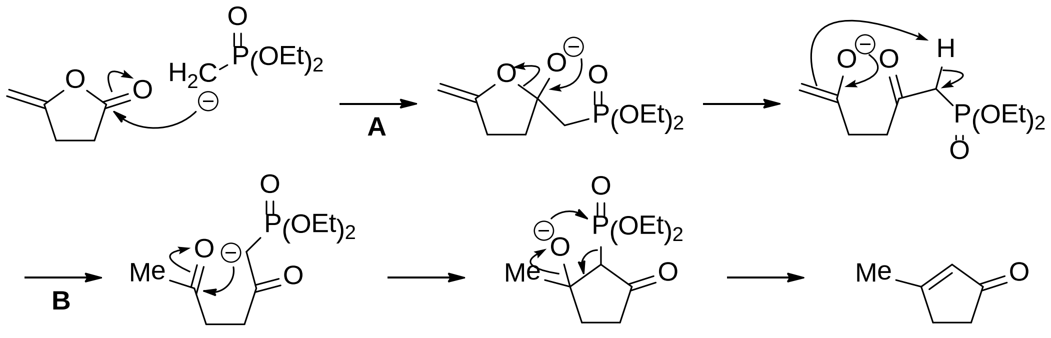


Barltrop, J. A.; Plant, P. J.; Schofield, P. *Chem. Commun.* **1996**, 822.

Photo-cleavable protecting group for acids. **A**: Photo-activated formation of a diradical. **B**:

Intramolecular abstraction of a hydrogen atom. **C**: Recombination of the diradical. **D**: Elimination of benzoic acid.

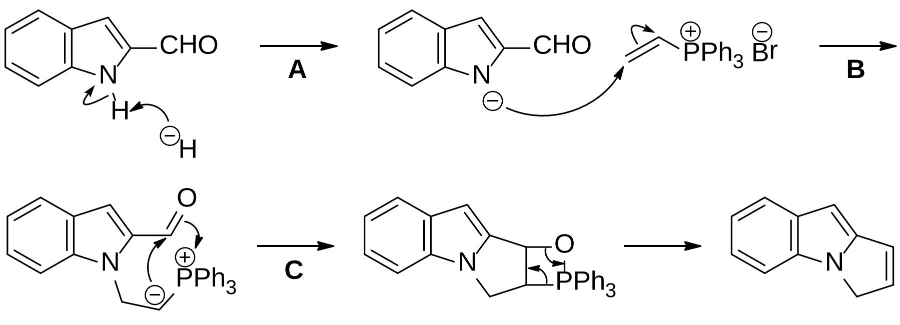
B099



Altenbach, H.-J.; Holzapfel, W.; Smerat, G.; Finkler, S. H. *Tetrahedron Lett.* **1985**, 26, 6329.

A: Addition to the reactive enol lactone. **B**: Intramolecular Horner-Wadsworth-Emmons reaction ref A071).

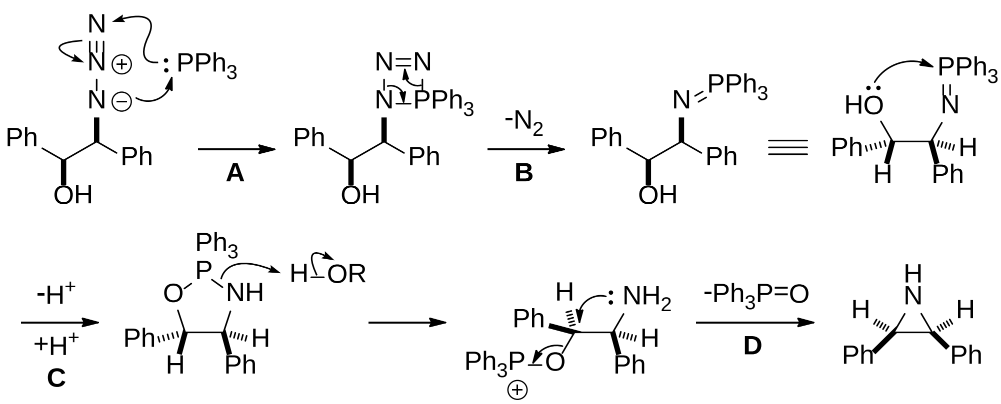
B100



Schweizer, E. E.; Light, K. K. *J. Org. Chem.* **1966**, 31, 870.

A: pKa of the parent indole NH = 17, H_2 = 35. **B**: Addition to the vinylphosphonium salt to form an ylide. **C**: Intramolecular Wittig reaction.

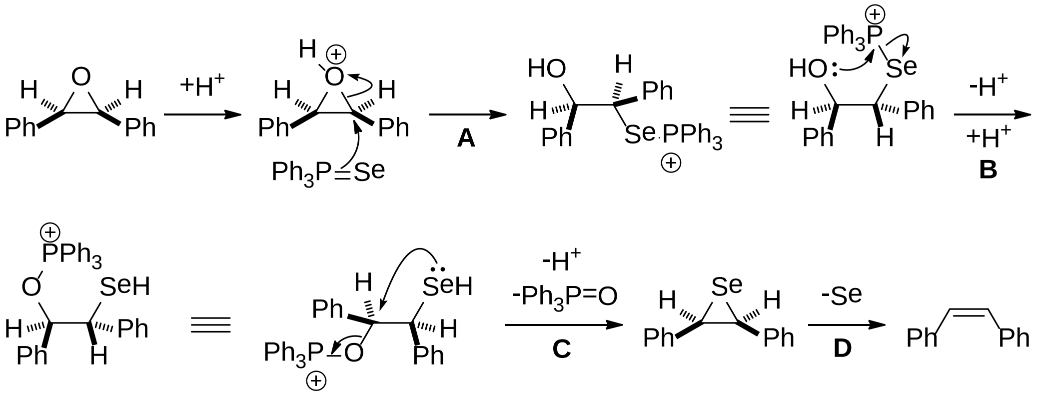
B101



Pöchlauer, P.; Müller, E. P.; Peringer, P. *Helv. Chim. Acta* **1984**, 67, 1238.

Staudinger reaction (A-B). **A**: Cheletropic reaction. **B**: Formation of an iminophosphorane. **C**: Migration of the phosphorus group. **D**: Intramolecular S_N2 reaction.

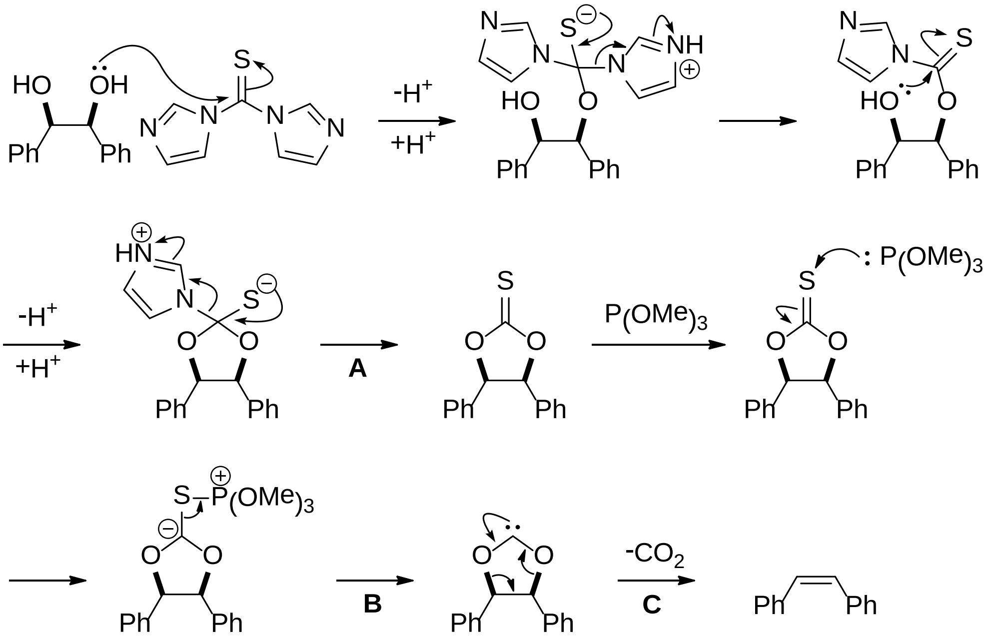
B102



Clive, D. L. J.; Denyer, C. V. *J. Chem. Soc., Chem. Commun.* **1973**, 253.

A: Acid-catalyzed cleavage of the epoxide with inversion of configuration. **B**: Migration of the phosphorus group. **C**: Intramotecular S_N2 reaction with inversion of configuration to form a cis-episelenide. **D**: Spontaneous extrusion of selenium.

B103



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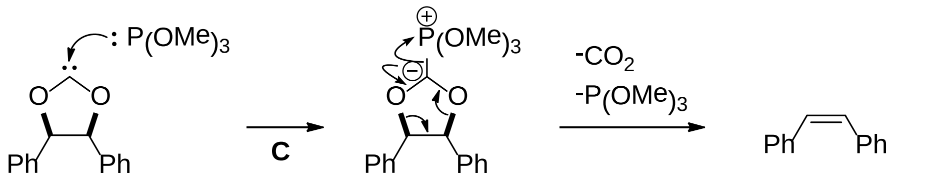
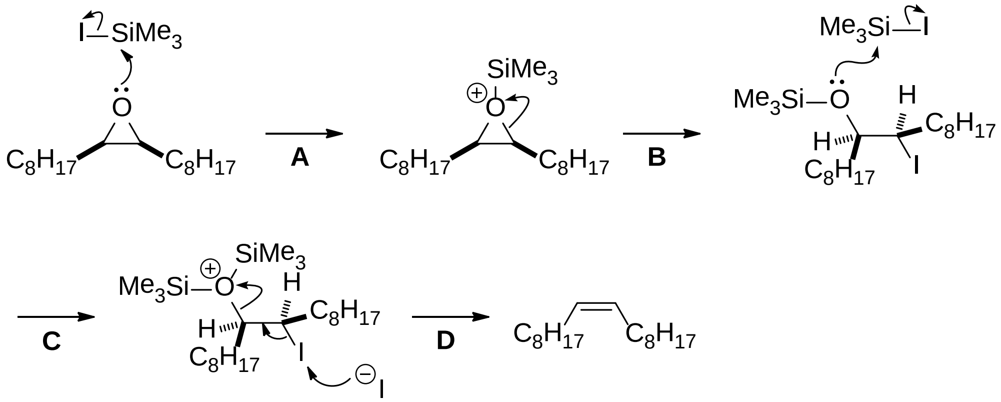
or



Corey, E. J.; Winter, R. A. E. *J. Am. Chem. Soc.* **1963**, 85, 2677.

Corey-Winter olefination. **A**: Formation of a thionocarbonate. **B**: Reductive desulfurization of the thionocarbonate to generate a carbene. **C**: The resulting carbene might undergo a direct fragmentation to form the cis-olefin. Alternatively, it would react with a phosphite to form an ylide, which then collapses to give the product.

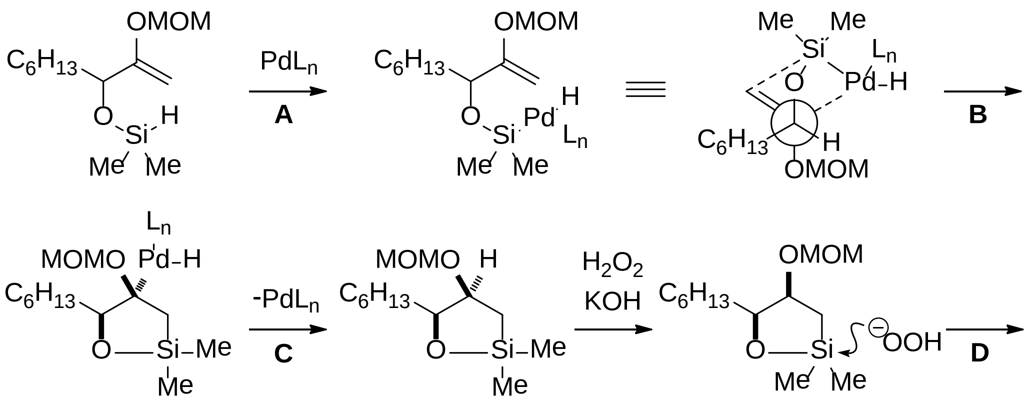
B104

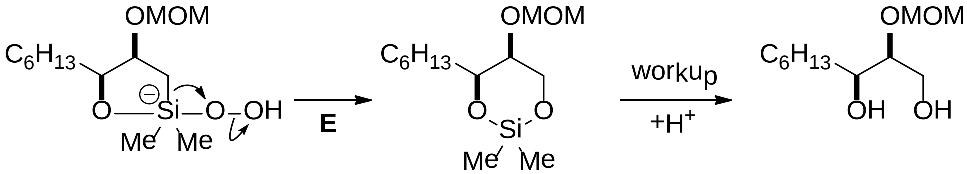


Denis, J. N.; Magnane, R.; Eenoo, M. V.; Krief, A. *Nouv. J. Chim.* **1979**, 3, 705.

A: Silylation of the epoxide. **B**: S_N2 reaction with inversion of configuration. **C**: Silylation of the silyl ether. **D**: E2 elimination.

B105

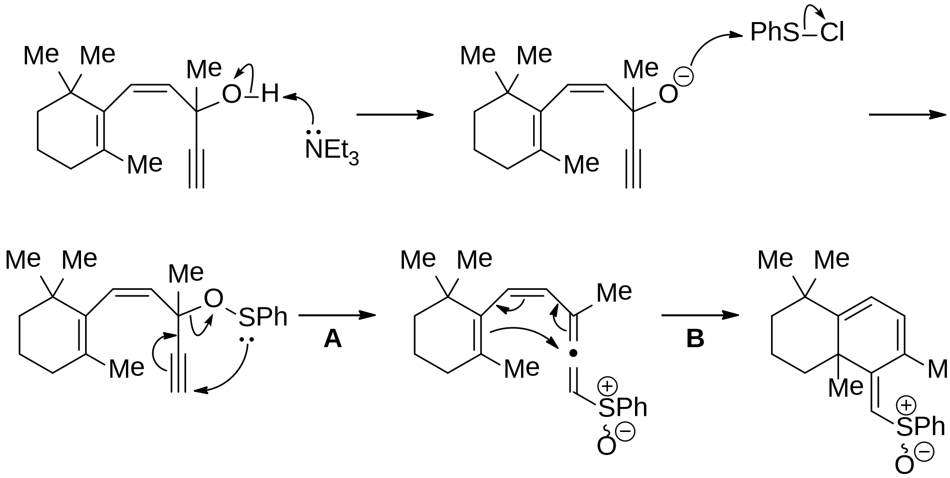




Tamao, K.; Nakagawa, Y.; Arai, H.; Higuchi, N.; Ito, Y. *J. Am. Chem. Soc.* **1988**, 110, 3712.

Tamao oxidation (D-E). **A**: Oxidative addition to the Si-H bond. **B**: Intramolecular diastereoselective silametallation to the olefin. **C**: Reductive elimination. **D**: Formation of a silicate ion. **E**: Migration of the Si-C bond.

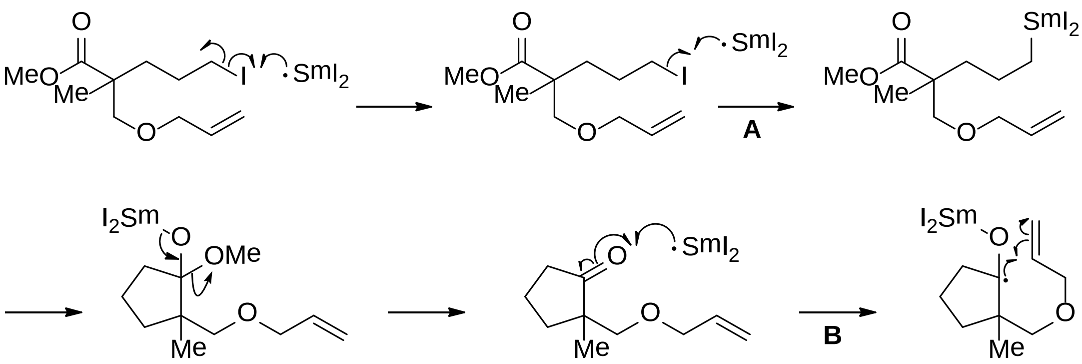
B106

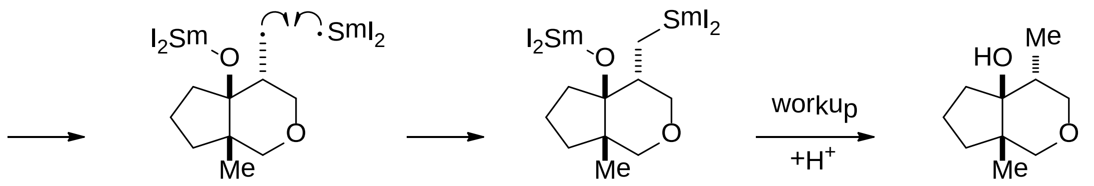


Okamura, W. H.; Peter, R.; Reischl, W. *J. Am. Chem. Soc.* **1985**, 107, 1034.

A: [2,3] Sigmatropic rearrangement of the propargyl sulfenate. **B**: 6e Disrotatory electrocyclic reaction.

B107

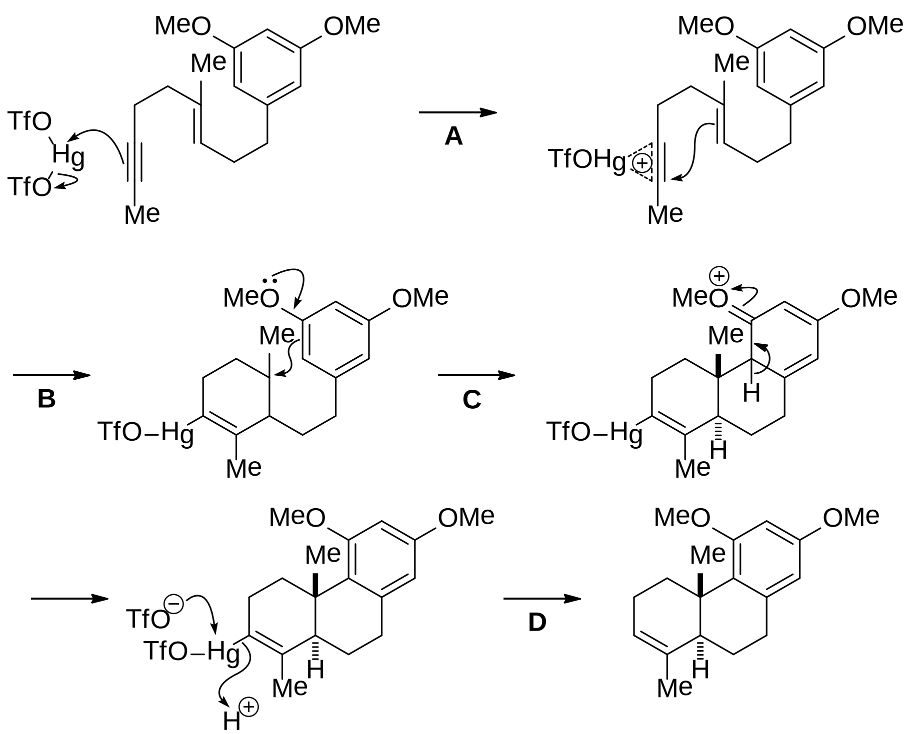




Molander, G. A.; Harris, C. R. *J. Org. Chem*. **1997**, 62, 2944

A: Since SmI_2 is a single electron reductant, two molecules of SmI_2 are needed to convert an alkyl iodide to the corresponding organosamarium species. **B**: SET to the ketone followed by radical cyclization.

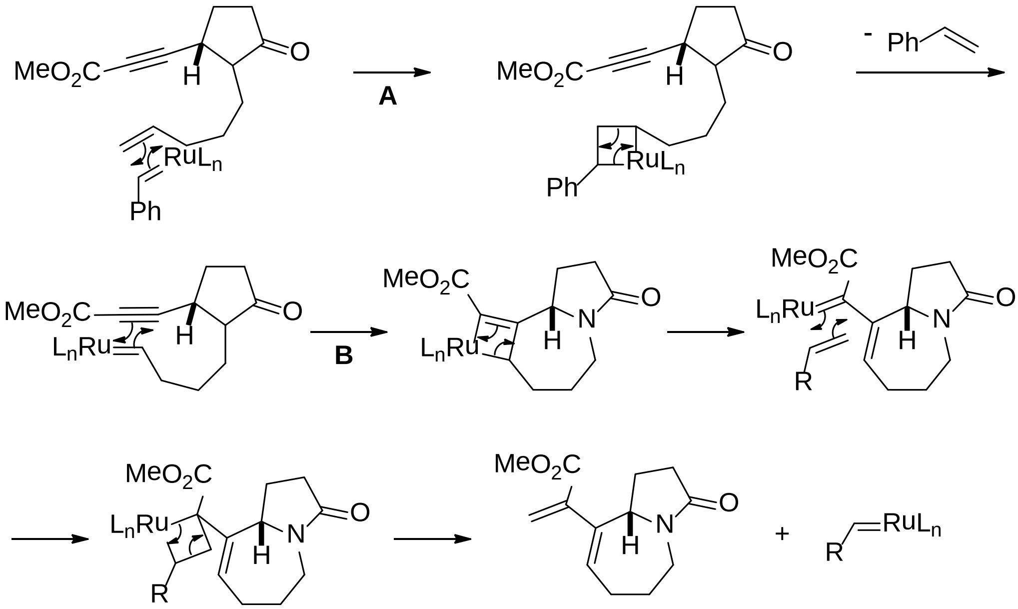
B108



Imagawa, H.; Iyenaga, T.; Nishizawa, M. *Org. Lett*. **2005**, 7, 451.

A: Coordination of $Hg(OTf)_2$ to the alkyne. **B**: 6-endo-dig cation cyclization to form a stable tertiarycarbocation. **C**: Attack of the electron-rich aromatic ring to the carbocation. **D**: Protonolysis of the C-Hg bond to regenerate the catalyst.

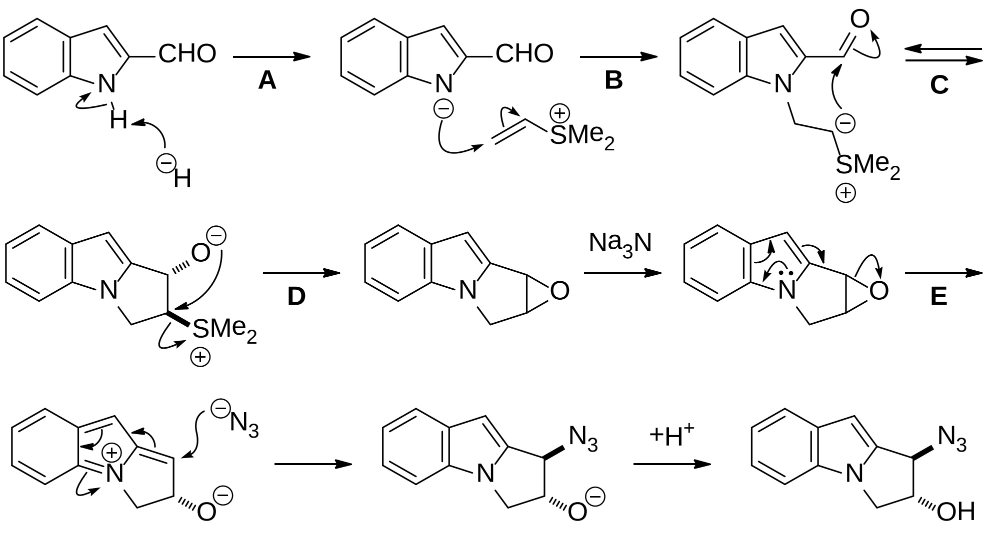
B109



Kinoshita, A.; Mori, M. *J. Org. Chem*. **1996**, 61, 8356.

Intramolecular enyne metathesis (ref A078). **A**: Intermolecular alkene metathesis. **B**: Intramolecular alkyne metathesis.

B110

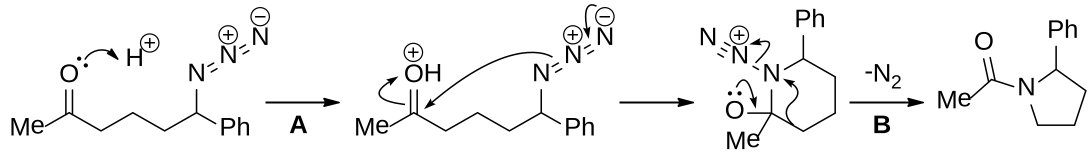


Wang, Y.; Zhang, W.; Colandrea, V. J.; Jimenez, L. S. *Tetrahedron* **1999**, 55, 10659.

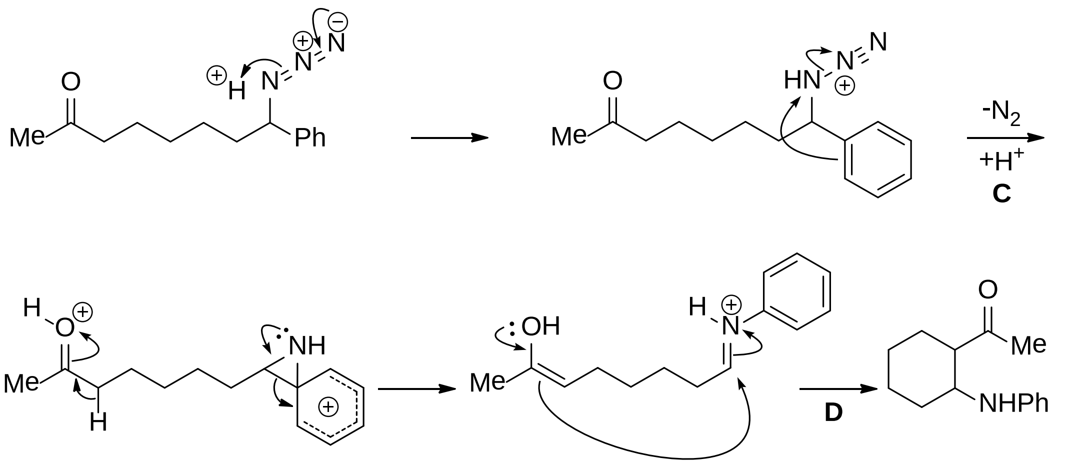
A: pKa indole NH = 17, H_2 = 35. **B**: Addition of the vinylsulfonium salt to form an ylide. **C**: Intramolecular addition to the aldehyde (reversible). **D**: Intramolecular S_N2 reaction to form an epoxide. **E**: Cleavage of the epoxide helped by the indole nitrogen lone pair.

B111

n=1



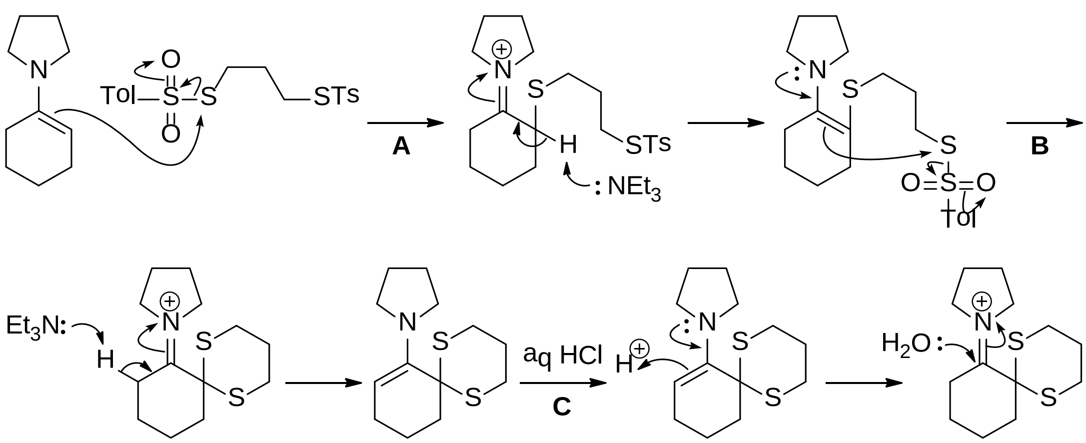
n=3

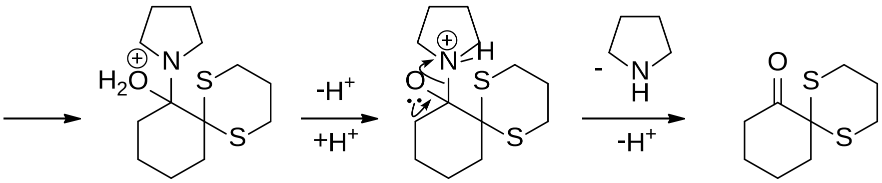


Wrobleski, A.; Aube, J. *J. Org. Chem*. **2001**, 66, 886.

Intramolecular Schmidt reaction. **A**: Activation of the carbonyt group by protonation followed by intramolecular addition of the azide (six-membered ring is easy to form). **B**: Ring contraction. **C**: The formation of a phenonium ion is preferred over the formation of the eight-membered ring. **D**: Intramolecular Mannich reaction.

B112

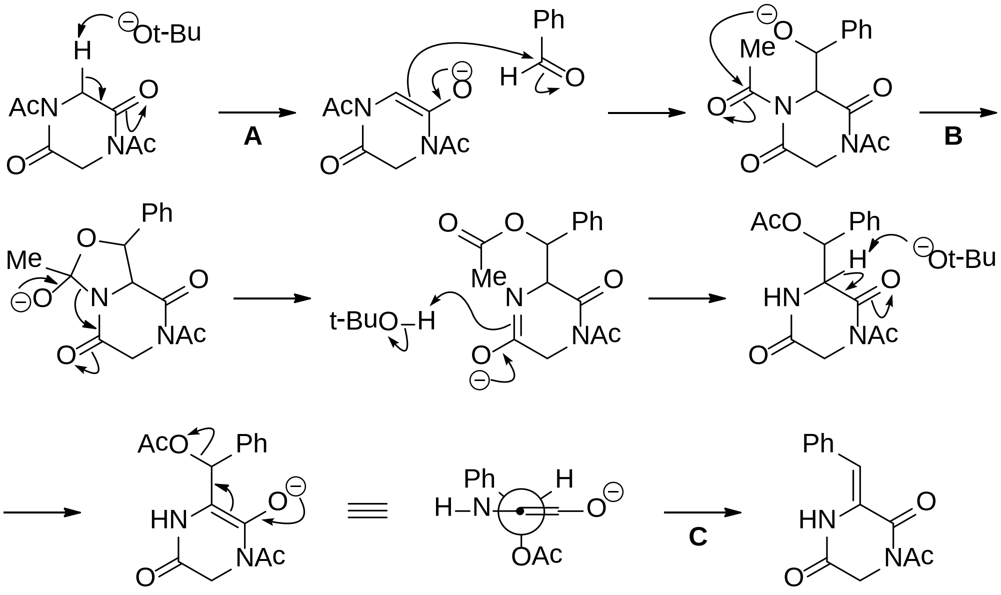




Woodward, R. B.; Pachter, I. J.; Scheinbaum, M. L. *Org. Synth., Coll*. Vol. Ⅵ **1988**, 1014.

A: pKa $PhSO_2H$ = 1.5. **B**: Formation of an easy to form six-membered ring. **C**: Hydrolysis of the enamine.

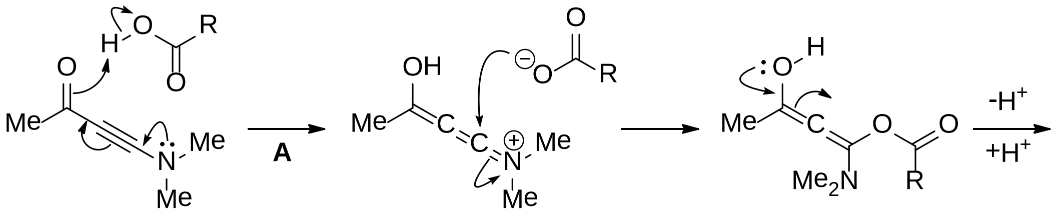
B113

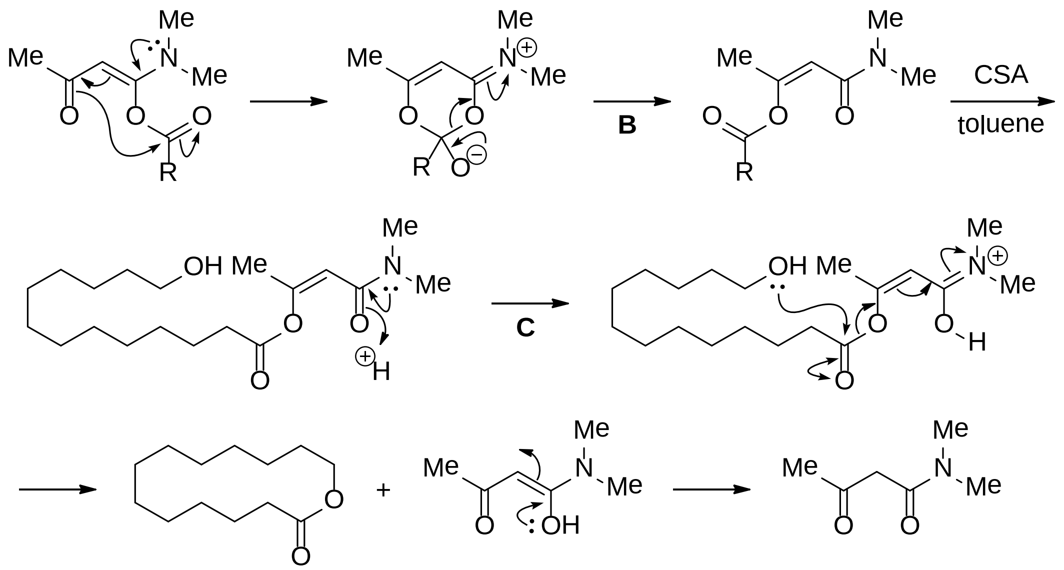


Gallina, C.; Liberatori, A. *Tetrahedron Lett*. **1973**, 1135.

A: Deprotonation of the α-position of an imide (more acidic than amides). **B**: Aldol reaction followed by an intramolecular acyl transfer via a five-membered ring transition state. **C**: Elimination of the acetoxy group.

B114

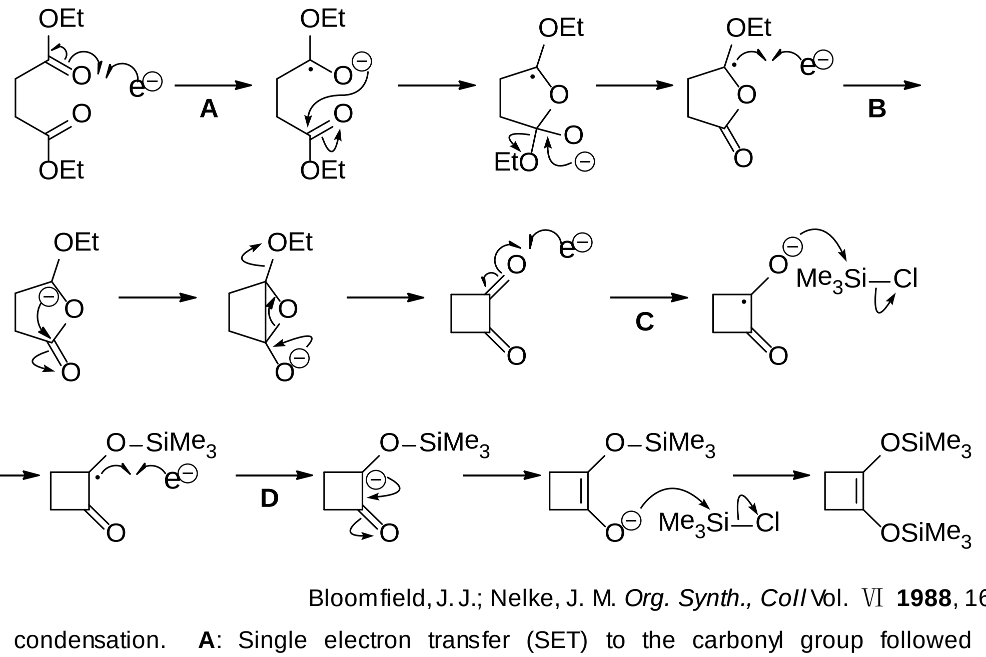




Gais, H. J. *Tetrahedron Lett*. **1984**, 25, 273.

A: Protonation of the carbonyl group followed by addition of the carboxylate to the iminium ion. **B**: Intramolecular acyl transfer to form a vinylogous anhydride. **C**: Activation of the vinylogous anhydride by protonation resulted in the formation of the macrocyclic lactone.

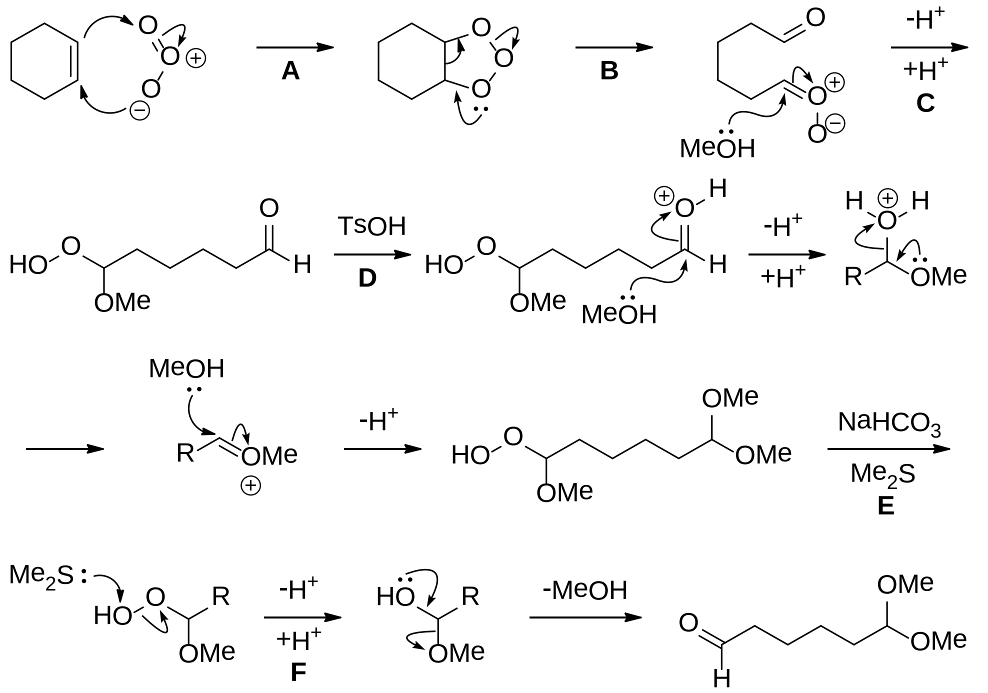
B115



Bloomfield, J. J.; Nelke, J. M. *Org. Synth., Coll* Vol. Ⅵ **1988**, 167.

Acyloin condensation. **A**: Single electron transfer (SET) to the carbonyl group followed by lactonization. **B**: SET followed by a ring contraction. **C**: SET followed by silylation. **D**: SET to form an enolate followed by silylation.

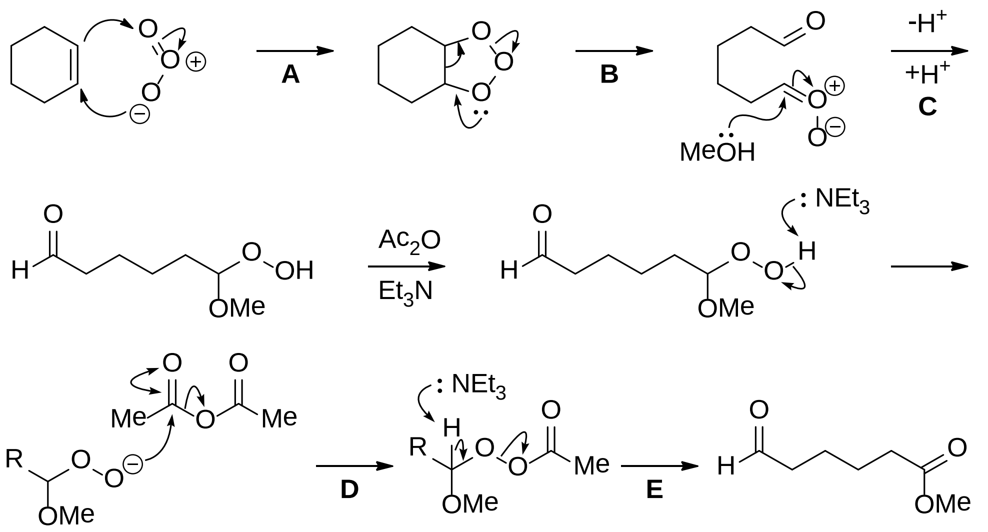
B116



Claus, R. E.; Schreiber, S. L. *Org. Synth., Coll* Vol. Ⅶ **1990**, 168.

A: 1,3-Dipolar cycloaddition of ozone to the olefin. **B**: Heterolytic cleavage of the initial ozonide. **C**: Trapping the dipole with methanol. **D**: Formation of a dimethyl acetal from the aldehyde (protonation of the less electron-dense hydroperoxy group is more difficult). **E**: Neutralization to kill TsOH. **F**: Reduction of the hydroperoxide with dimethyt sulfide.

B117



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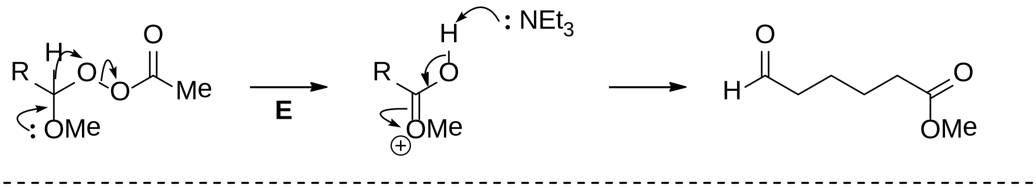
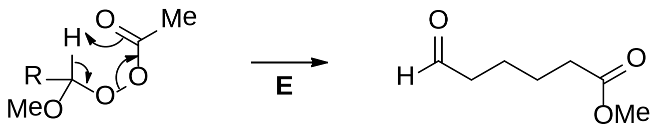


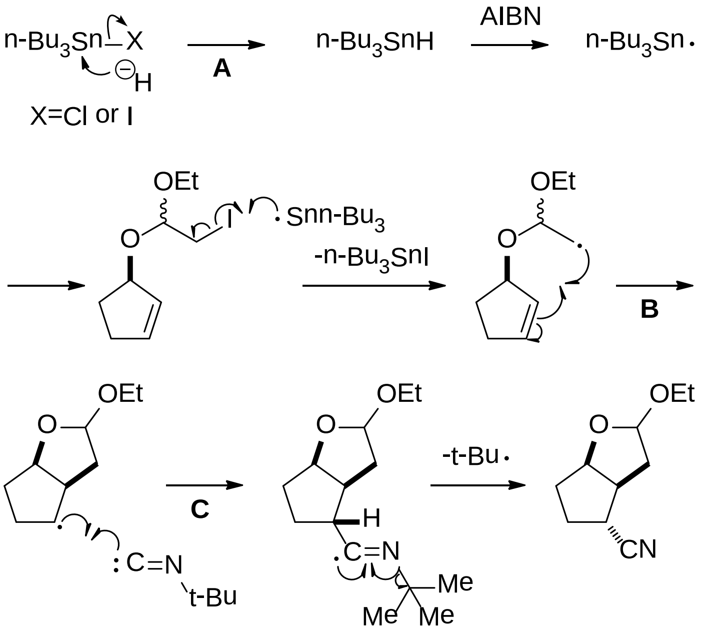
or



Claus, R. E.; Schreiber, S. L. *Org. Synth., Coll* VoL Ⅶ **1990**, 168

A: 1,3-Dipolar cycloaddition of ozone to the olefin. **B**: Heterolytic cleavage of the initial ozonide. **C**: Trapping the dipole with methanol. **D**: Acetylation. **E**: Elimination of acetic acid might proceed either by 1) deprotonation with triethylamine, 2) Baeyer-Villiger-type 1,2-hydride shift, or 3) thermal eliminatior via a six-membered transition state.

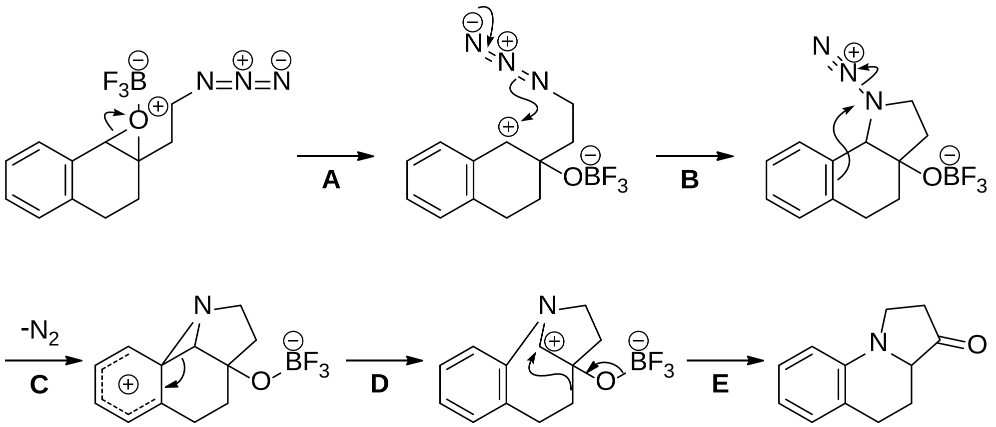
B118



Stork, G.; Sher, P. M. *J. Am. Chem. Soc.* **1986**, 108, 303.

A: Reduction of Bu_3SnX with $NaBH_3CN$ to form a low concentration of Bu_3SnH to avoid the premature reduction of the radical intermediates. **B**: 5-exo-trig Radical cyclization. **C**: Addition to the isocyanide followed by elimination of a stable t-butyl radical.

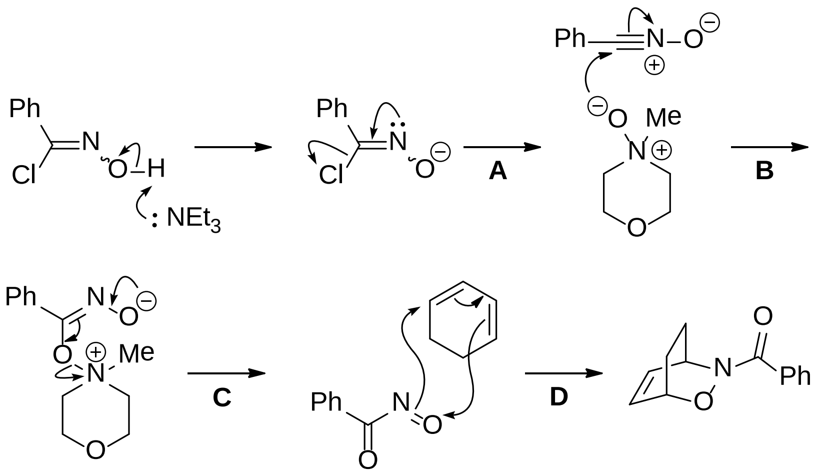
B119



Lang, S.; Kennedy, A. R.; Murphy, J. A.; Payne, A. H. *Org. Lett.* **2003**, 5, 3655.

A: Generation of a stable benzylic carbocation. **B**: Intramolecular attack of the azide. **C**: formation ofan aziridine. **D**: Restoration of the aromaticity. **E**: 1,2-Alkyl shift.

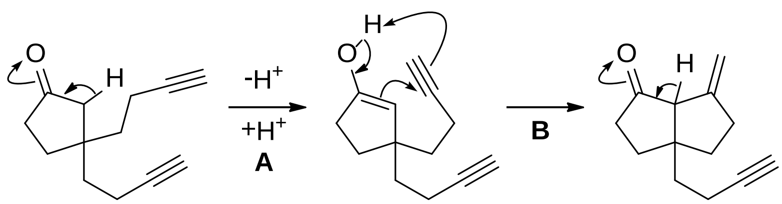
B120

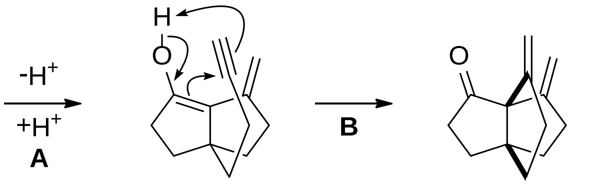


Quadrelli, P., Mella, M.; Invernizzi, A. G.; Caramella, P. *Tetrahedron* **1999**, 55, 10497.

A: Elimination of chloride ion is facilitated by the formation of an oxime anion. **B**: Addition of NMO to the nitrile oxide. **C**: Generation of an acylnitroso compound. **D**: Hetero-Diels-Alder reaction.

B121

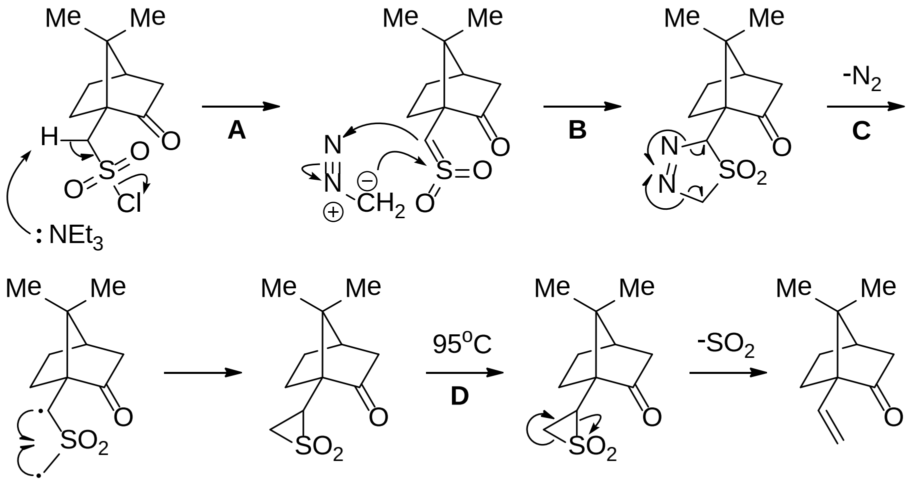




Drouin, J.; Leyendecker, F.; Conia, J., M. *Tetrahedron*. **1980**, 36, 1203.

A: Tautomerization. **B**: Oxy-ene reaction.

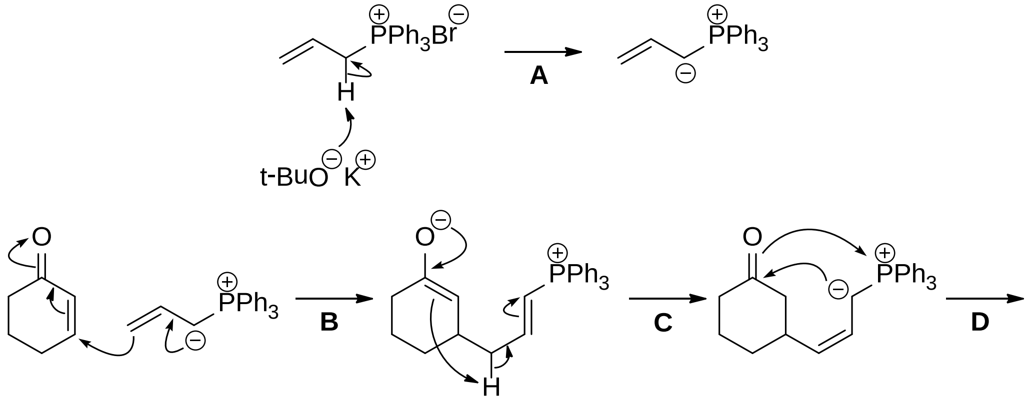
B122

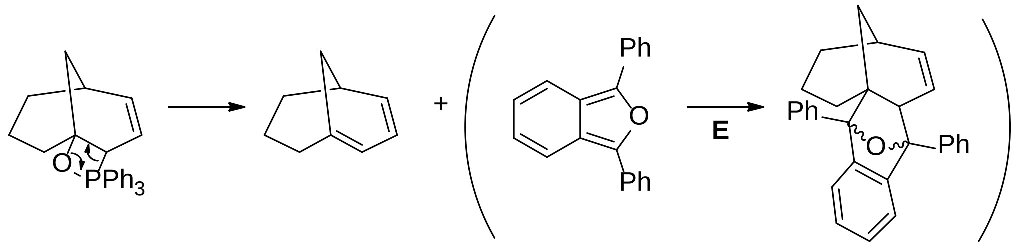


Fischer, N.; Opitz, G. *Org. Synth., Coll*. Vol. Ⅴ **1973**, 877.

A: Generation of a sulfene. **B**: 1,3-Dipolar cycloaddition of diazomethane to the sulfene. **C**: Extrusion of N_2 to form an episulfone. **D**: Ramberg-Bäcklund reaction.

B123

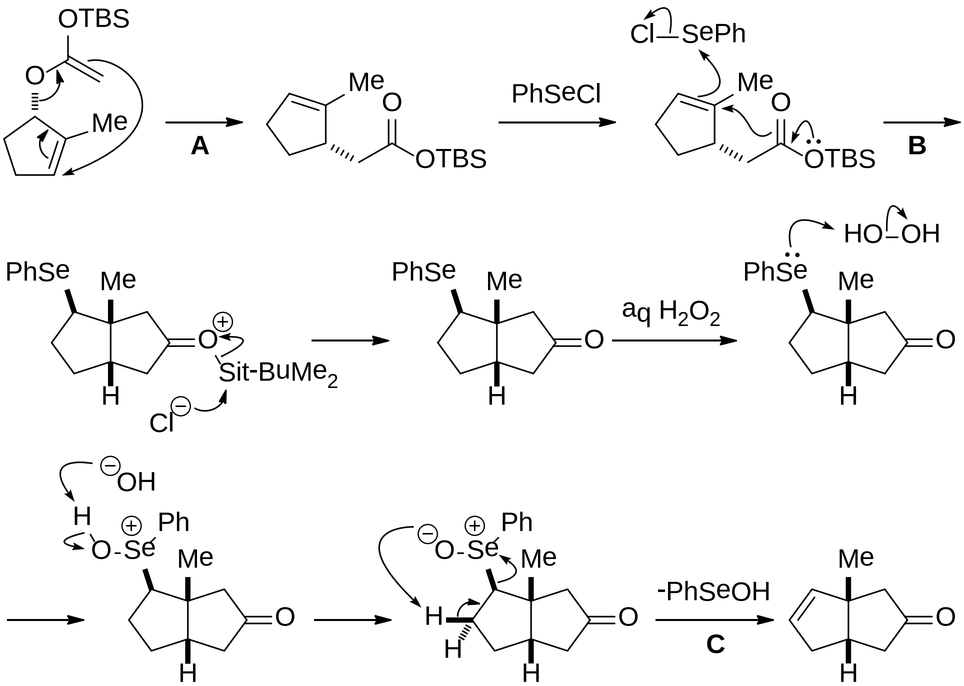




Dauben, W. G.; Ipaktschi, J. *J. Am. Chem. Soc.* **1973**, 95, 5088.

A: Generation of an ylide. **B**: Michael addition. **C**: Regeneration of a phosphorus ylide. **D**: Intramolecular Wittig reaction (irreversible). **E**: The unstable diene was trapped as the Diels-Alder product.

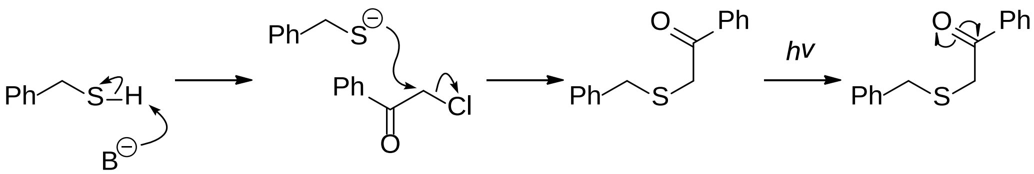
B124

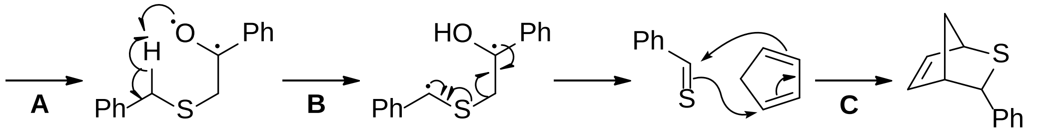


Curran, D. P.; Rakiewicz, D. M. *Tetrahedron* **1985**, 41, 3943,

A: Claisen-Ireland rearrangement. **B**: Selenolactonization. **C**: syn-Elimination of the selenoxide.

B125

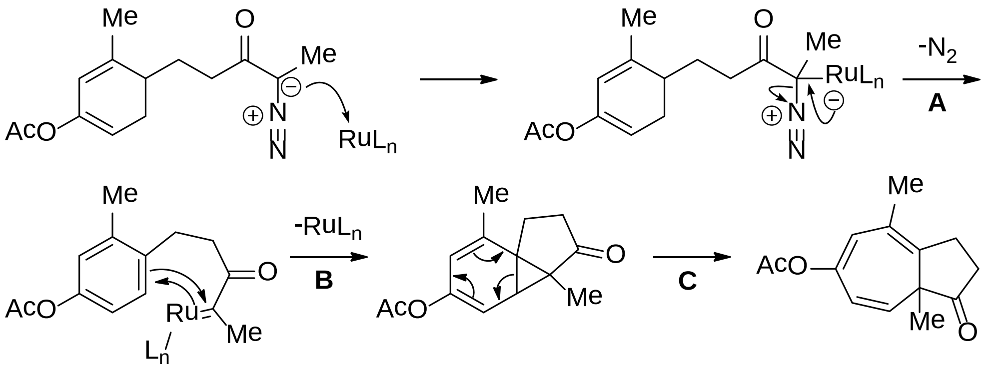




Vedejs, E.; Eberlein, T. H.; Mazur, D. J.; McClure, C. K.; Perry, D. A.; Ruggeri, R.; Schwartz, E.; Stults, J. S.; Varie, D. L.; Wilde, R. G.; Wittenberger, S. *J. Org. Chem*. **1986**, 51, 1556.

Norrish type II reaction. **A**: n-π* Transition. **B**: Intramolecular abstraction of a hydrogen atom followed by fragmentation to form a highly reactive thioaldehyde. **C**: Hetero-Diels-Alder reaction.

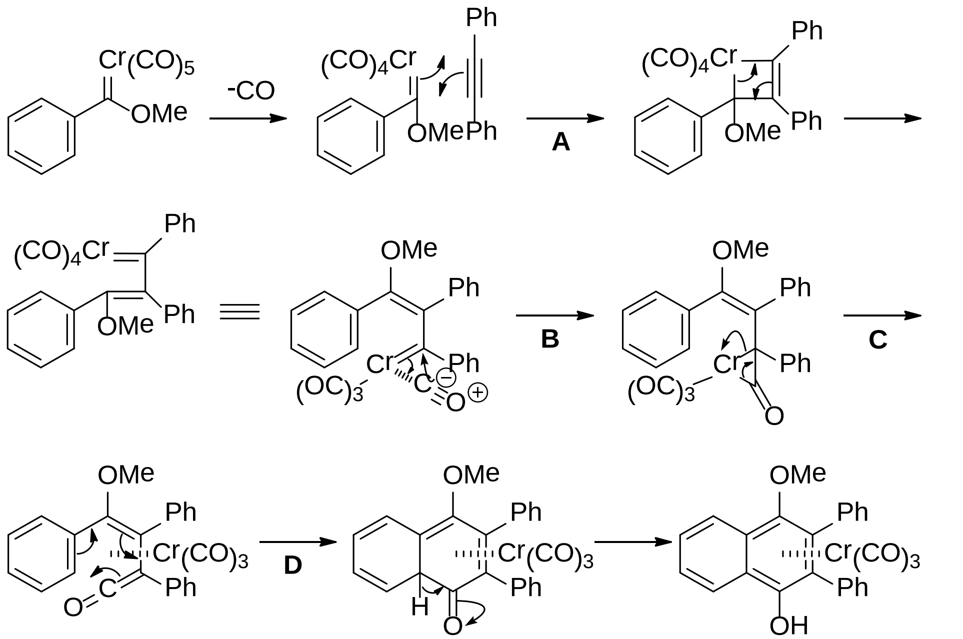
B126



Kennedy, M.; McKervey, M. A. *J. Chem. Soc., Perkin Trans*. I **1991**, 2565.

A: Formation of a rhodium carbene complex. **B**: Cyclopropanation of the aromatic ring. **C**: 6e Disrotatory electrocyclic reaction.

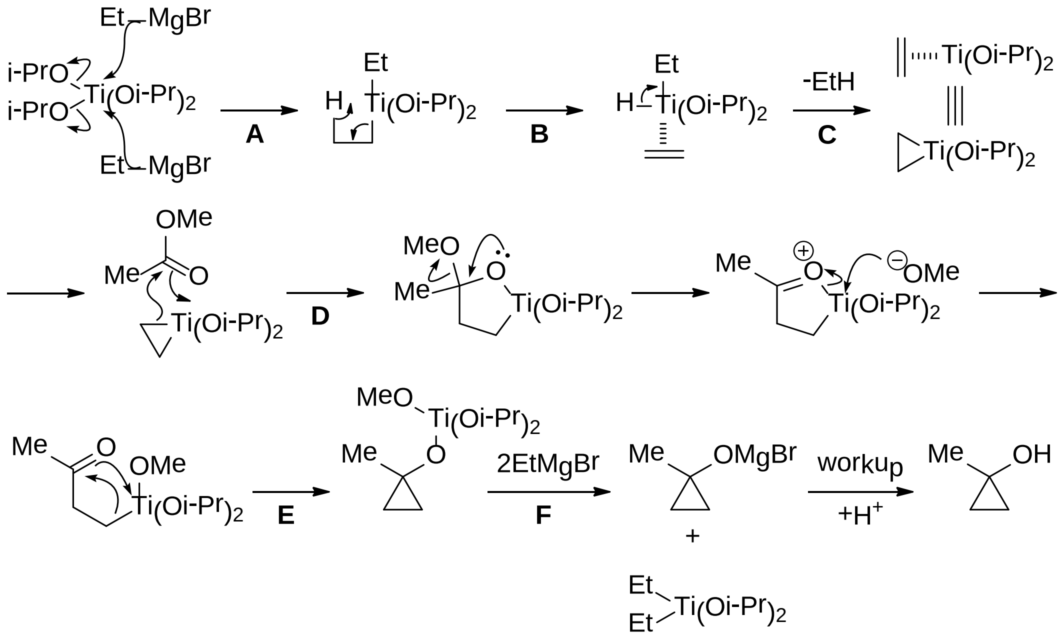
B127



Dötz, K. H. *Angew. Chem. Int. Ed. Engl.* **1975**, 14, 644.

Dötz reaction. **A**: Alkyne metathesis of Fischer carbene complex. **B**: Insertion of CO. **C**: Reductive elimination to form a ketene. **D**: 6e Electrocyclic reaction.

B128

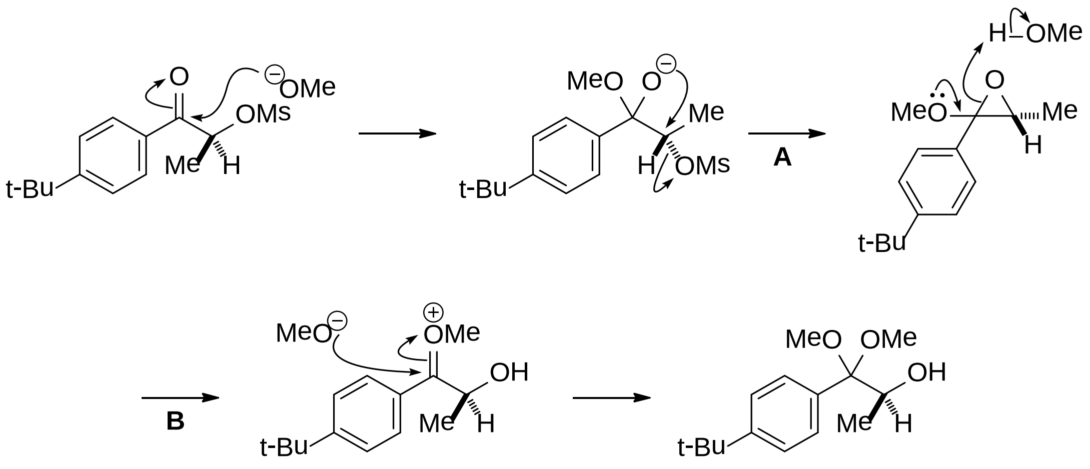


Kulinkovich, O. G.; Sviridov, S. V.; Vasilevski, D. A. *Synthesis* **1991**, 234.

Kulinkovich reaction. **A**: Substitution of the isopropoxide with EtMgBr. **B**: β-Elimination. **C**: Reductive elimination to form a titanium ethylene complex (or a titanocyclopropane). **D**: Carbotitanation. **E**.: Formation of a cyclopropane. **F**: Regeneration of the active reagent.

解答 上级编

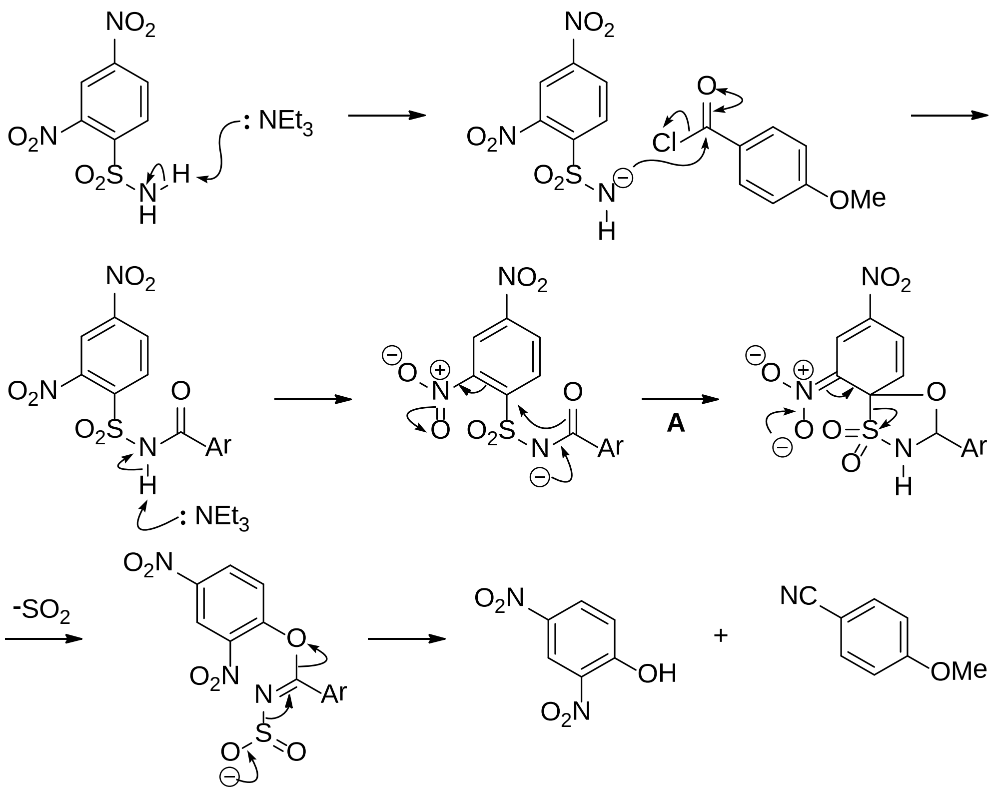
C001



Yamauchi, T.; Hattori, K.; Nakao, K.; Tamaki, K. *Bull. Chem. Soc. Jpn*. **1987**, 60, 4015.

A: Formation of an epoxide by intramolecular S_N2 reaction of a hemiacetal. **B**: E1-like cleavage of the reactive epoxide.

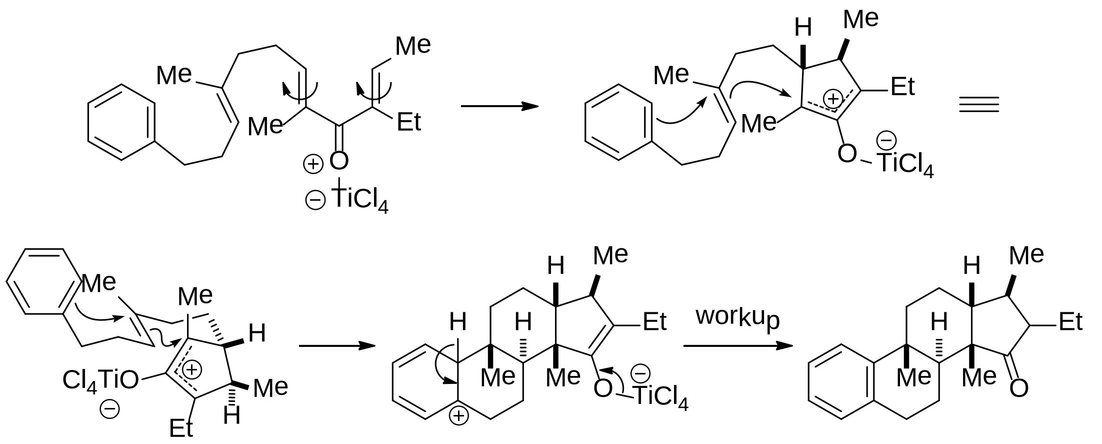
C002



Huber, V. J.; Bartsch, R. A. *Tetrahedron* **1998**, 54, 9281.

Smiles rearrangement. **A**: Addition-elimination process via a Meisenheimer complex.

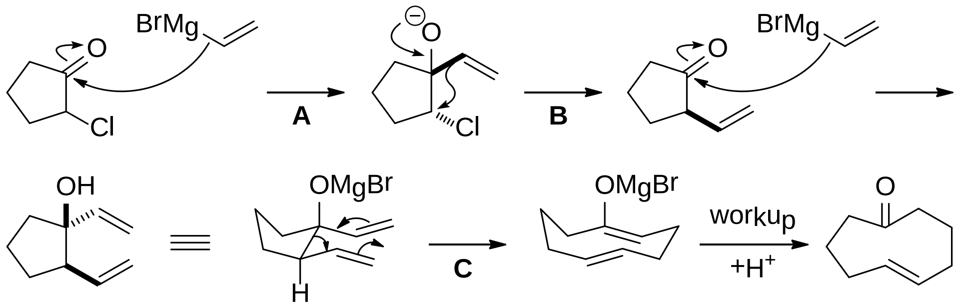
C003



Bender, J. A.; Arif, A. M.; West, E G. *J. Am. Chem. Soc.* **1999**, 121, 7443.

Cation-olefin cyclization initiated by Nazarov reaction (ref B026).

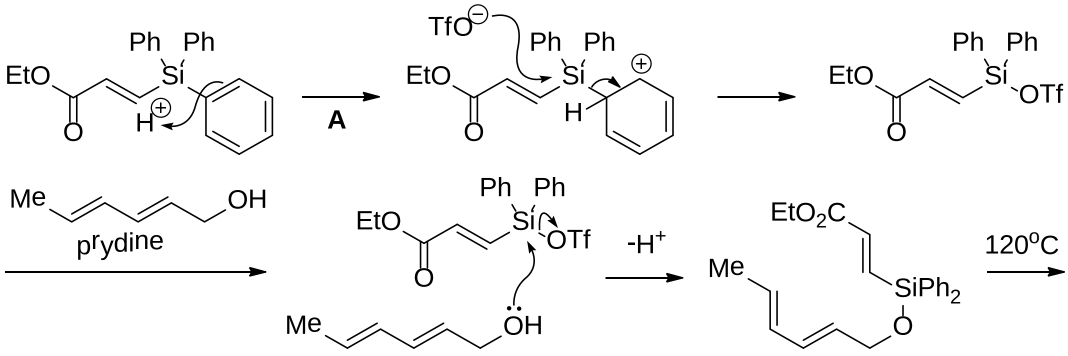
C004

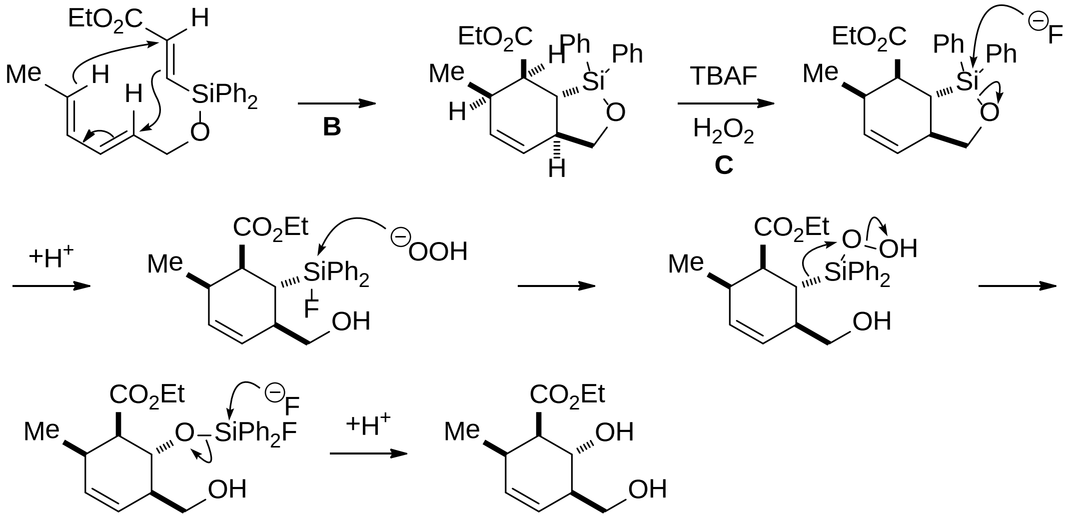


Kato, T.; Kondo, H. ; Nishino, M.; Tanaka, M.; Hata, G.; Miyake, A. *Bull. Chem. Soc. Jpn.* **1980**, 53, 2958.

A: Addition of CH2=CHMgBr to the ketone from the opposite side of the α-substituent. **B**: 1,2-Alkenyl shift. **C**: Anion-accelerated oxy-Cope rearrangement via a chair-like transition state.

C005

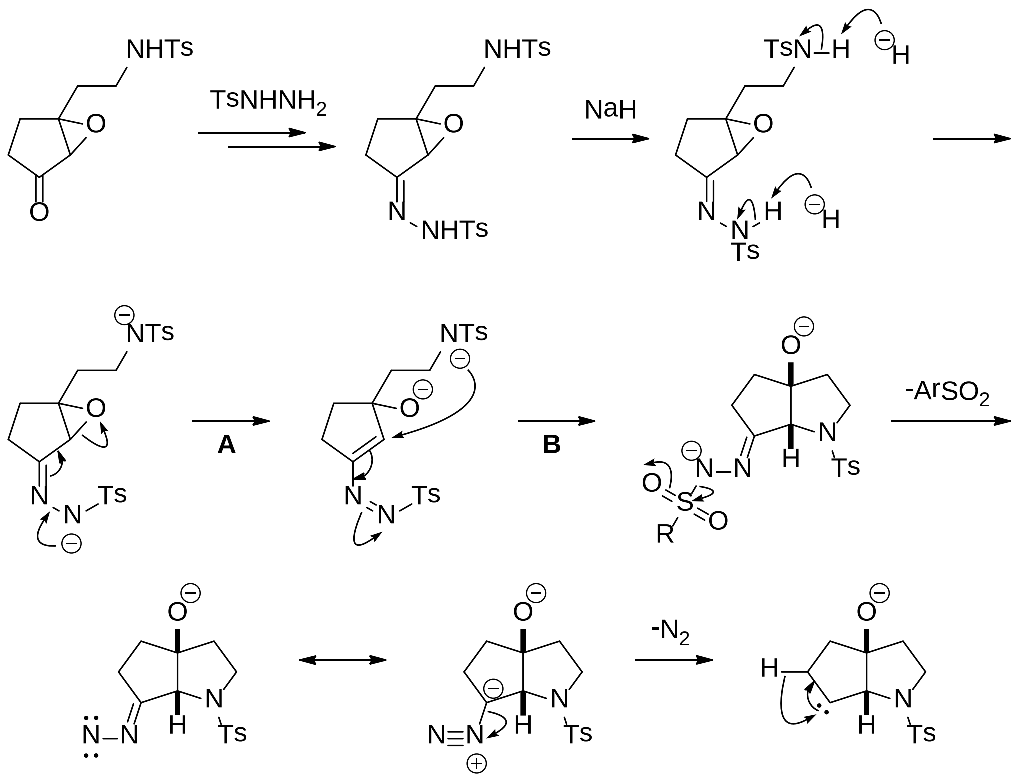


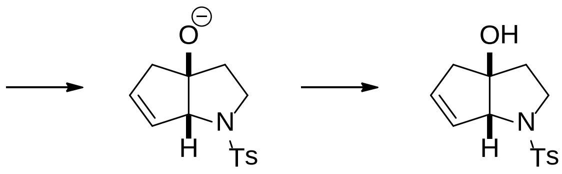


Sieburth, S. M.; Lang, J. *J. Org. Chem.* **1999**, 64, 1780.

A: Protodesilylation to form a silyl triflate. **B**: Intramolecular Diels-Alder reaction. **C**: Tamao-Fleming oxidation.

C006

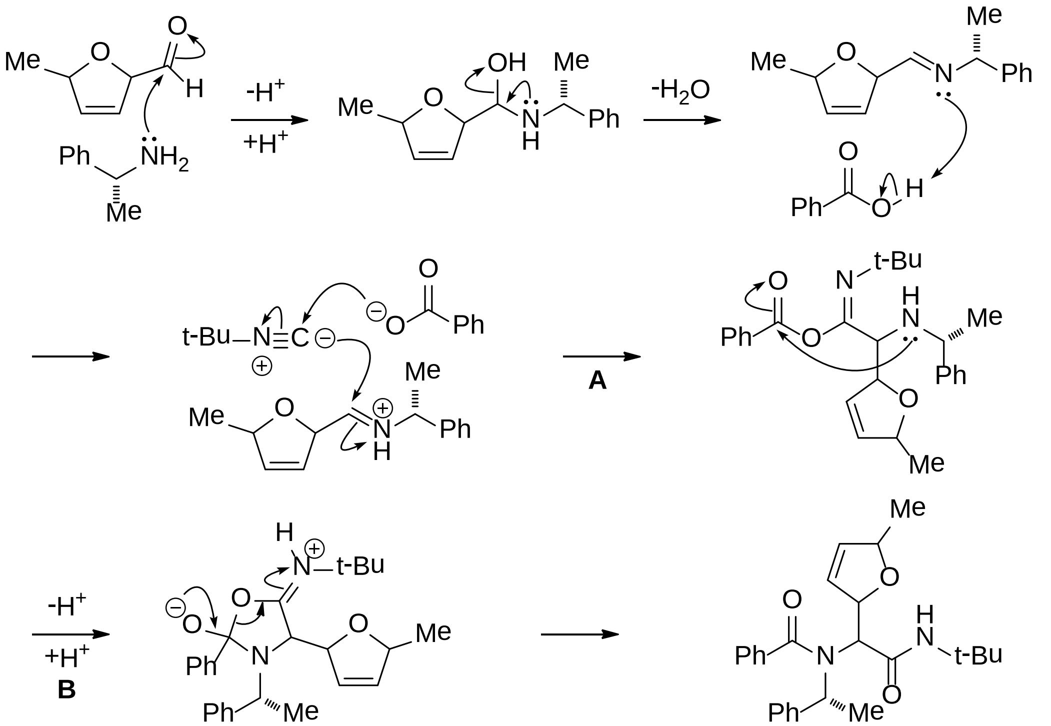




Kim, S. H.; Fuchs, P. L. *Tetrahedron Lett.* **1996**, 37, 2545.

A: Cleavage of the epoxide helped by the hydrazone anion. **B**: Conjugate addition of the sulfonamide anion.

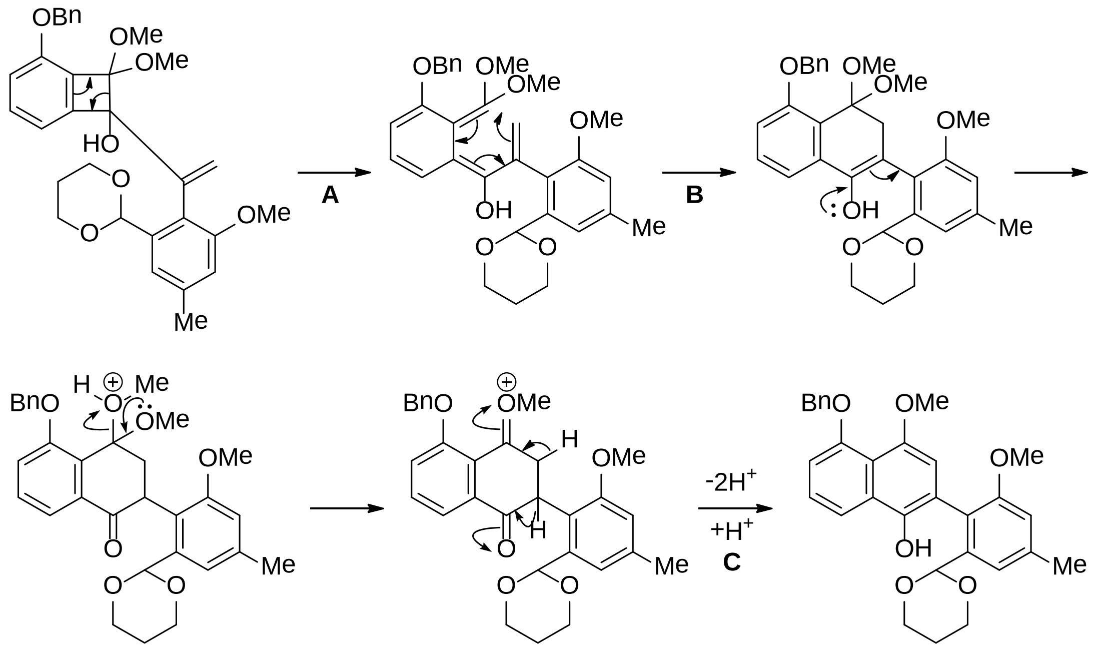
C007



Semple, J. E.; Wang, P. C.; Lysenko, Z.; Joullie, M. M. *J. Am. Chem. Soc.* **1980**, 102, 7505.

Ugi reaction (four-component condensation, 4CC). **A**: Most likely, addition of the isocyanide to the iminium ion and addition of the benzoate ion to the ensuing nitrilium ion takes place simultaneously. **B**: Intramolecular acyl transfer reaction (the benzoyl group is activated).

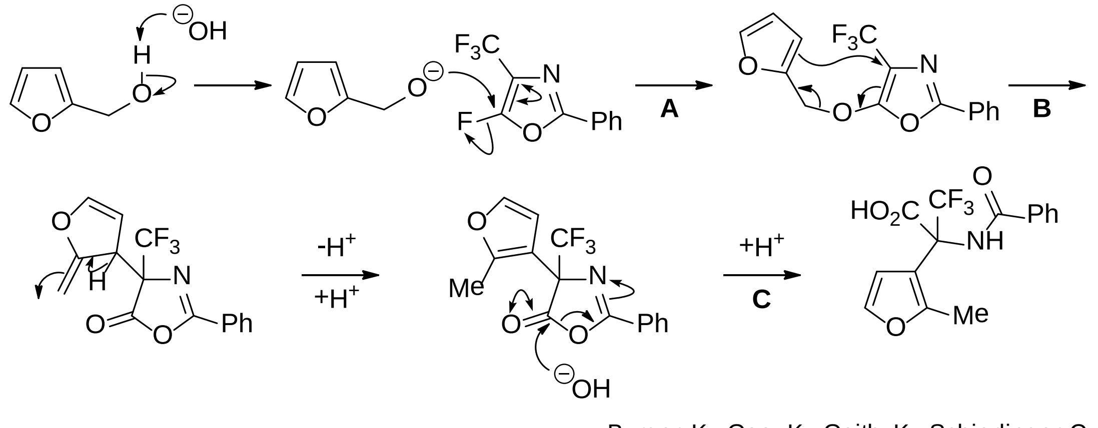
C008



Takemura, I.; Imura, K.; Matsumoto, T.; Suzuki, K. *Org. Lett.* **2004**, 6, 2503.

A: 4e Electrocyclic reaction. **B**: 6e Electrocyclic reaction. **C**: Aromatization.

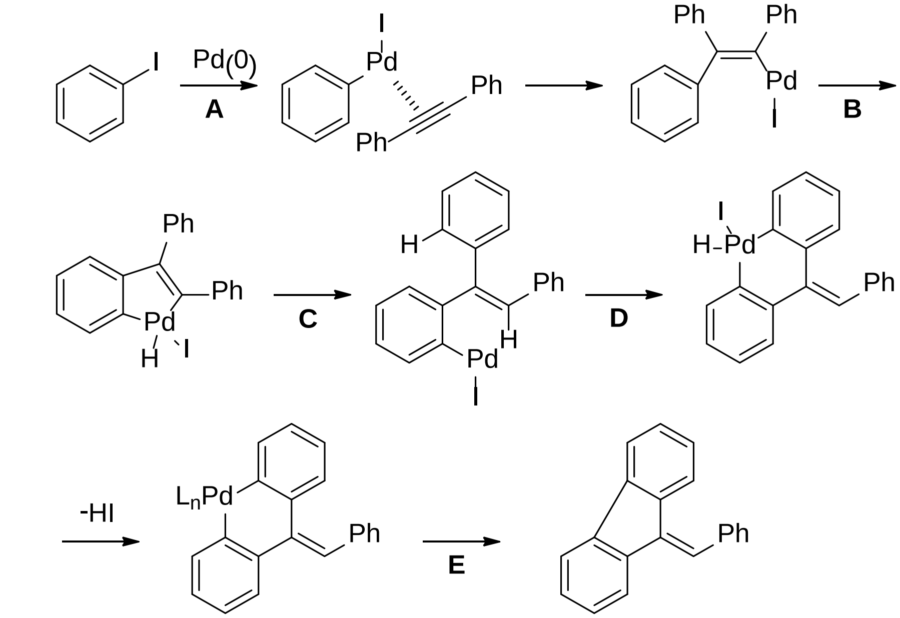
C009



Burger, K.; Gaa, K.; Geith, K.; Schierlinger, C. *Synthesis* **1989**, 850.

A: ipso-Substitution of the electron-deficient oxazole. **B**: Claisen rearrangement. **C**: Hydrolysis of the azlactone.

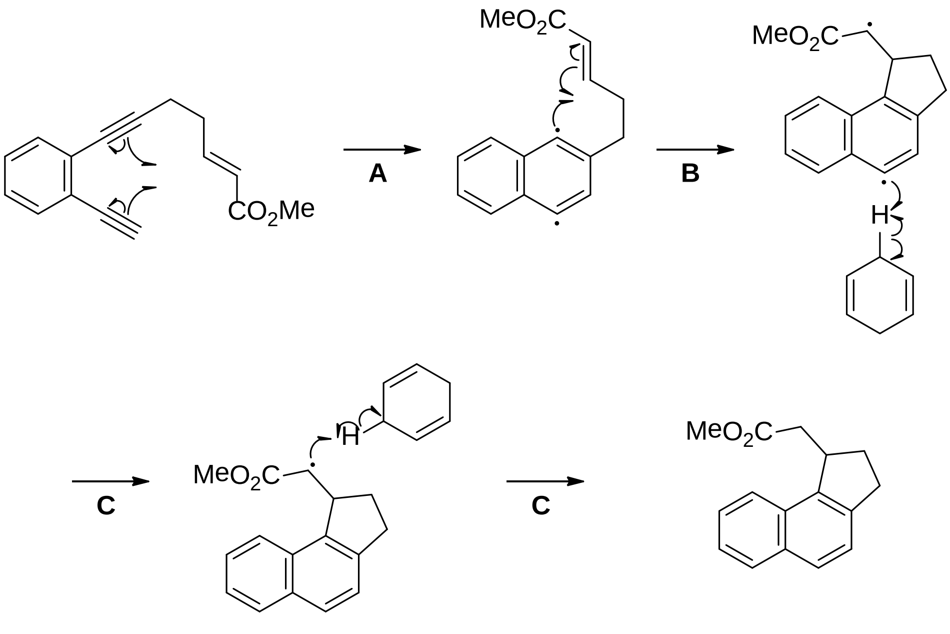
C010



Larock, R. C.; Tian, Q. *J. Org. Chem*. **2001**, 66, 7372.

A: Oxidative addition followed by carbopalladation to an alkyne. **B**: Oxidative addition to the aromatic C-H bond. **C**: Reductive elimination. **D**: Oxidative addition to another aromatic C-H bond. **E**: Reductive elimination to form the C-C bond.

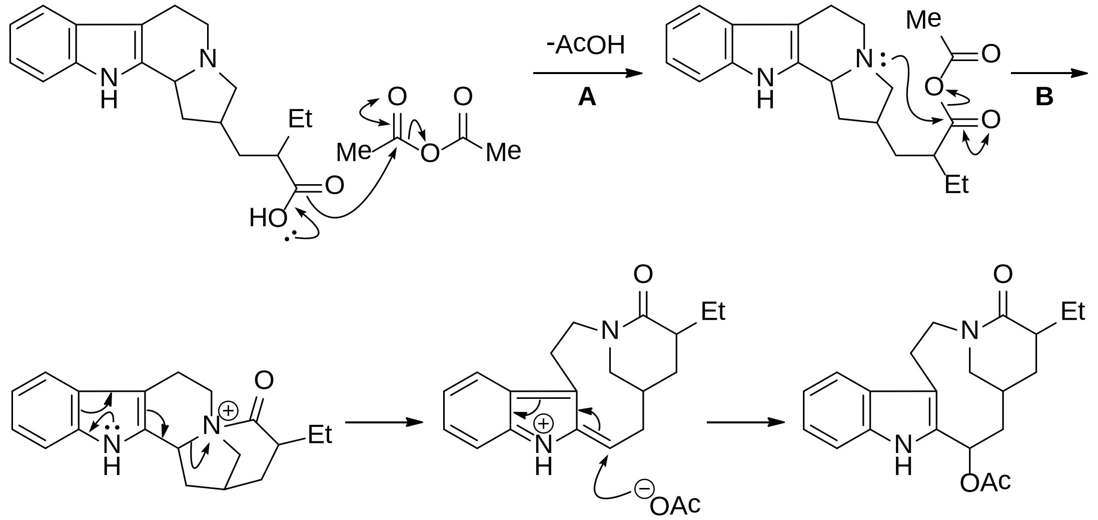
C011



Grissom, J. W.; Calkins, T. L.; Egan, M. *J. Am. Chem. Soc.* **1993**, 115, 11744.

Masamune-Bergman cyclization. **A**: Radical cyclization of an endiyne. **B**: Kinetically favored 5-exo-trig radical cyclization. **C**: Abstraction of a hydrogen atom from 1,4-cyclohexadiene.

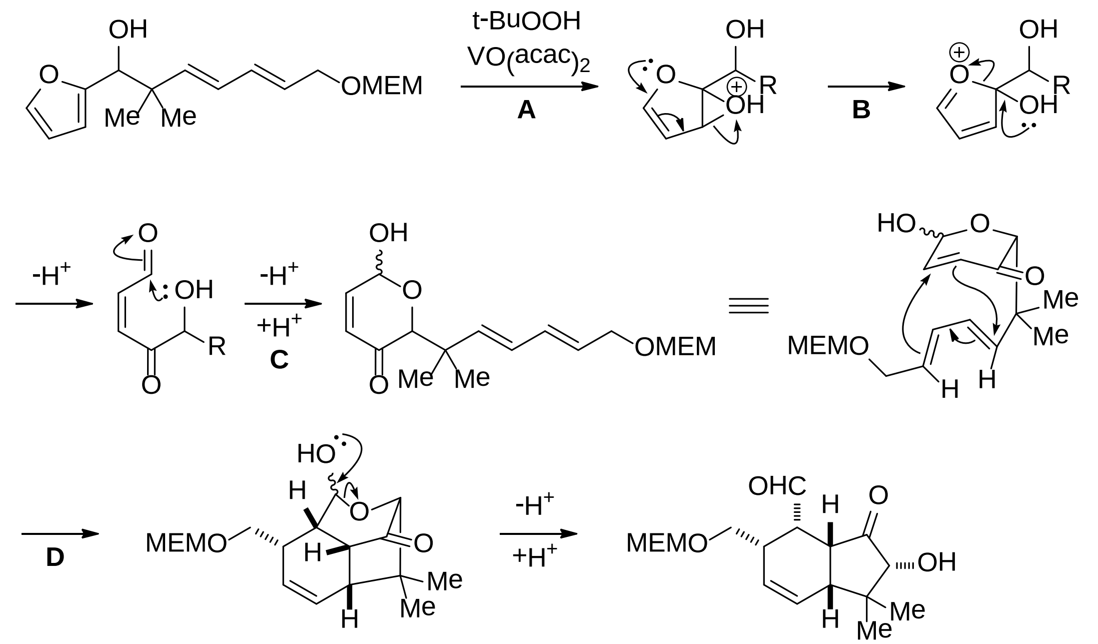
C012



Harley-Mason, J.; Atta-ur-Rahman *Tetrahedron* **1980**, 36, 1057.

A: Formation of a mixed anhydride. **B**: Acylation of the tertiary amine followed by cleavage of the C-N bond assisted by the nitrogen lone pair of the indole.

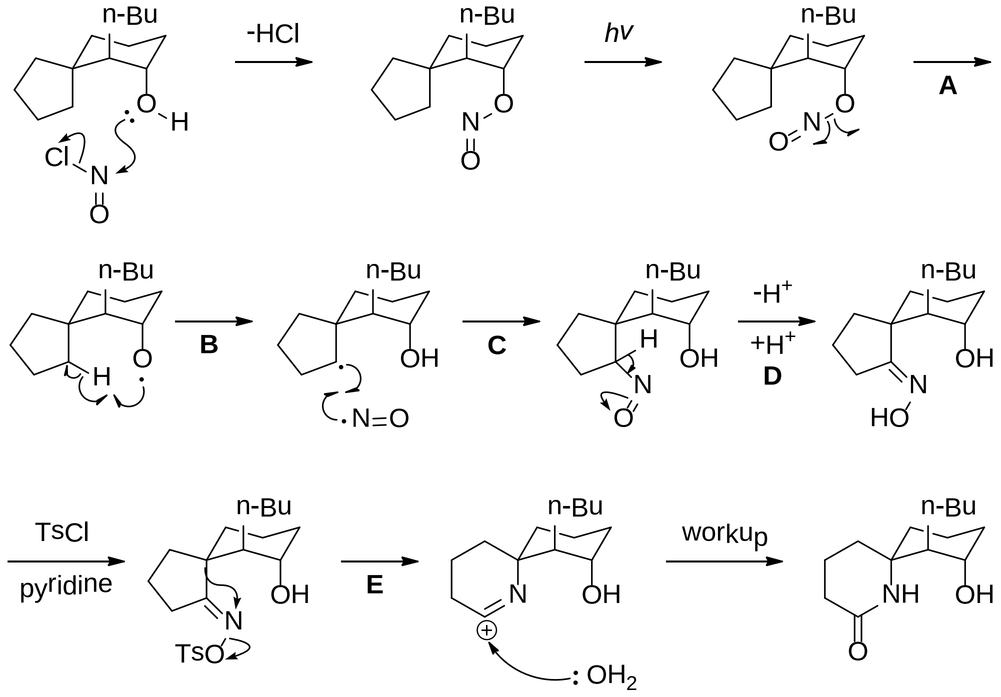
C013



Richter, E; Maichle-Mossmer, C.; Maier, M E. *Synlett.* **2002**, 1097.

Achmatowicz reaction (A-C). **A**: Epoxidation directed by the hydroxy group. **B**: Cleavage of theepoxide followed by the ring opening to form a cis-enal. **C**: Cyclization to form a lactol. **D**: Intramolecular Diels-Alder reaction.

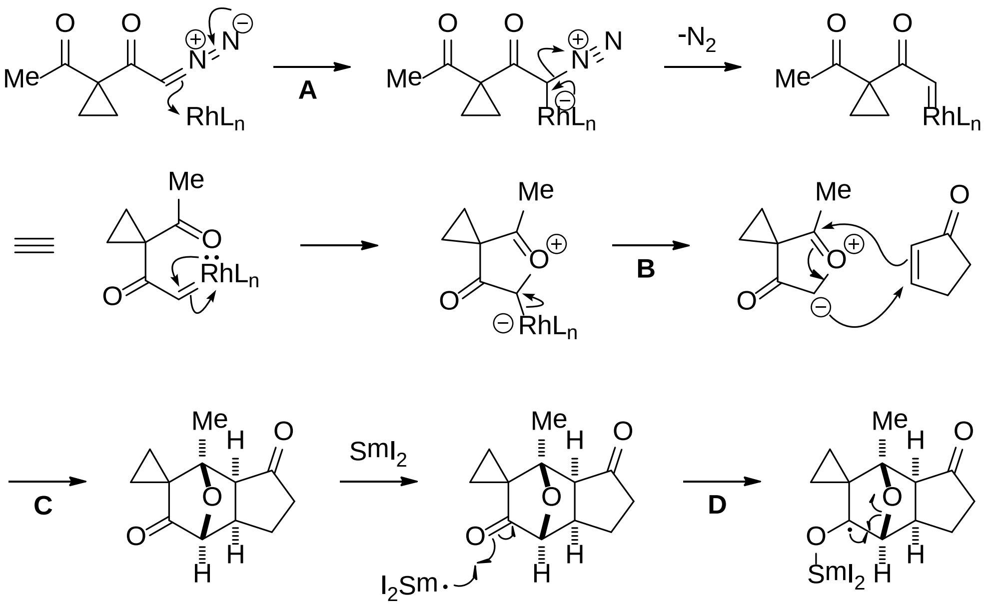
C014

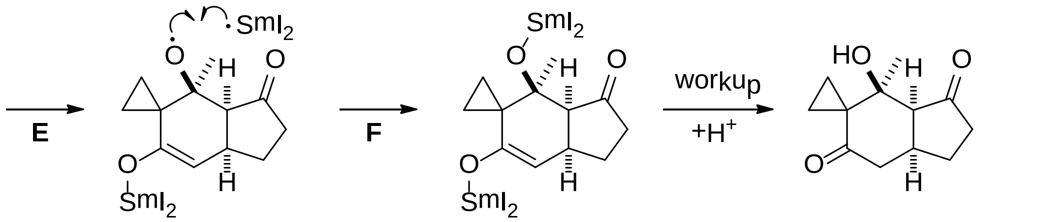


Corey, E. J.; Arnett, J. E; Widiger, G. N. *J. Am. Chem. Soc.* **1975**, 97, 430.

Barton reaction (A-D, ref 097). **A**: Photo-induced homolytic cleavage of the nitrite. **B**: Abstraction of a hydrogen atom via a six-membered transition state. **C**: Recombination of .NO with the resulting radical. **D**: Tautomerization to form an oxime. **E**: Beckmann rearrangement (ref A055).

C015



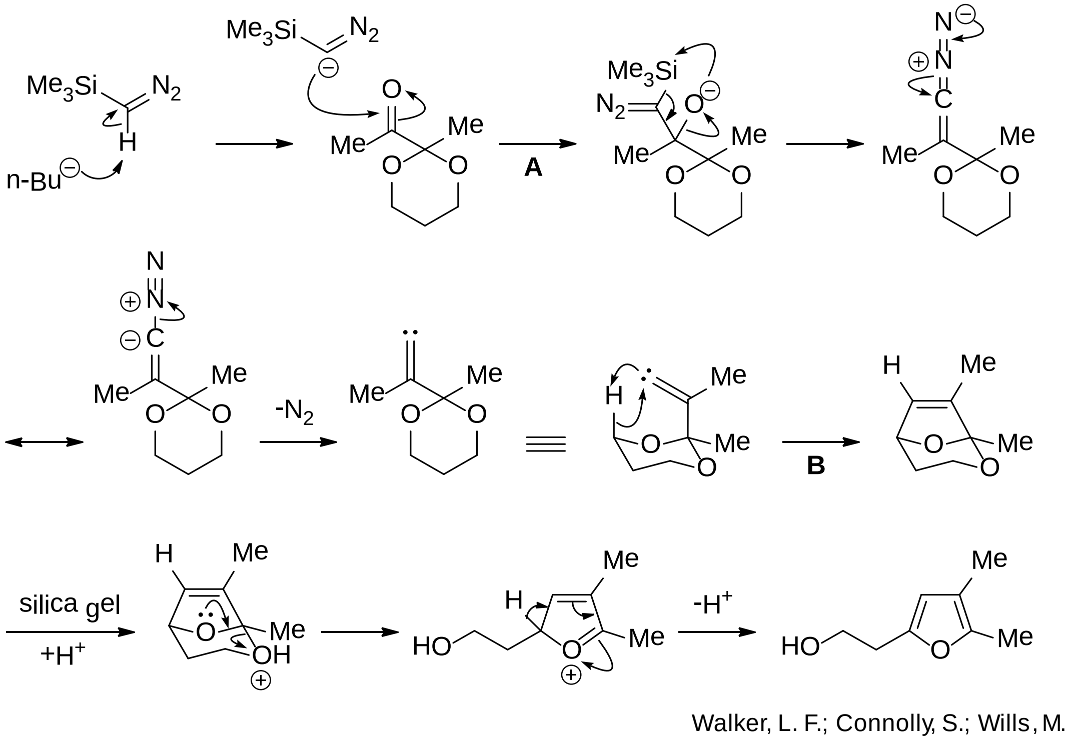


Padwa, A.; Sandanayaka, V. P.; Curtis, E. A.

J. Am. Chem. Soc. **1994**, 116, 2667.

A: Formation of a rhodium carbene complex. **B**: Formation of a carbonyl ylide. **C**: 1,3-Dipolar cycloaddition. **D**: SET to form a ketyl radical. **E**: Homolytic cleavage of the C-O bond. **F**: SET.

C016

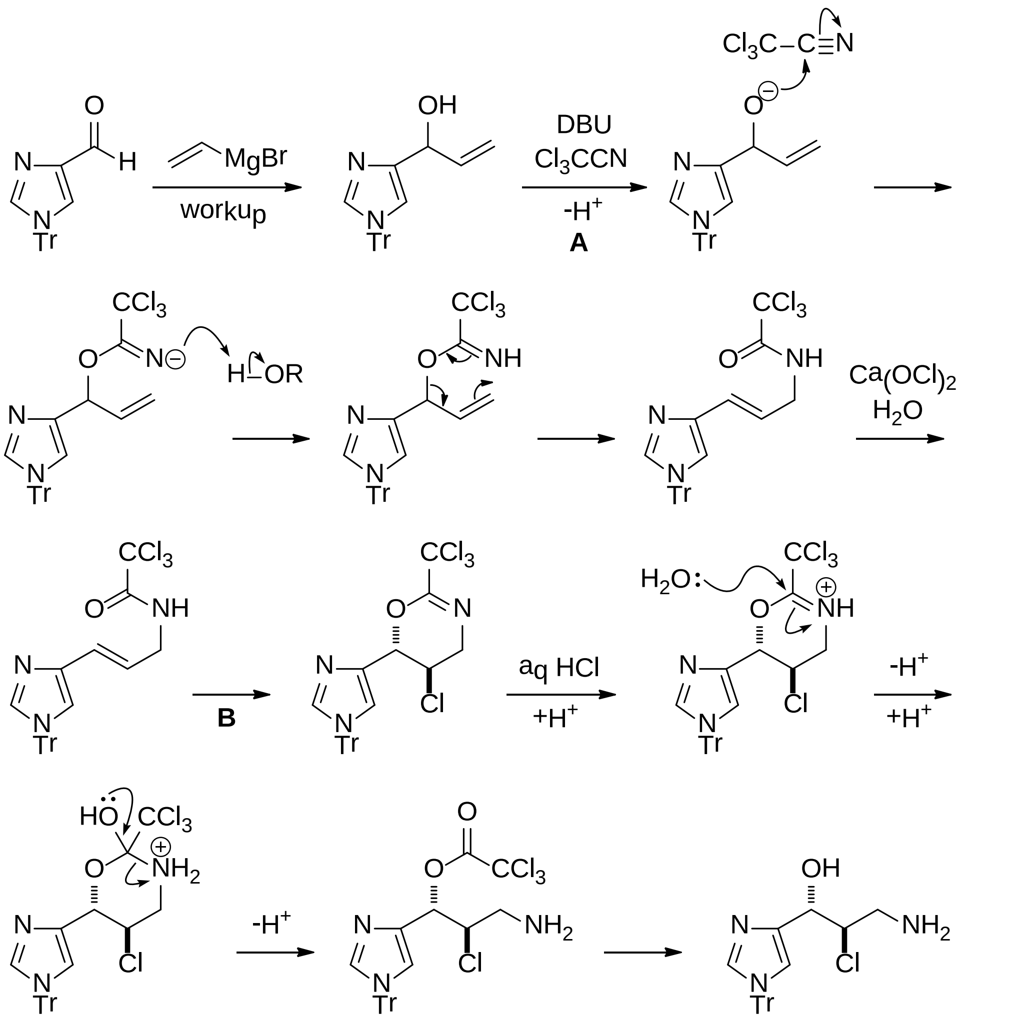


Walker, L. F.; Connolly, S.; Wills, M.

Tetrahedron Lett., **1998**, 39, 5273.

A: Peterson olefination (ref A074) followed by elimination of N_2 to form an alkylidene carbene. **B**: C-H insertion.

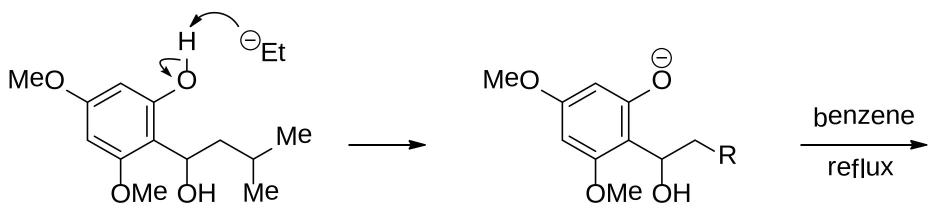
C017

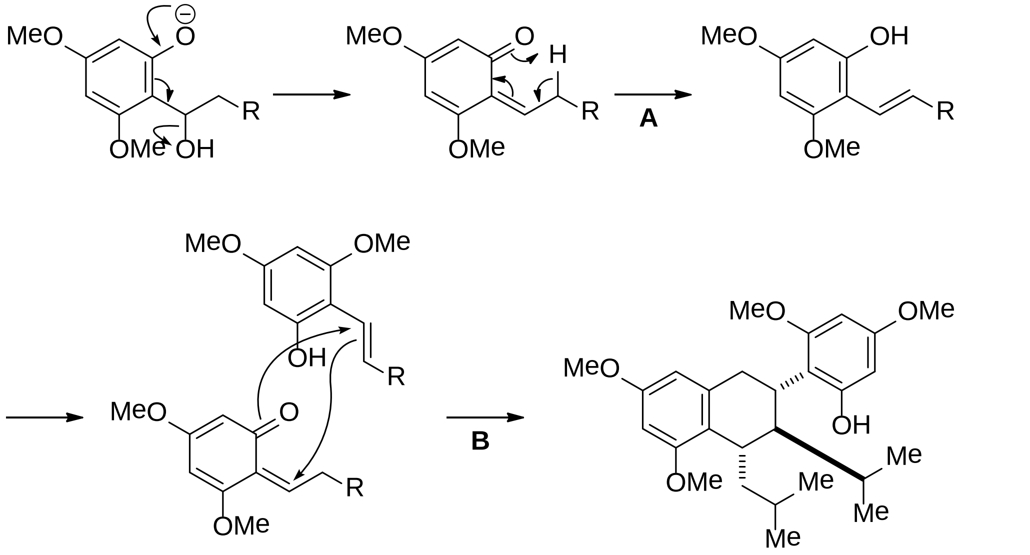


Commercon, A.; Ponsinet, G. *Tetrahedron Lett*. **1990**, 31, 3871.

A: Formation of a trichloroacetimidate followed by aza-Claisen rearrangement. **B**: While formation of five-membered rings is kinetically favored, activation by the imidazole ring directed the cyclization to form a six-membered ring.

C018

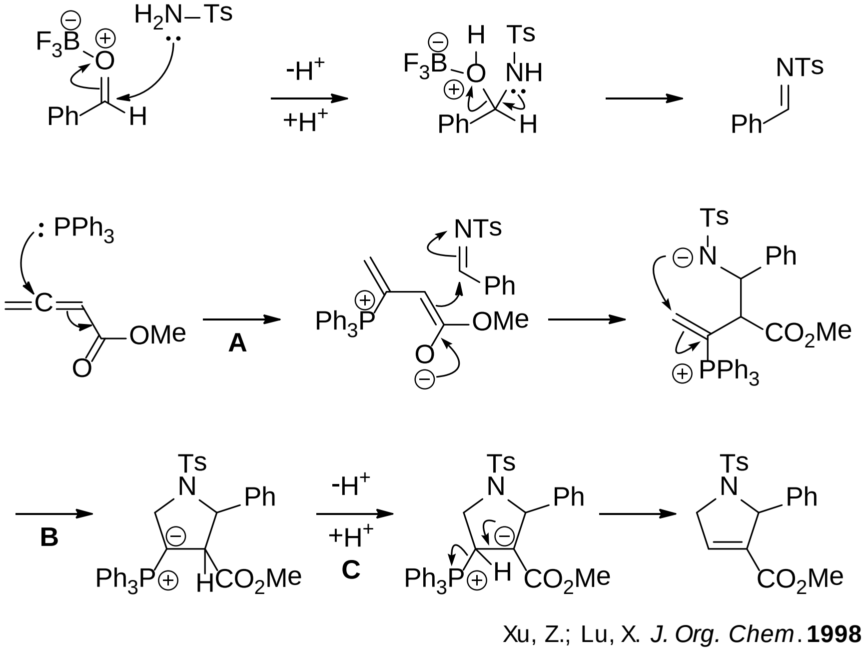




Tatsuta, K.; Tamura, T.; Mase, T. *Tetrahedron Lett.* **1999**, 40, 1925.

A: Restoration of the aromaticity. **B**: Hetero-Diels-Alder reaction.

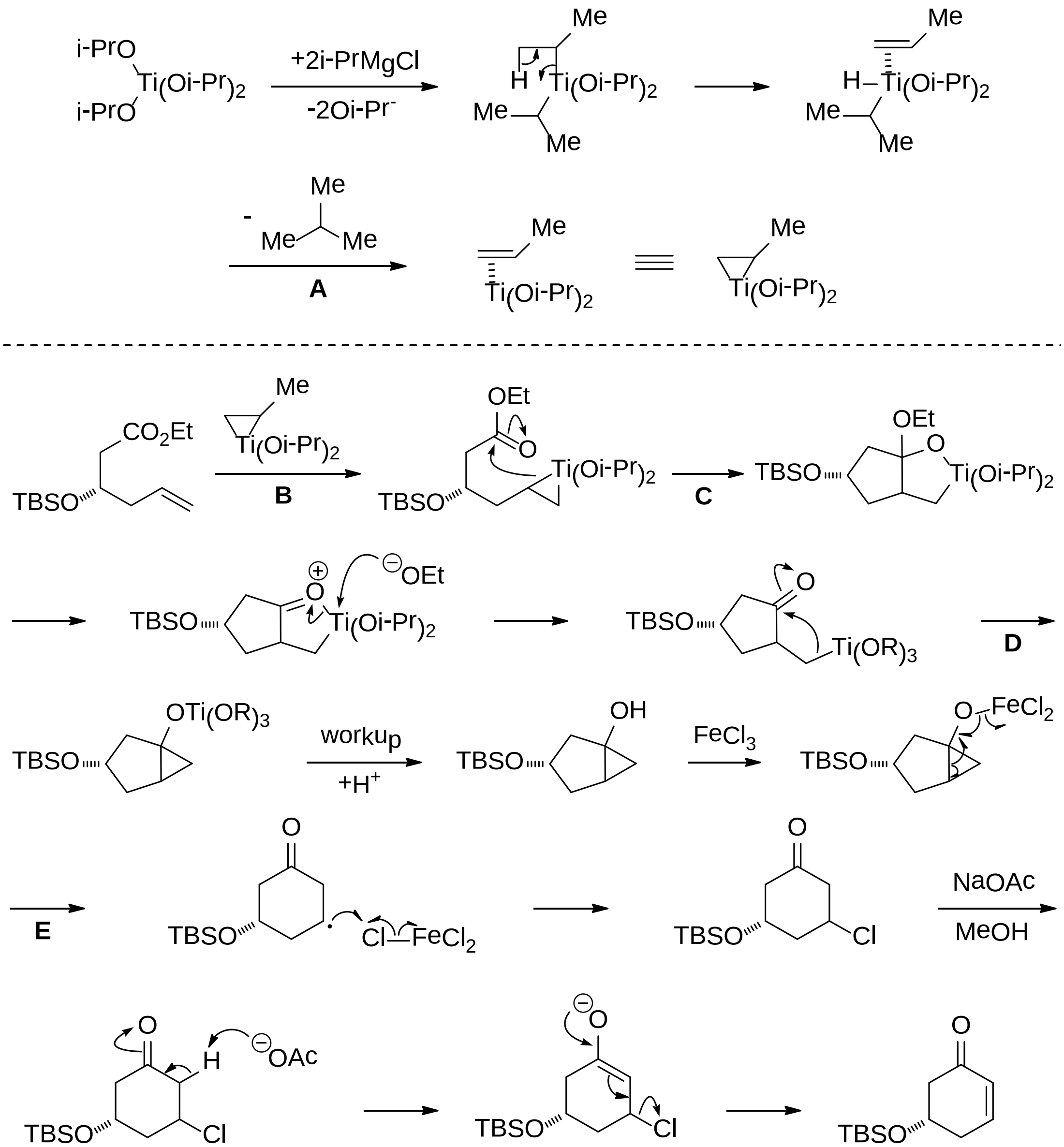
C019



Xu, Z.; Lu, X. *J. Org. Chem.* **1998**, 63, 5031.

A: Conjugate addition of Ph_3P to the allenyl ester to form an enolate. **B**: 5-endo-trig Cyclization to form an ylide. **C**: Proton transfer followed by elimination of Ph_3P.

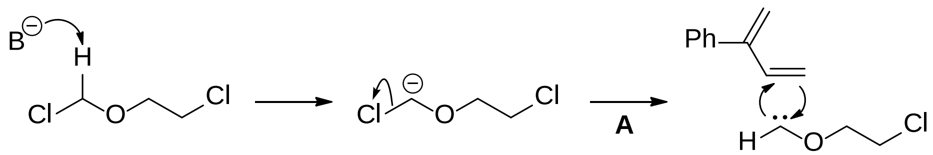
C020

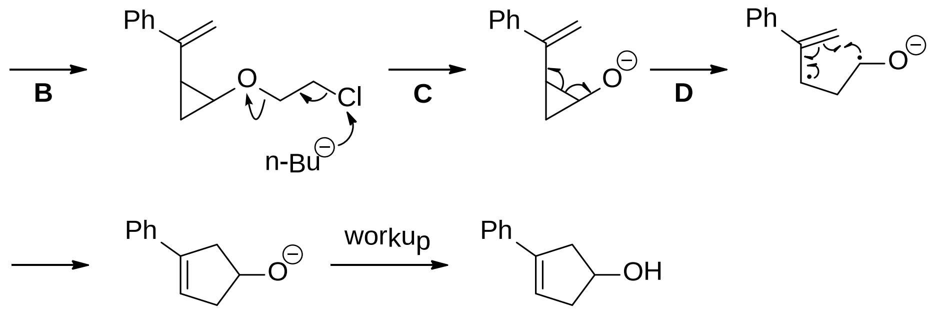


Hanazawa, T.; Okamoto, S.; Sato, F. *Tetrahedron Lett.* **2001**, 42, 5455.

A: Formation of a titanium-propylene complex or a titanacyclopropane derivative (ref B128). **B**: Olefin exchange. **C**: Intramolecular insertion of the carbonyl group to the titanium complex. **D**: Formation of a cyclopropane. **E**: Oxidative cleavage of the cyclopropane ring.

C021

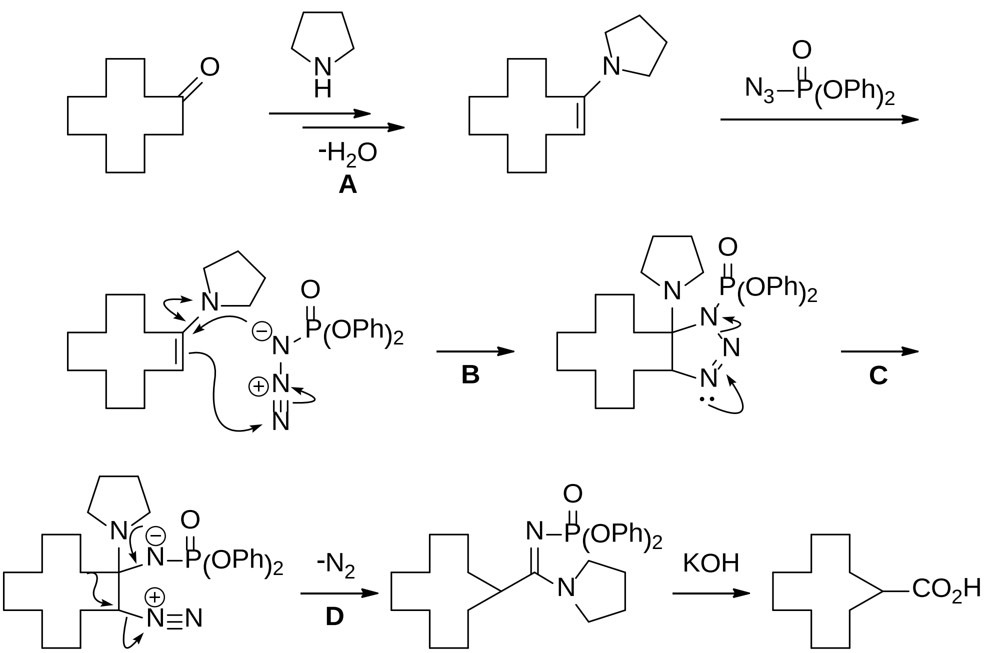




Danheiser, R. L.; Martinez-Davila, C.; Morin, J. M., Jr. *J. Org. Chem*. **1980**, 45, 1340.

A: α-Elimination to form a carbene. **B**: Cyclopropanation. **C**: β-Elimination to form a cyclopropanol anion. **D**: Anion-accelerated vinylcyclopropane rearrangement (homolytic cleavage followed by recombination of the diradical).

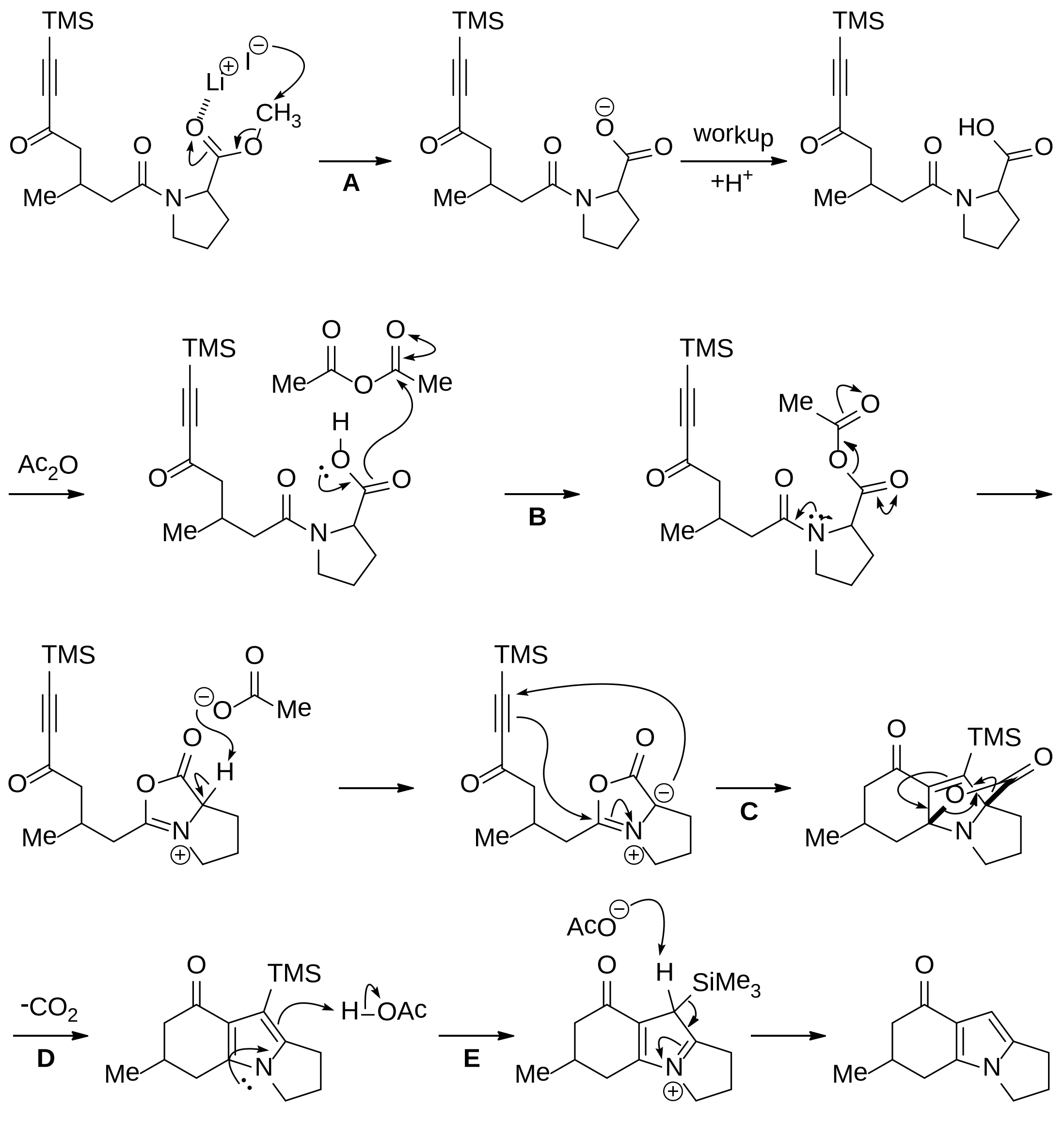
C022



Hamada, Y.; Shioiri, T. *Org. Synth., Coll*. Vol. Ⅶ **1990**, 207

A: Formation of an enamine. **B**: 1,3-Dipolar cycloaddition. **C**: Cleavage of the N-N bond. **D**: Tiffeneau-Demjanov-type ring contraction.

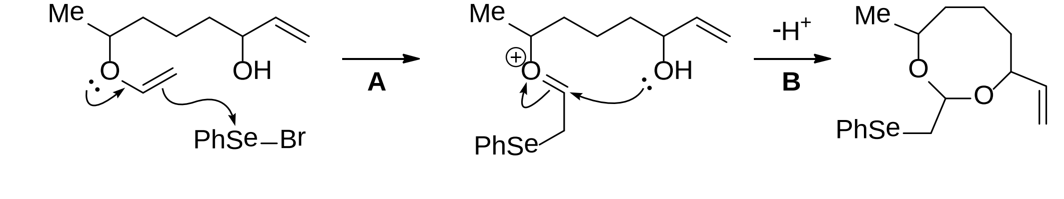
C023

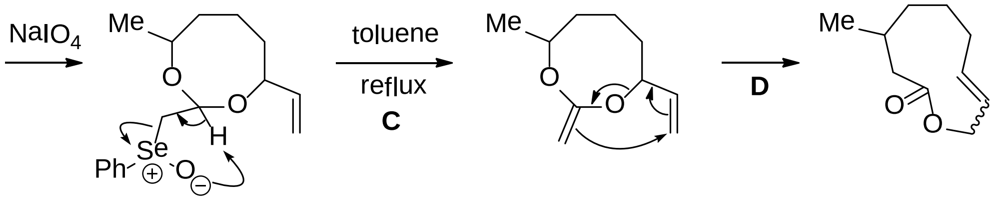


Nayyar, N. K.; Hutchison, D. R.; Martinelli, M. J. *J. Org. Chem.* **1997**, 62, 982.

A: Demethylation via an S_N2 process. **B**: Cyclization of the mixed anhydride followed by formation of a 1,3-dipole. **C**: Intramolecular 1,3-dipolar cycloaddition. **D**: Decarboxylation. **E**: Protodesilylation.

C024

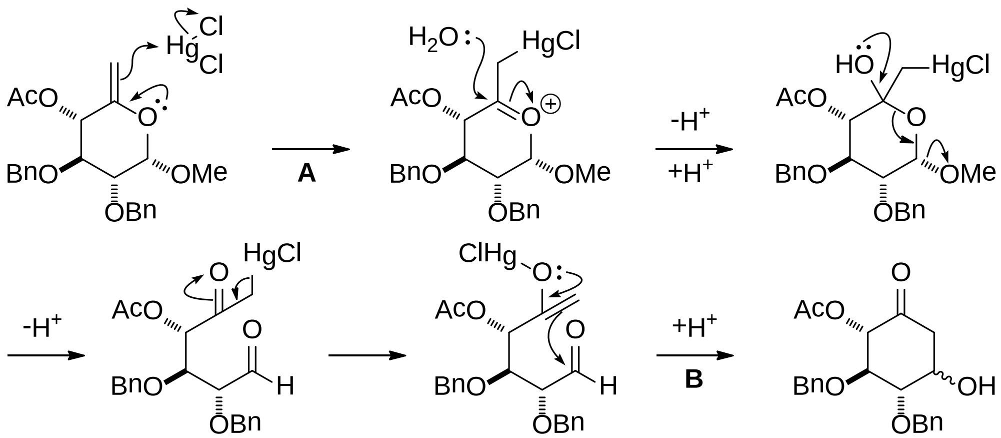




Petrzilka, M. Heir. *Chim. Acta* **1978**, 61, 3075.

A: Selenation of the electron-rich enol ether. **B**: Intramolecular acetal formation. **C**: β-Elimination of the selenoxide. **D**: Claisen rearrangement.

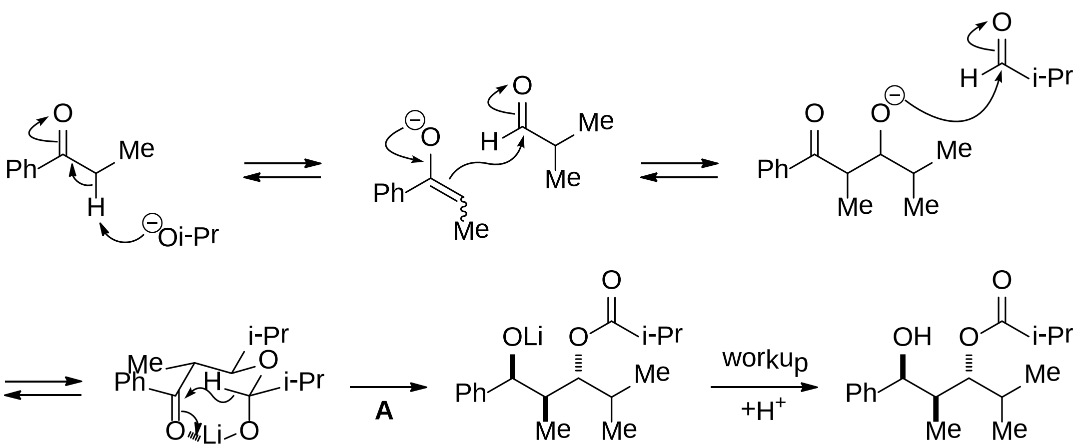
C025

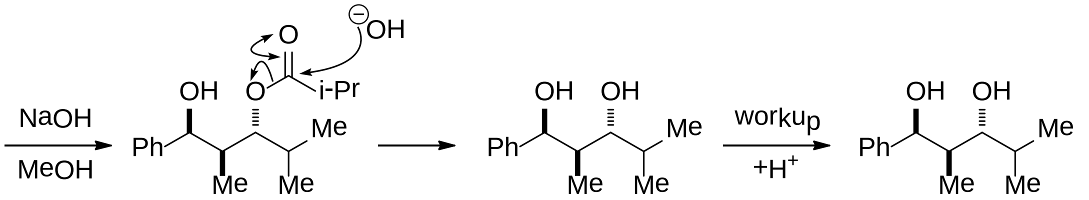


Chida, N.; Ohtsuka, M.; Nakazawa, K.; Ogawa, S.
J. Chem. Soc., Chem. Commun. **1989**, 436.

Ferrier rearrangement. **A**: Oxymercuration of enol ether. **B**: Intramolecular aldol reaction of the mercury enolate with the aldehyde.

C026

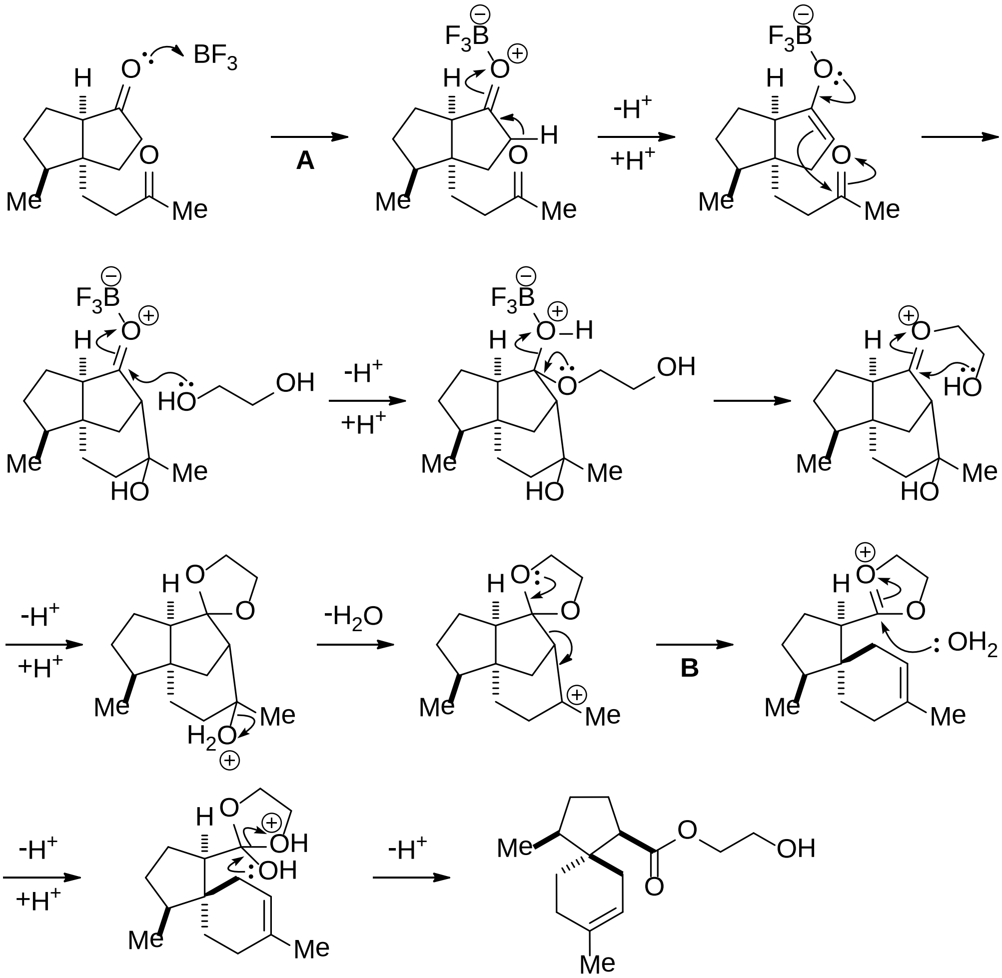




Mascarenhas, C. M.; Duffey, M. O.; Liu, S.-Y.; Morken, J. P. *Org. Lett*. **1999**, 1, 1427.

Tishchenko reaction. **A**: Intramolecular hydride transfer (Cannizzaro-type reaction) through a chair-like transition state.

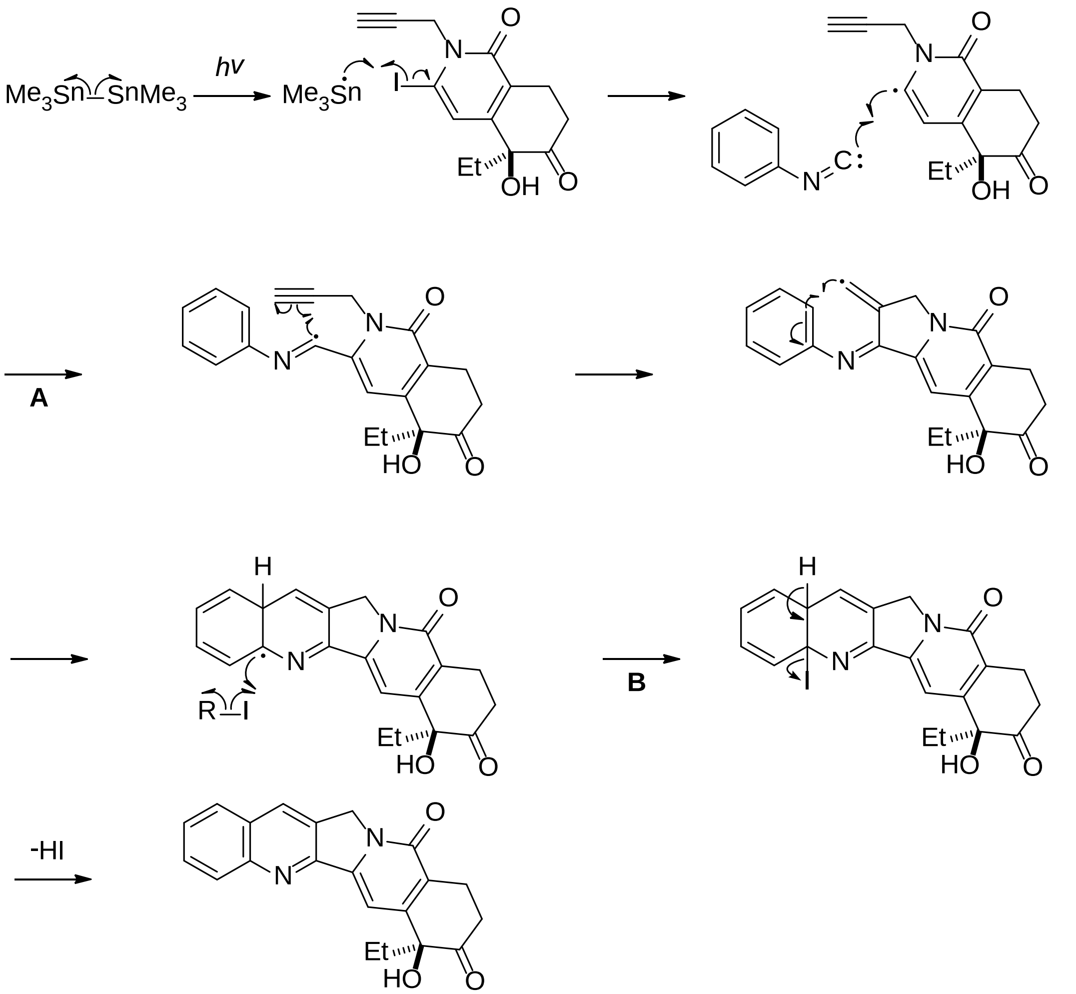
C027



Nagumo, S.; Suemune, H.; Sakai, K. *J. Chem. Soc., Chem. Commun*. **1990**, 1778.

A: Intramolecular acid-catalyzed aldol reaction. **B**: Grob-type fragmentation.

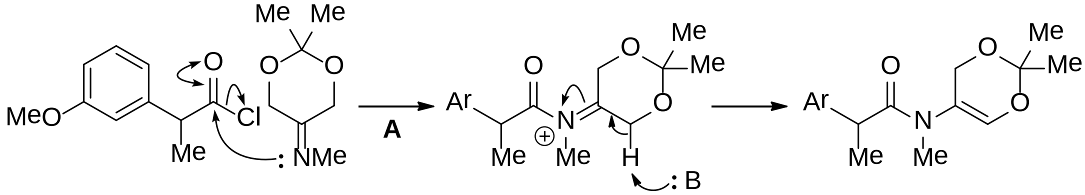
C028

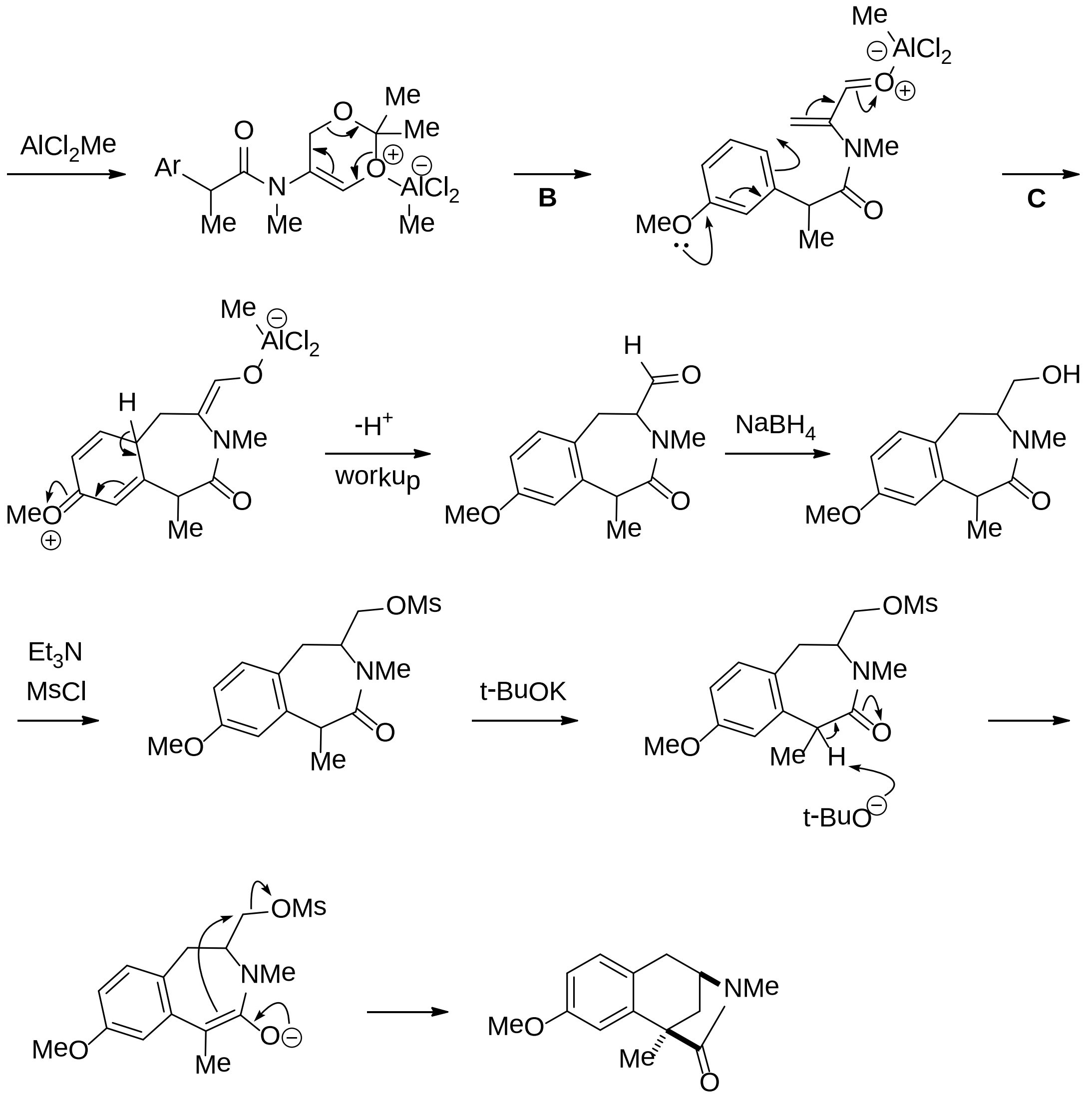


Curran, D. P.; Ko, S.-B.; Josien, H. *Angew. Chem. Int. Ed*. **1995**, 34, 2683.

A: Radical addition of an isocyanide to form an imidoyl radical. **B**: Atom transfer reaction.

C029

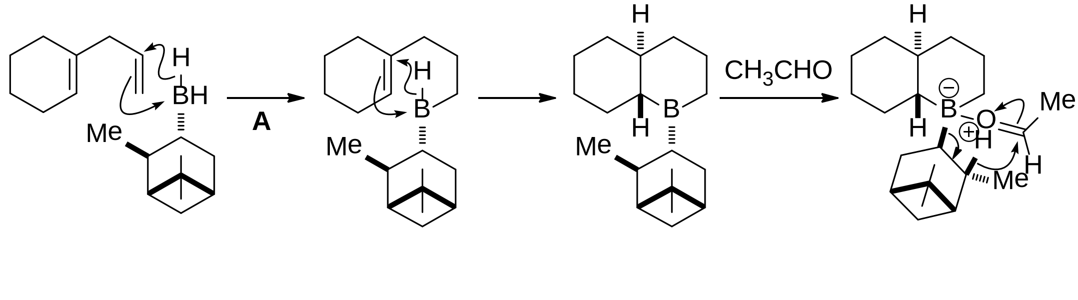


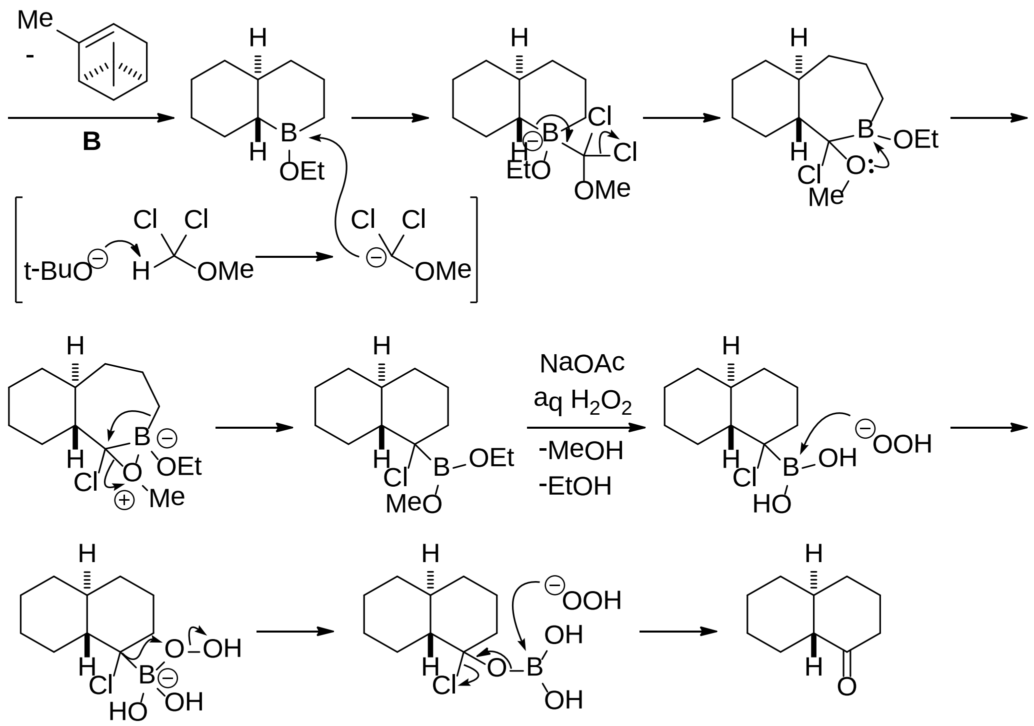


Fuchs, J. R.; Funk, R. L. *Org. Lett.*, **2001**, 3, 3923.

A: Acylation of the imine to form an enamide. **B**: Retro cycloaddition to form an (α-amidoacrolein. **C**: Intramolecular conjugate addition of the electron-rich aromatic ring to the amidoacrolein.

C030

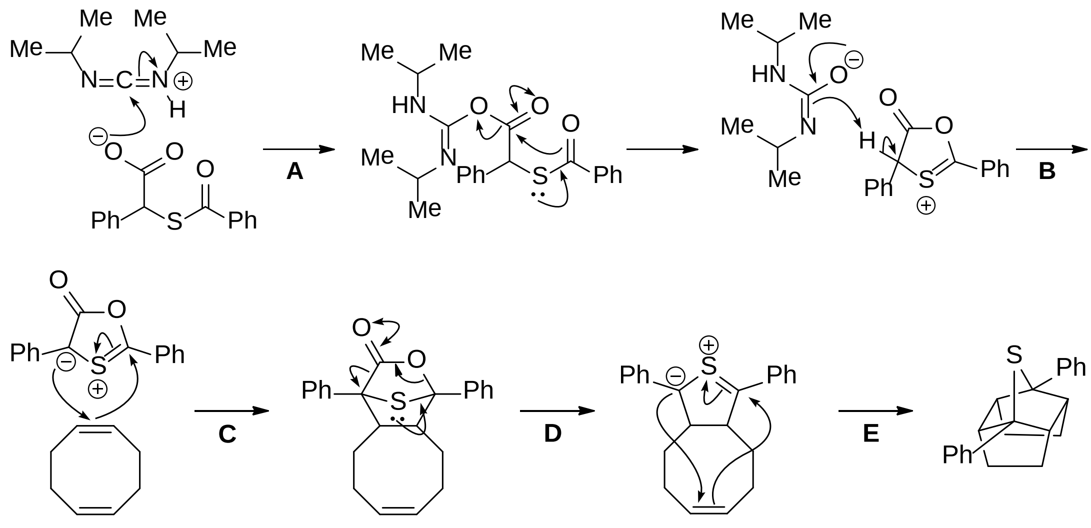




Brown, H. C.; Mahindroo, V. K.; Dhokte, U. P. *J. Org. Chem.* **1996**, 61, 1906.

A: Sequential hydroboration to form a trialkylborane. **B**: Hydride transfer via a six-membered transition state. See Meerwein-Ponndorf-Verley reduction (ref B002).

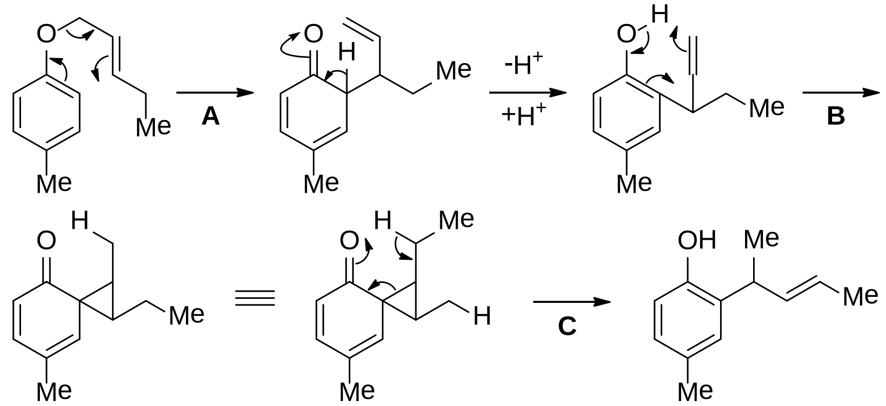
C031



Sponholtz III, W. R.; Trujillo, H. A.; Gribble, G. W. *Tetrahedron Lett.* **2000**, 41, 1687.

A: Activation of the carboxyl group as an O-acylisourea. **B**: Generation of a 1,3-dipole. **C**: 1,3-Dipolar cycloaddition. **D**: Decarboxylation to form a 1,3-dipole. **E**: Intramolecular 1,3-dipolar cycloaddition.

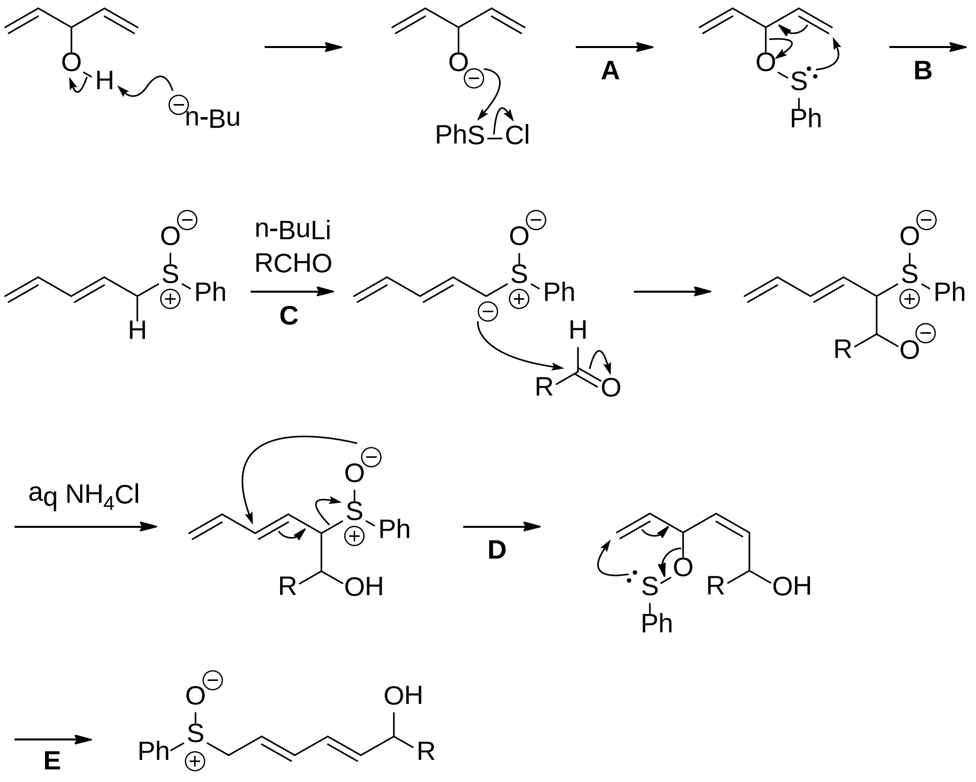
C032



Fukuyama, T.; Li, T.; Peng, G. *Tetrahedron Lett.* **1994**, 35, 2145.

Abnormal Claisen rearrangement. **A**: Claisen rearrangement followed by tautomerization. **B**: Intramolecular oxy-ene reaction to form a cyclopropane. **C**: Retro oxy-ene reaction.

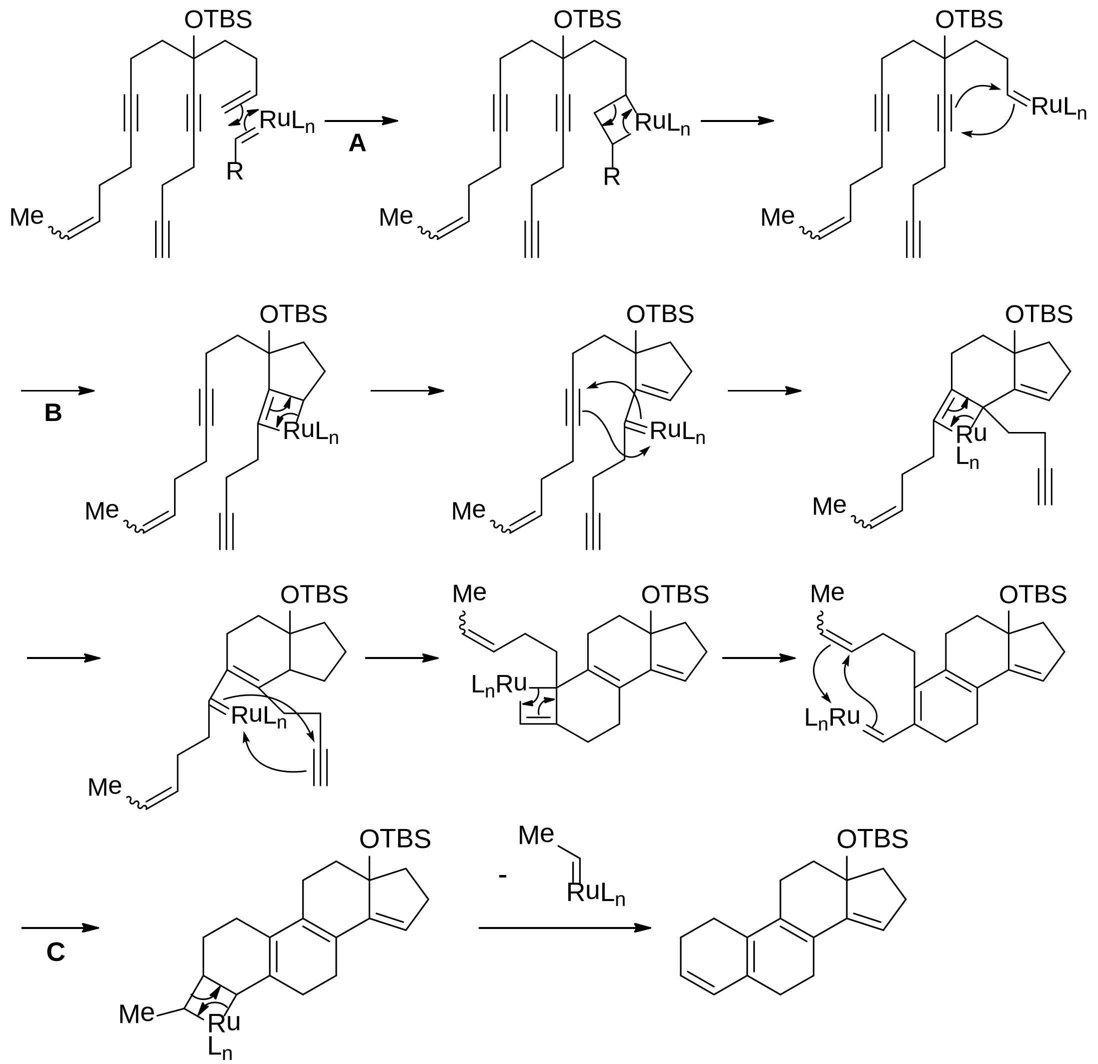
C033



Schreiber, S. L.; Satake, K. *J. Am. Chem. Soc.* **1984**, 106, 4186.

A: Formation of a sulfenate. **B**: [2,3] Sigmatropic rearrangement. **C**: Deprotonation followed by addition to the aldehyde (pKa DMSO = 35). **D**: [2,3] Sigmatropic rearrangement of the sulfoxide. **E**: [2,3] sigmatropic rearrangement of the sulfenate.

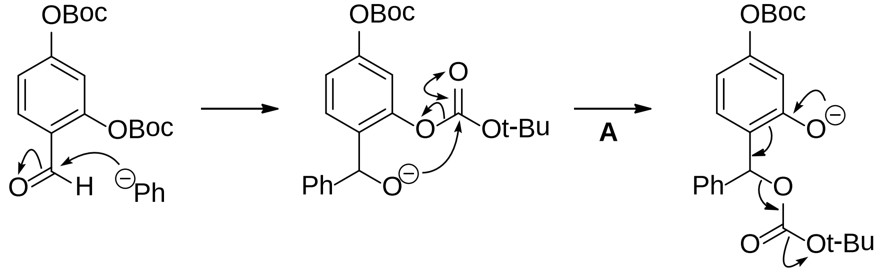
C034

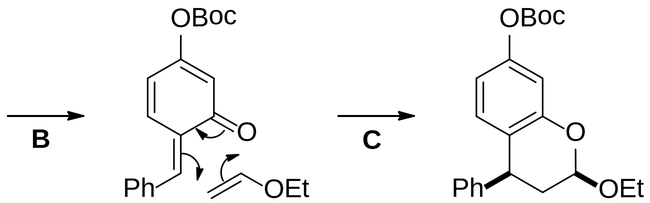


Zuercher, W. J.; Scholl, M.; Grubbs, R. H. *J. Org. Chem*. **1998**, 63, 4291.

Domino intramolecular enyne metathesis. **A**: Alkene metathesis at the terminal olefin. **B**: Sequential intramolecular alkyne metathesis to form a kinetically favored, six-membered intermediates. **C**: Intramolecular alkene metathesis.

C035

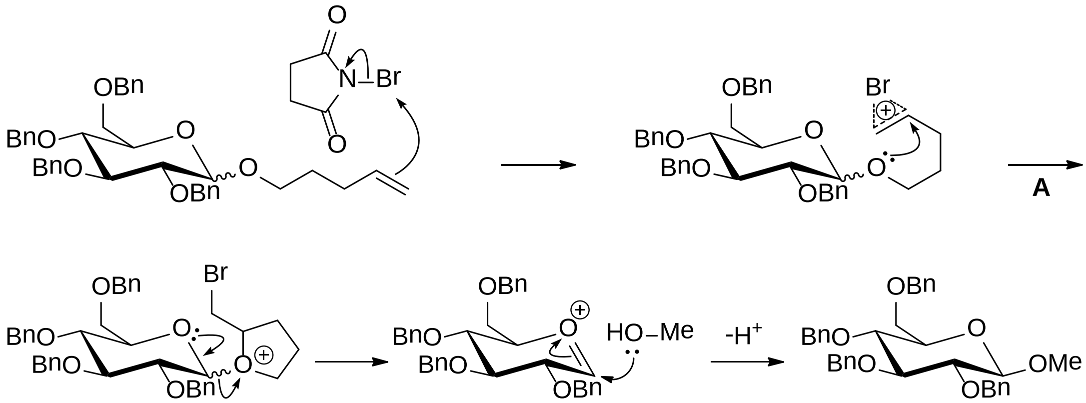




Jones, R. M.; Selenski, C.; Pettus, T. R. R. *J. Org. Chem.* **2002**, 67, 6911

A: Intramolecular acyl transfer (pKa PhOH = 10, t-BuOH = 19). **B**: Generation of o-quinonemethide
C: Hetero-Diels-Alder reaction to form an endo-adduct.

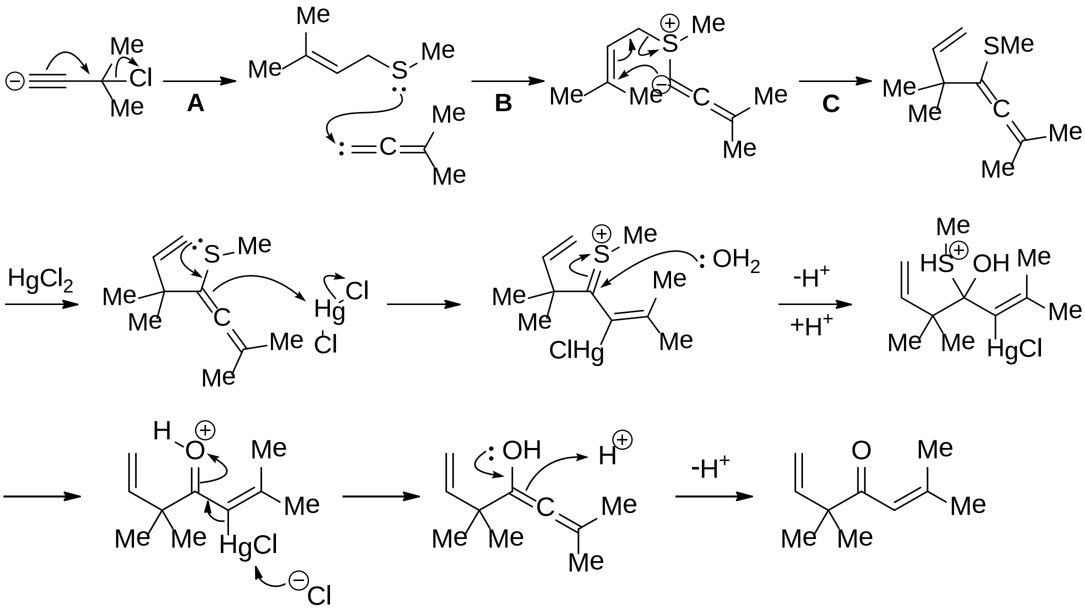
C036



Fraser-Reid, B.; Konradsson, P.; Mootoo, D. R.; Udodong, U.
J. Chem. Soc., Chem. Commun. **1988**, 823.

A: Bromination of the olefin causes the formation of a five-membered oxonium ion.

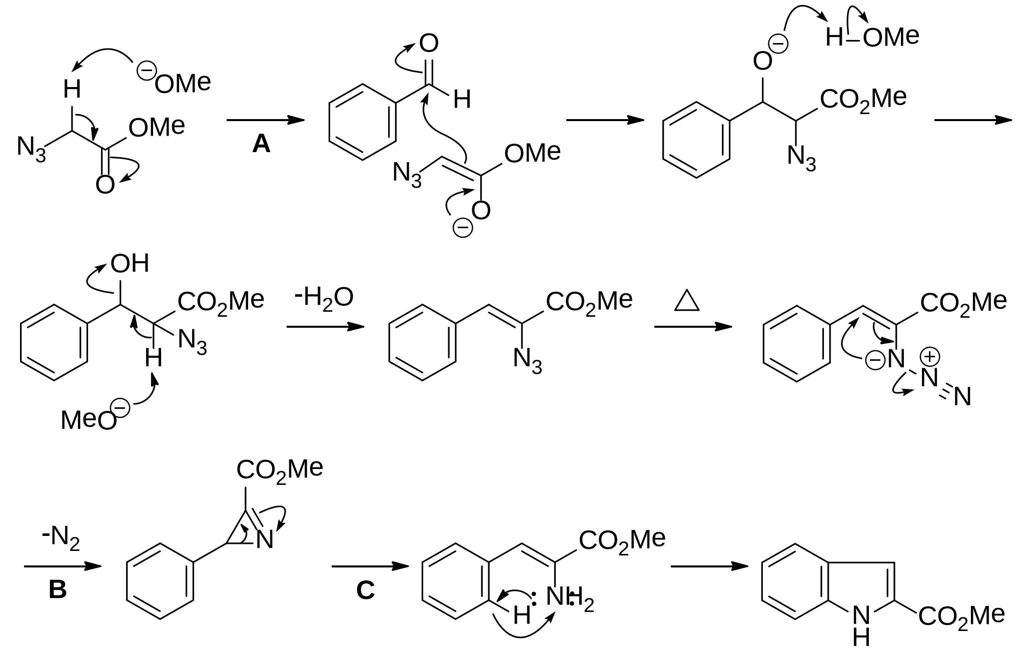
C037



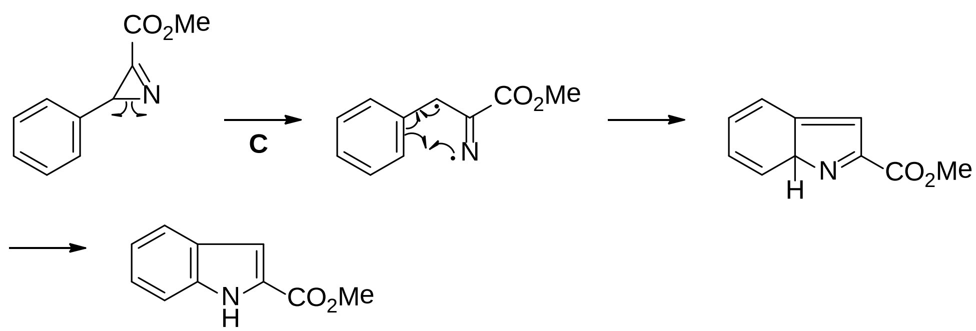
Michelot, D.; Linstrumelle, G.; Julia, S. *J. Chem. Soc., Chem. Commun.* **1974**, 3, 10.

A: Generation of an alkylidene carbene. **B**: Formation of a sulfur ylide (carbene is electrophilic). **C**: [2,3] Sigmatropic rearrangement.

C038



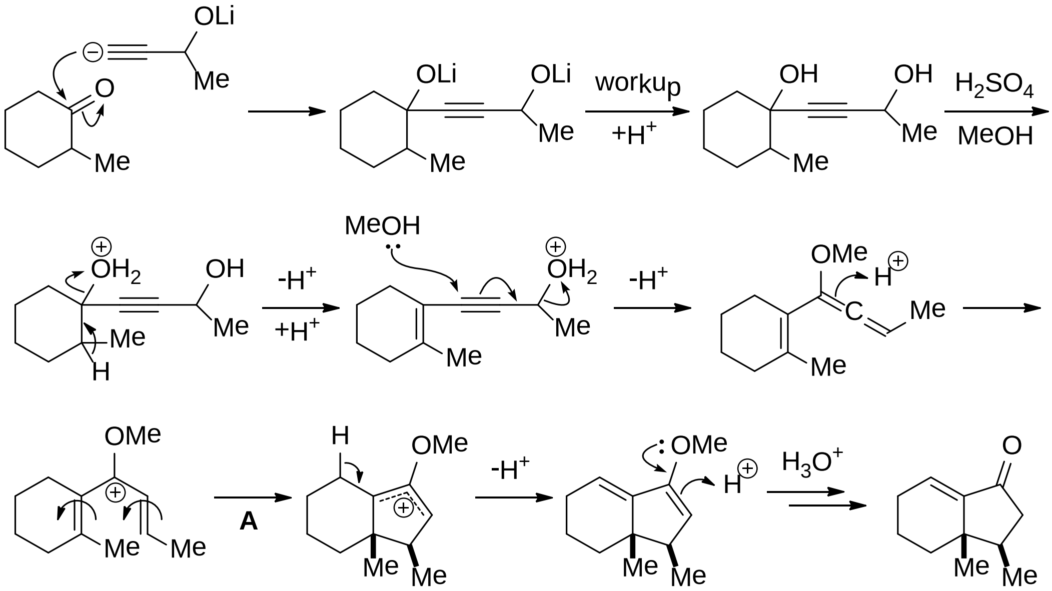
or



Knittel, D. *Synthesis* **1985**, 186.

A: Claisen-Schmidt reaction. **B**: Formation of an azirine. **C**: Cleavage of the azirine ring to form either 1) a nitrene which undergoes C-H insertion or 2) a diradical that recombines to form, upon aromatization.an indole.

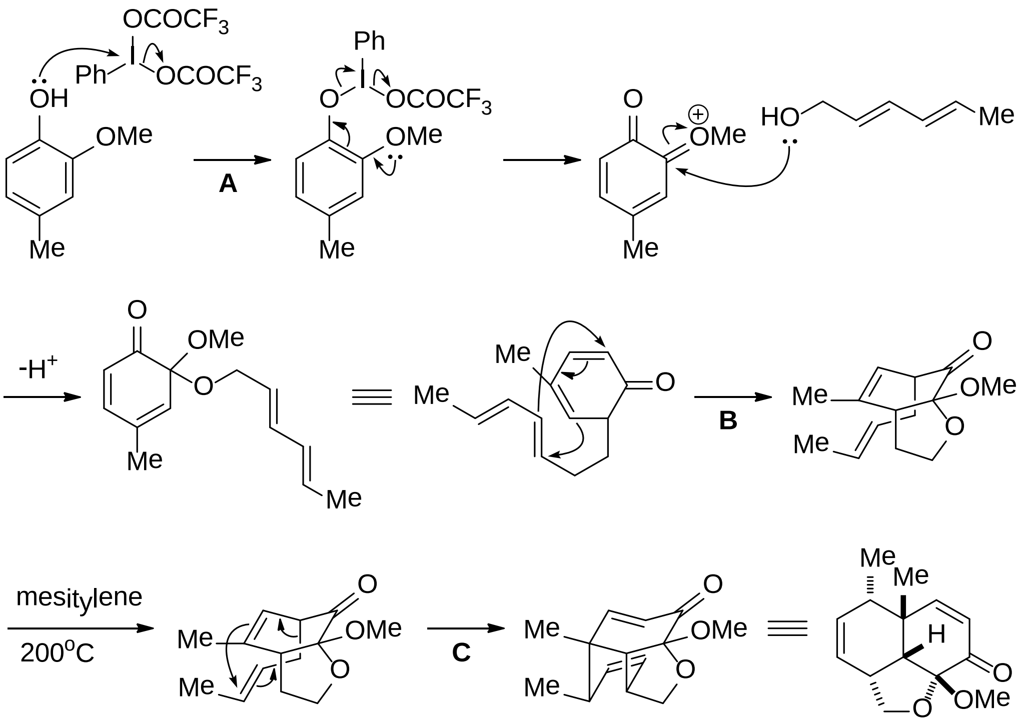
C039



Hiyama, T.; Shinoda, M.; Nozaki, H. *J. Am. Chem. Soc.* **1979**, 101, 1599.

A: Nazarov reaction (ref B026).

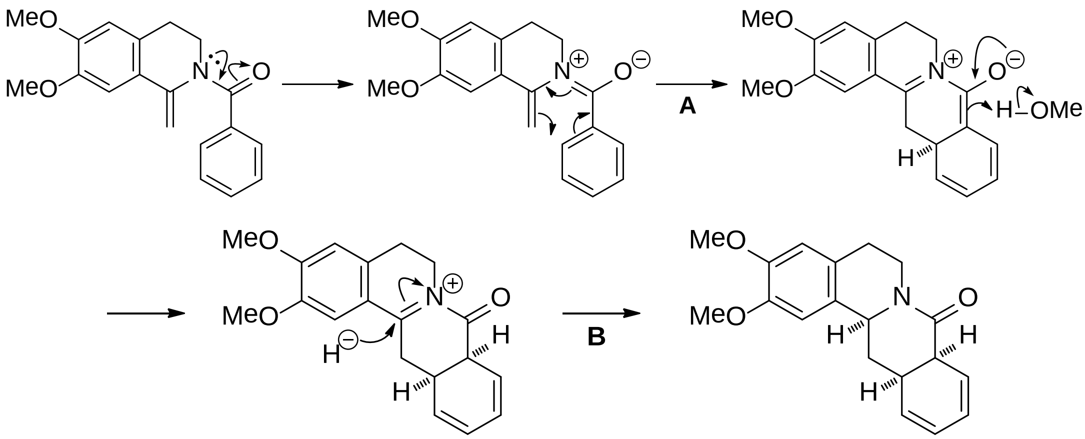
C040



Hsiu, P.-Y.; Liao, C.-C. *J. Chem. Soc., Chem. Commun.* **1997**, 1085.

A: Oxidation of the phenol to form a mixed o-quinone monoacetal. **B**: Intramolecular Diels-Alder reaction. **C**: Cope rearrangement.

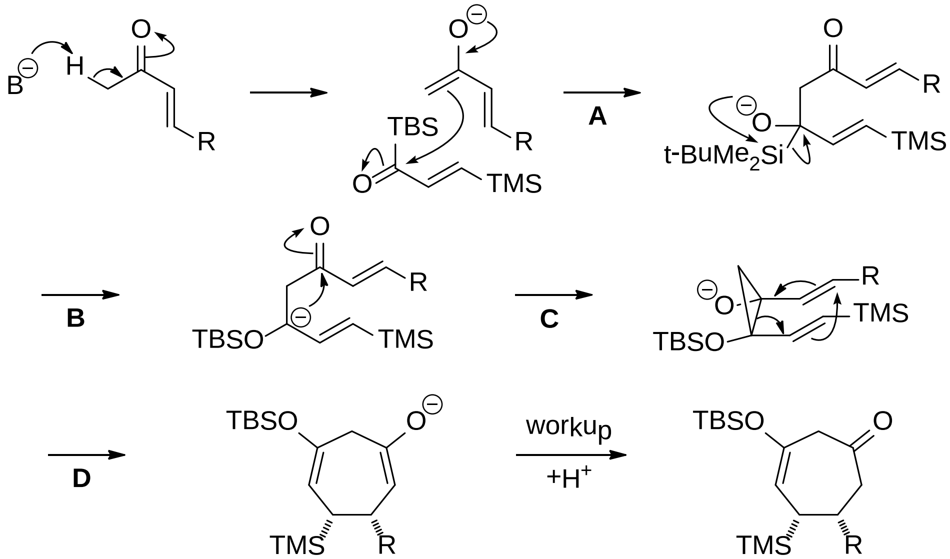
C041



Naito, T.; Tada, Y.; Nishiguchi, Y.; Ninomiya, I.
Heterocycles **1981**, 16, 1137.

A: 6e Electrocyclic reaction. **B**: Reduction of the acyliminium ion from the convex face.

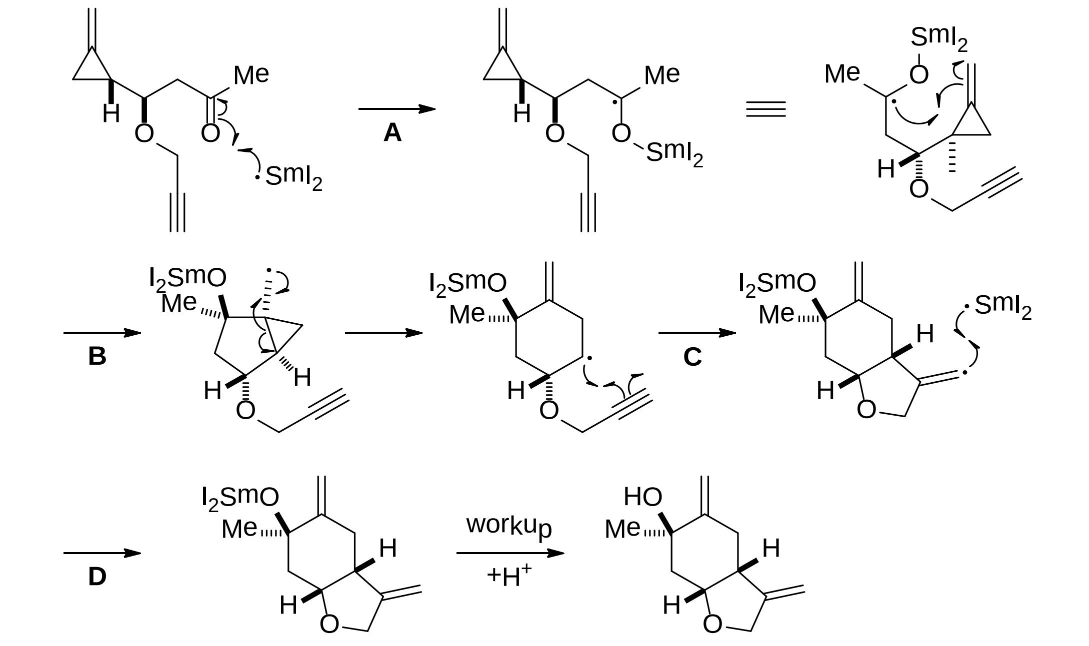
C042



Takeda, K.; Takeda, M.; Nakajima, A.; Yoshii, E.
J. Am. Chem. Soc. **1995**, 117, 6400.

A: 1,2-Addition of the enolate to the acylsilane. **B**: Brook rearrangement. **C**: Cyclopropanation. **D**: Anion-accelerated divinylcyctopropane rearrangement.

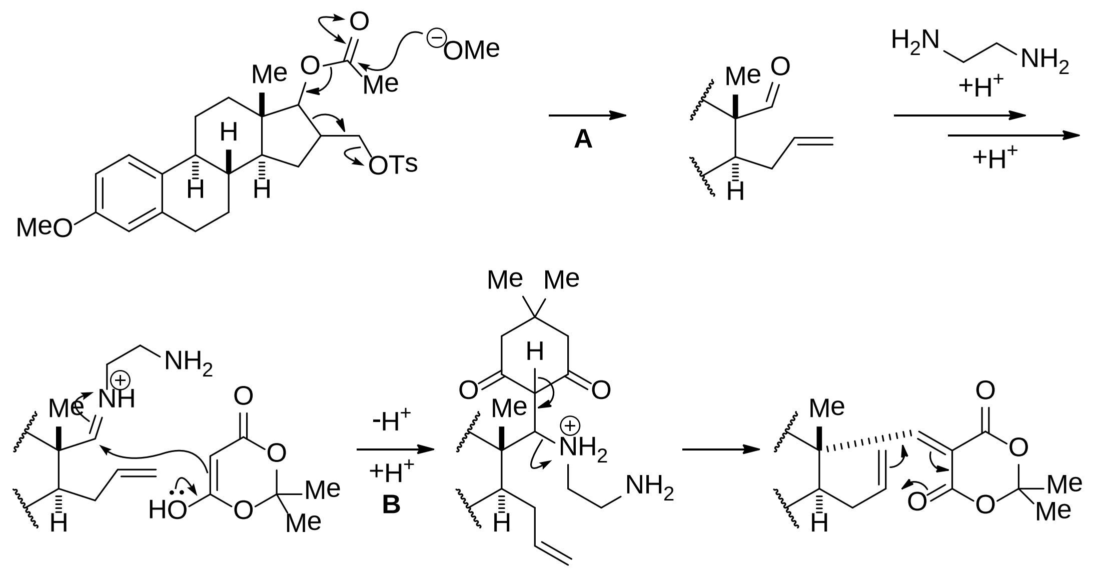
C043

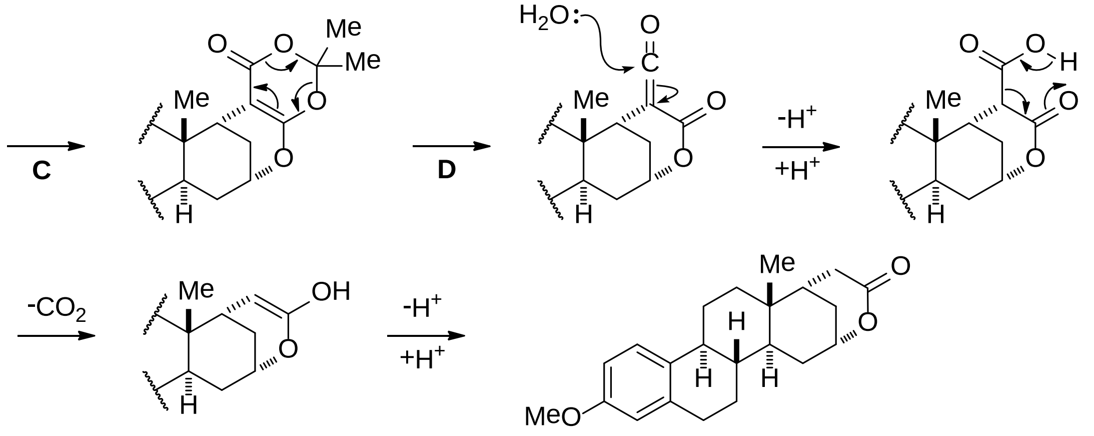


Boffey, R. J.; Santagostino, M.; Whittingham, W. G.; Kilburn, J. D.
Chem. Commun. **1998**, 1875.

A: SET. **B**: 5-exo-trig Radical cyclization to form a radical at a cyclopropylcarbinyl position which induces cleavage of the cyclopropane ring (cf. radical clock). **C**: 5-exo-dig Radical cyclization. **D**: SET.

C044

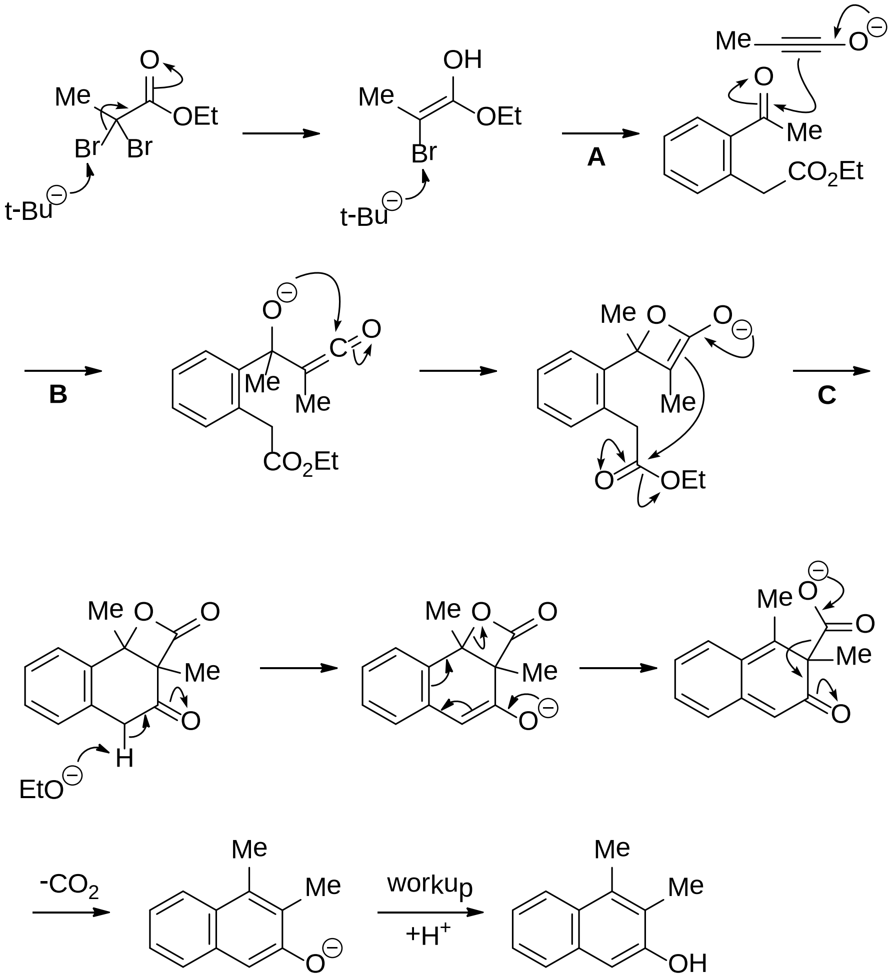




Tietze, L. F.; Wölfling, J.; Schneider, G. *Chem. Ber.* **1991**, 124, 591.

A: Grob-type fragmentation. **B**: Knoevenagel reaction (ref A018). **C**: Intramolecular hetero-Diels-Alder reaction. **D**: Retro Diels-Alder reaction to generate a highly reactive acylketene.

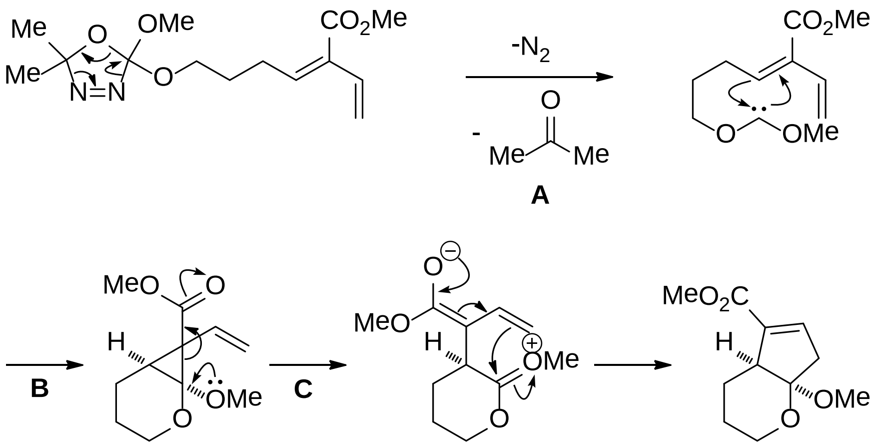
C045



Shindo, M.; Sato, Y.; Shishido, K. *J. Org. Chem*. **2001**, 66, 7818.

A: Formation of an ynolate. **B**: Addition of the ynolate to the ketone leads to the formation of a strained β-lactone enolate. **C**: Claisen condensation followed by aromatization with decarboxylation.

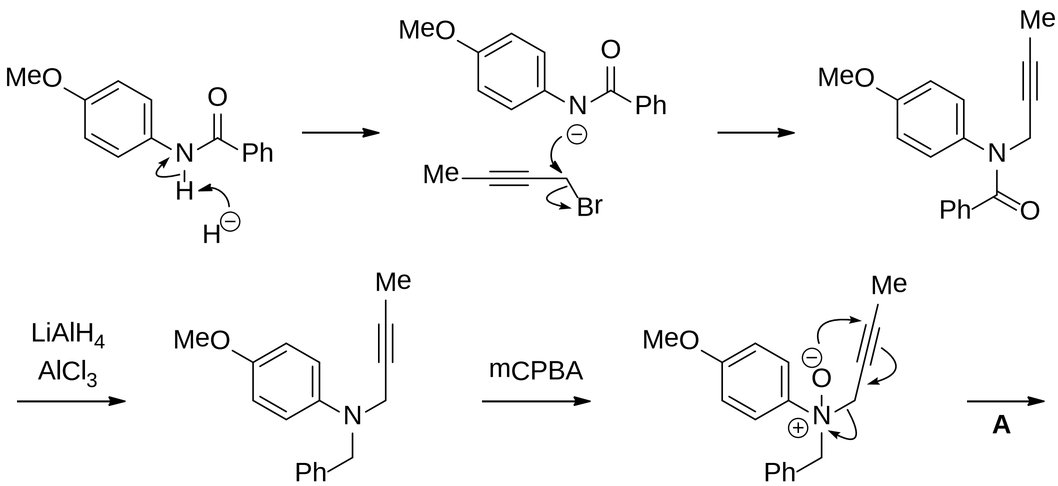
C046

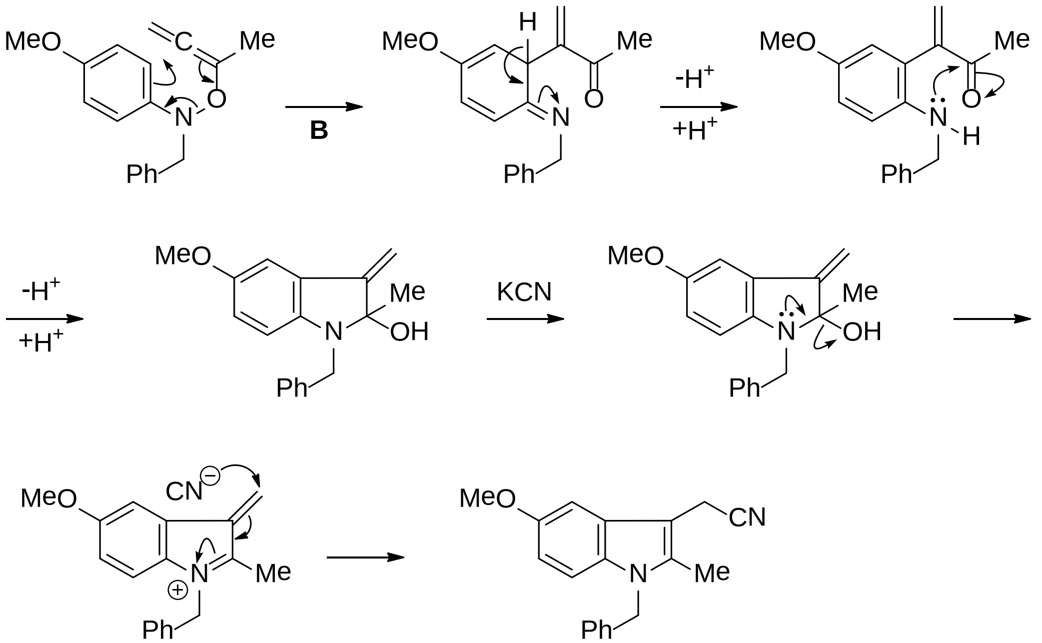


Spino, C.; Rezaei, H.; Dupont-Gaudet, K.; Belanger, F. *J. Am. Chem. Soc*. **2004**, 126, 9926.

A: Fragmentation to form a dialkoxycarbene. **B**: Cyclopropanation. **C**: Cleavage of the cyclopropane ring.

C047

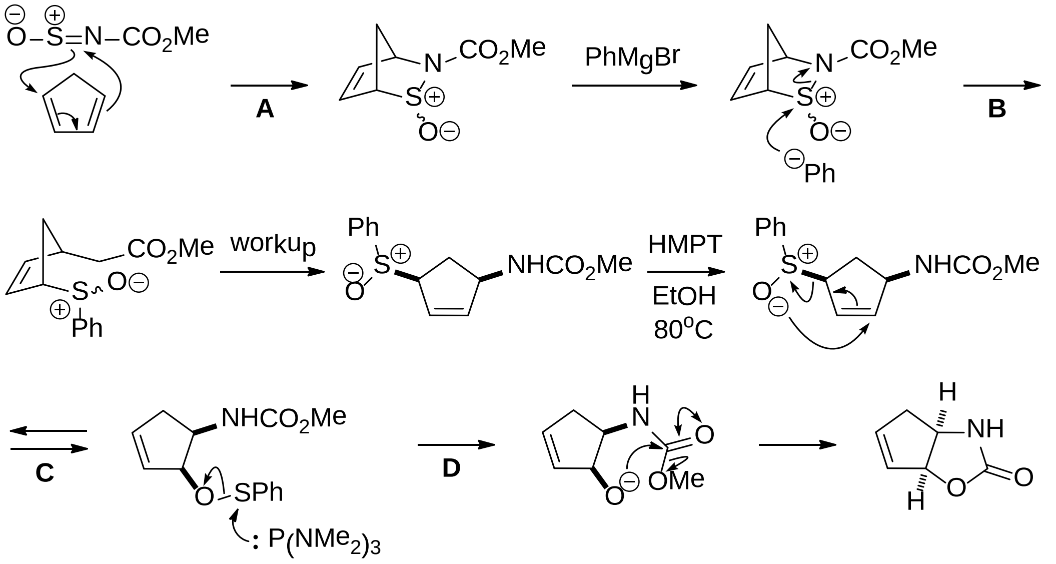




Makisumi, Y.; Takada, S. *Chem. Pharm. Bull.* **1976**, 24, 770.

A: [2,3] Sigmatropic rearrangement of the N-oxide. **B**: [3,3] Sigmatropic rearrangement.

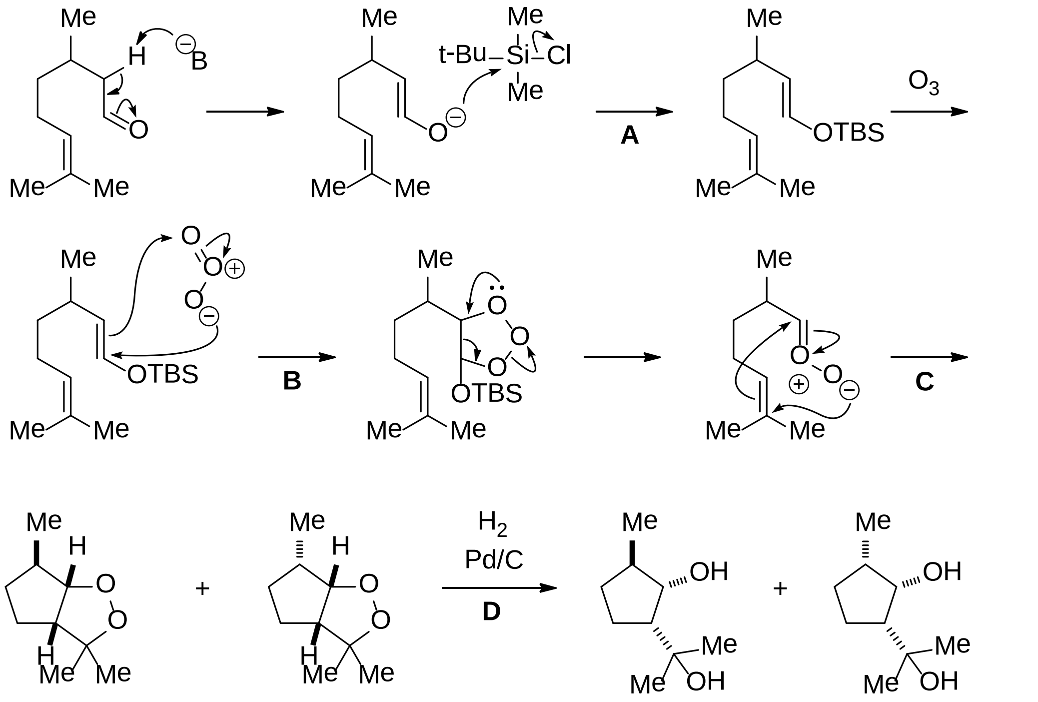
C048



Anderson, G. T.; Chase, C. E.; Koh, Y-H.; Seien, D.; Weinreb, S. M. *J. Org. Chem.* **1998**, 63, 7594.

A: Hetero-Diels-Alder reaction. **B**: Cleavage of the S-N bond by S_N2 attack of PhMgBr. **C**: [2,3] Sigmatropic rearrangement (reversible process). **D**: Irreversible cleavage of the S-O bond by attack of a thiophile ($P(NMe_2)_3$) generates an alkoxide ion which then cyclizes to give an oxazolidinone.

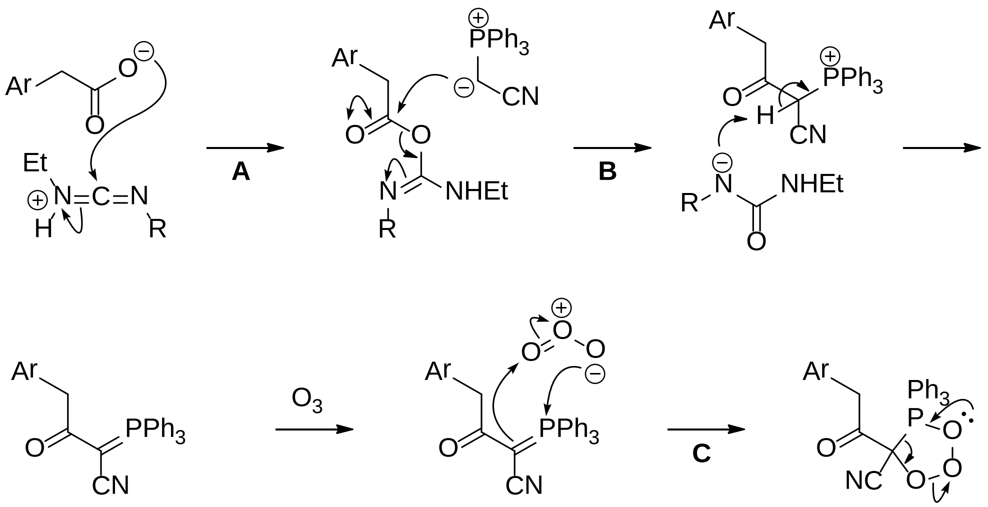
C049

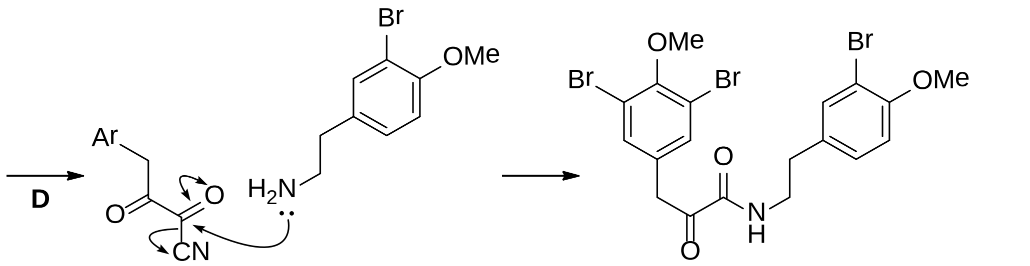


Casey, M.; Culshaw, A. J. *Synlett*

A: Formation of a silyl enol ether. **B**: 1,3-Dipolar cycloaddition of O_3 followed by cleavage of the ozonide to form a 1,3-dipole (carbonyl oxide). **C**: 1,3-Dipolar cycloaddition. **D**: Reductive cleavage of the O-O bond.

C050

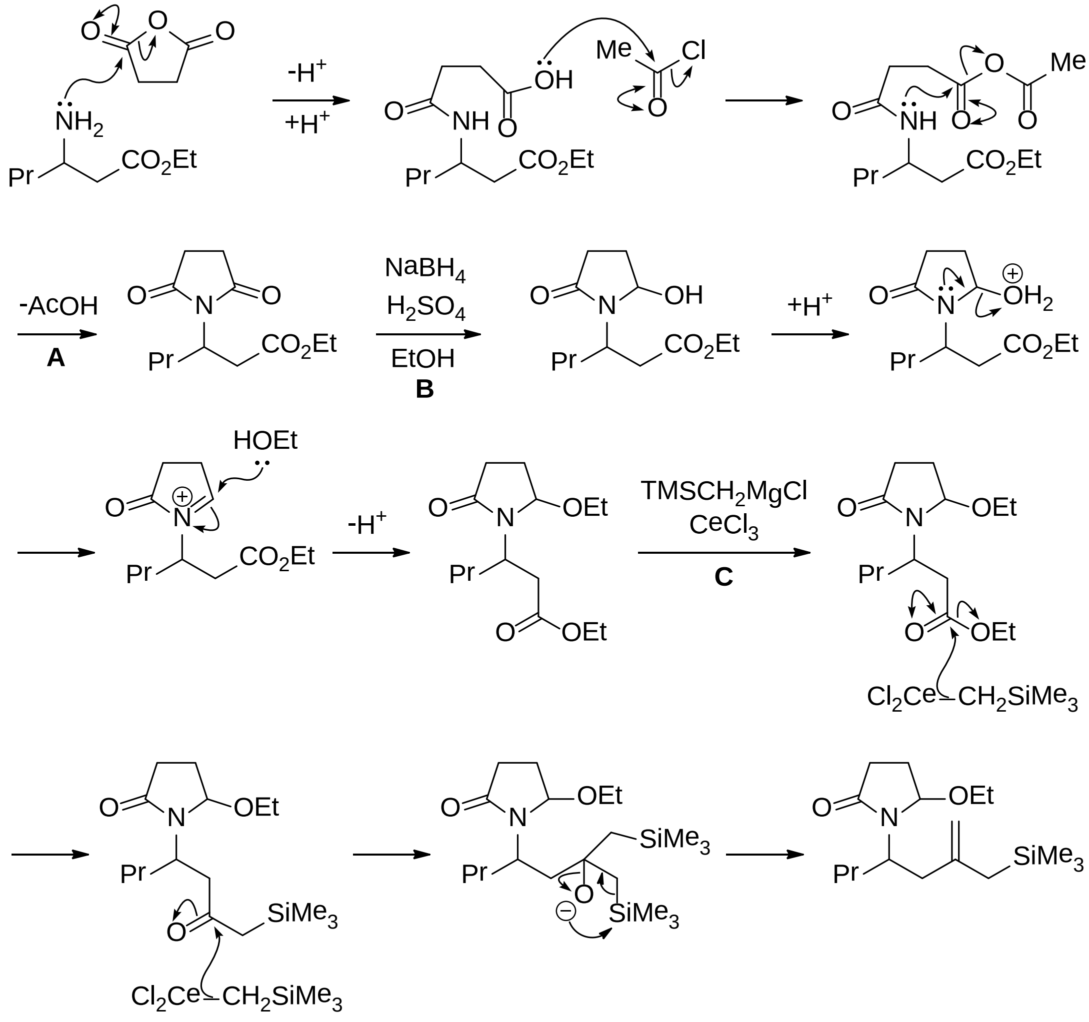


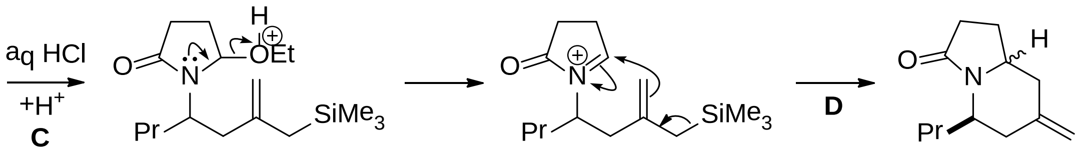


Wasserman, H. H.; Wang, J. *J. Org. Chem*. **1998**, 63, 5581.

A: Activation of the carboxylic acid as an O-acylisourea. **B**: Acylation of the stabilized ylide. **C**: 1,3-Dipolar cycloaddition of O_3 to the ylide. **D**: Fragmentation to generate an acyl cyanide.

C051

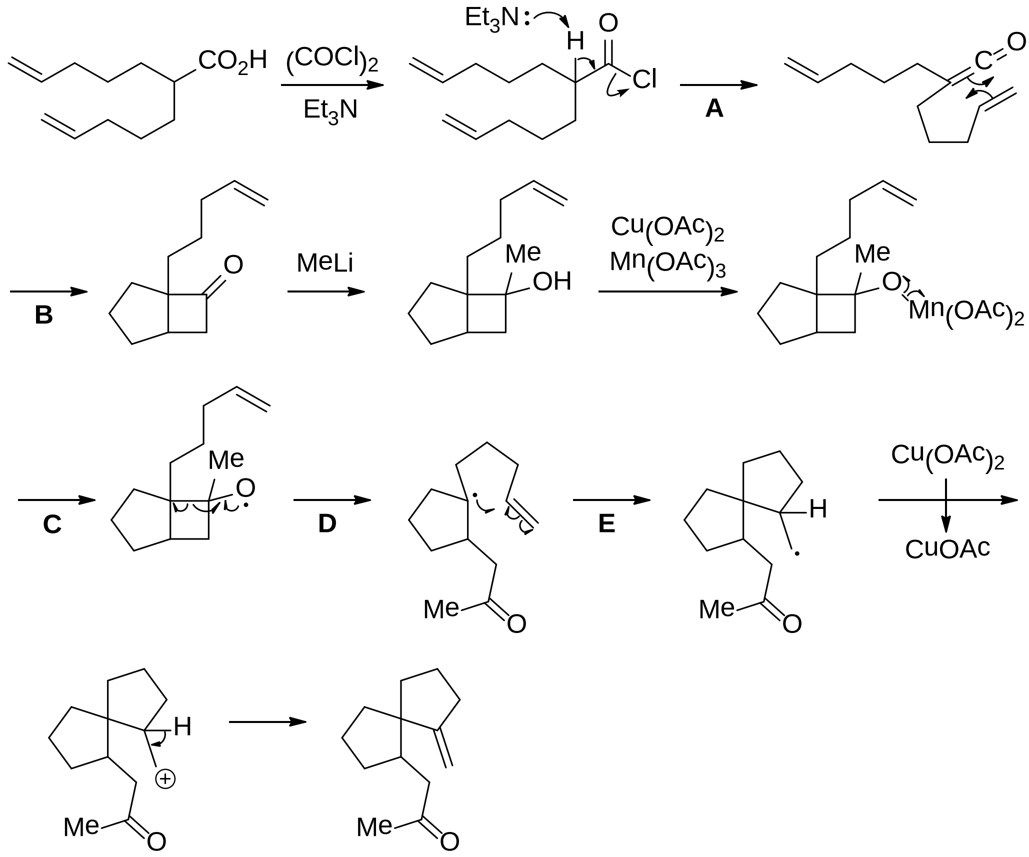




Chalard, E; Remuson, R.; Gelas-Mialhe Y.; Gramain J.-C.; Canet I. *Tetrahedron Lett.* **1999**, 40, 1661.

A: Formation of a succinimide via a mixed anhydride. **B**: Partial reduction of the imide. **C**: Peterson olefination (ref A074) to form an allylsilane. **D**: Intramolecular addition of the allylsilane to the acyliminium ion.

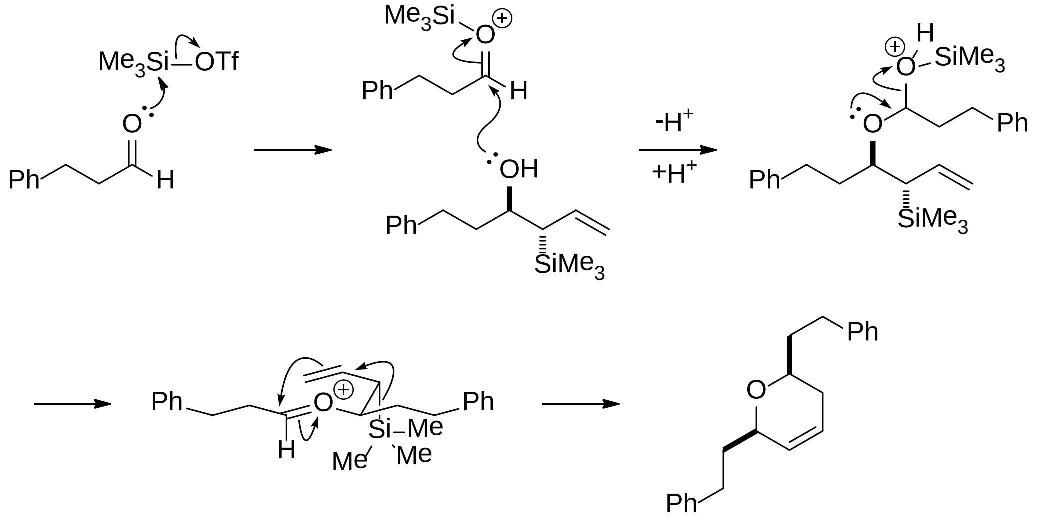
C052



Snider, B. B.; Vo, N. H.; Foxman, B. M. *J. Org. Chem*. **1993**, 58, 7228.

A: Formation of a ketene. **B**: Intramolecular [2+2] cycloaddition. **C**: Generation of an oxygen radical. **D**: Cleavage of the cyclobutane ring to form a stable tertiary carbon radical. **E**: 5-exo-trig Radical cyclization followed by oxidation with $Cu(OAc)_2$.

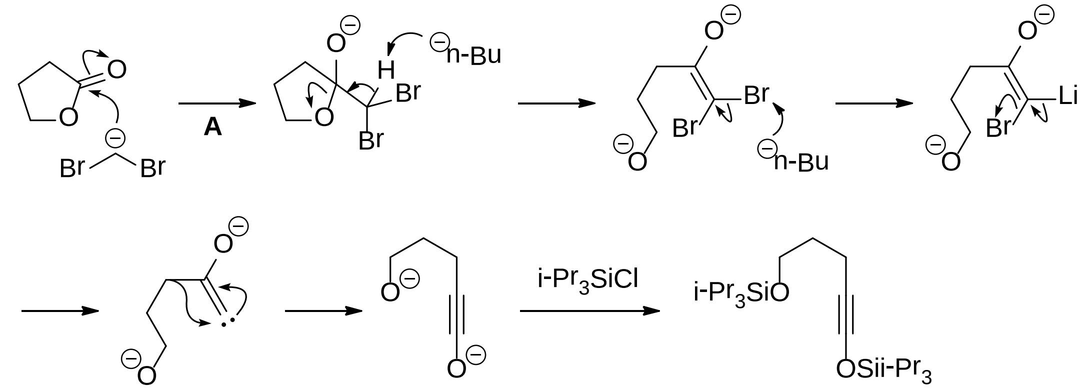
C053

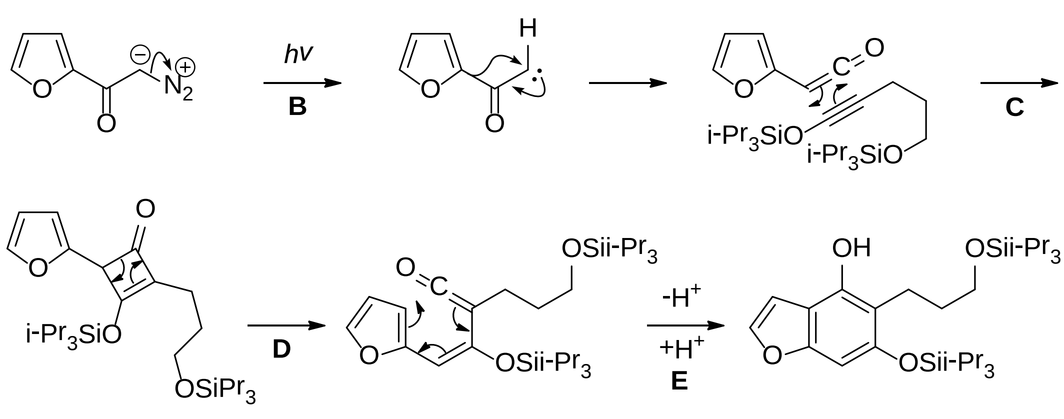


Roush, W. R.; Dilley, G. J. *Synlett.* **2001**, 955

Intramolecular Hosomi-Sakurai-type reaction.

C054

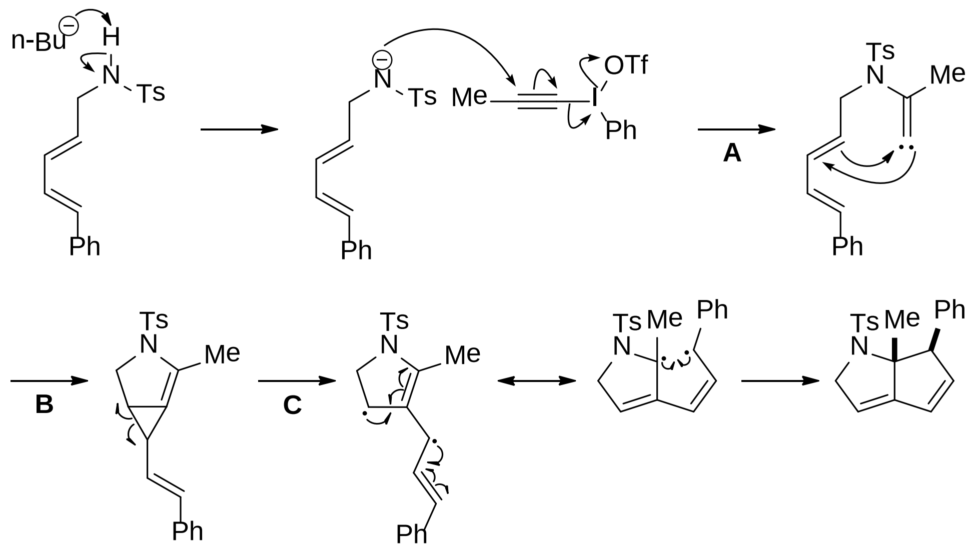




Danheiser, R. L.; Trova, M. P. *Synlett.* **1995**, 573.

A: Formation of an alkylidene carbene via α-elimination followed by insertion of the carbene into the C-C bond (Kowalski reaction). **B**: Wolff rearrangement. **C**: [2+2] Ketene cycloaddition. **D**: 4e Electrocyclic reaction. **E**: 6e Electrocyclic reaction followed by aromatization.

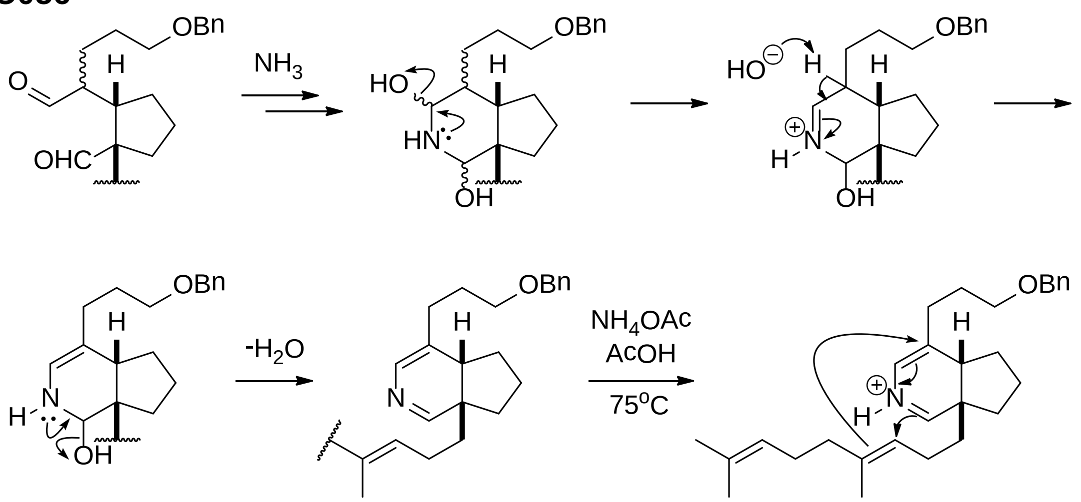
C055

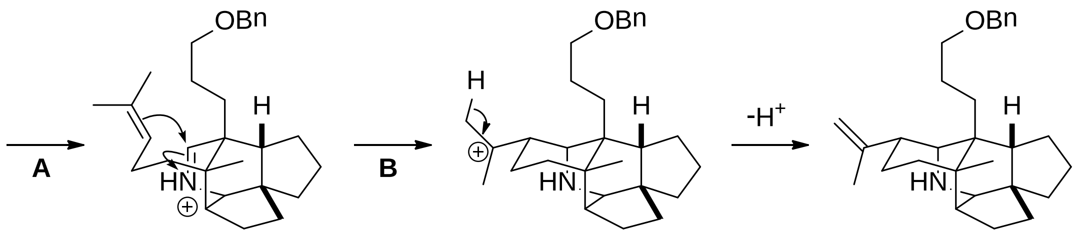


Feldman, K. S.; Mareska, D. A. *J. Org. Chem*. **1999**, 64, 5650.

A: Addition of a sulfonamide ion to the electron-deficient acetylene to form an alkylidene carbene. **B**: Cyclopropanation. **C**: Homolytic cleavage of the strained cyclopropylidene ring.

C056

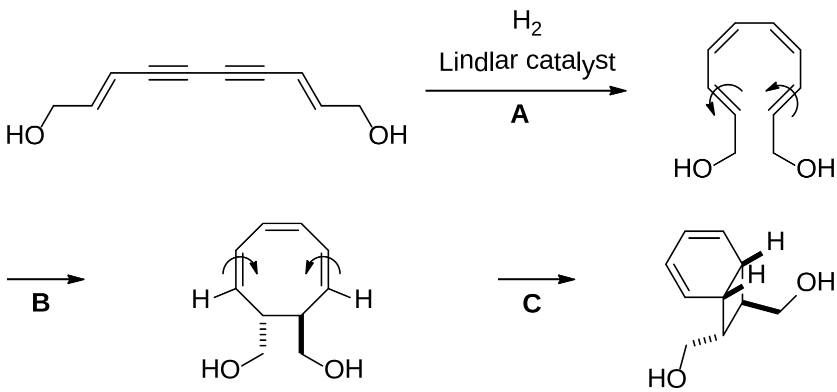




Heathcock, C. H.; Stafford, J. A. *J. Org. Chem*. **1992**, 57, 2566.

A: Aza-Diels-Alder reaction. **B**: Cation-olefin cyclization.

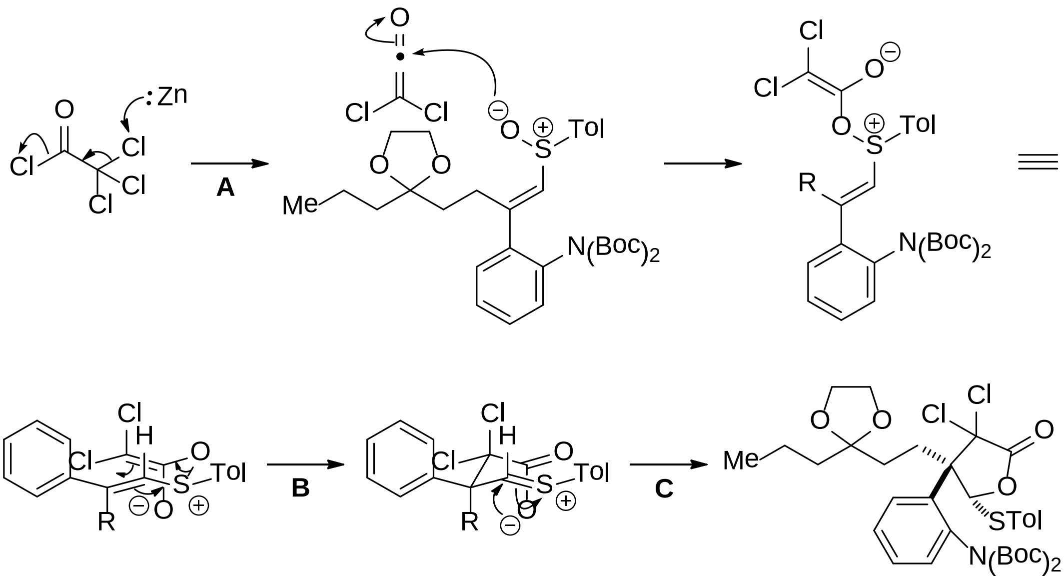
C057



Nicolaou, K. C.; Petasis, N. A.; Zipkin, R. E.; Uenishi, J.
J. Am. Chem. Soc. **1982**, 104, 5555.

A: Partial reduction of the alkynes to form a tetraene. **B**: 8e Conrotatory electrocyclic reaction. **C**: 6e Disrotatory electrocyclic reaction.

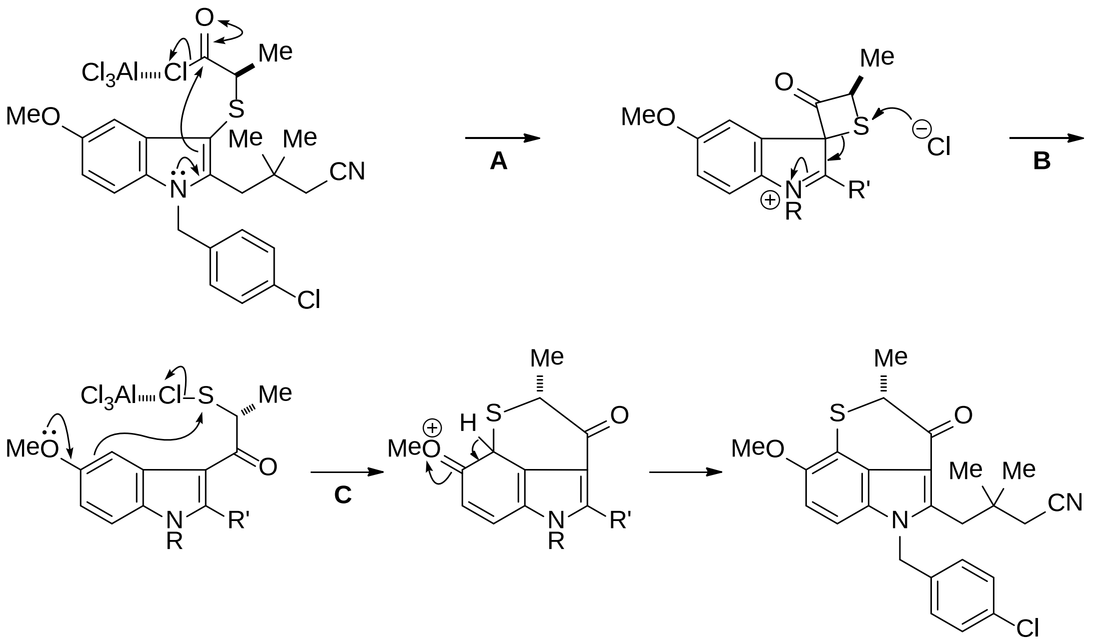
C058



Marino, J. P.; Rubio, M. B.; Cao, G.; de Dios, A.
J. Am. Chem. Soc. **2002**, 124, 13398.

A: Generation of dichloroketene. **B**: [3,3] Sigmatropic rearrangement. **C**: Cyclization of the carboxylate to the sulfenium ion.

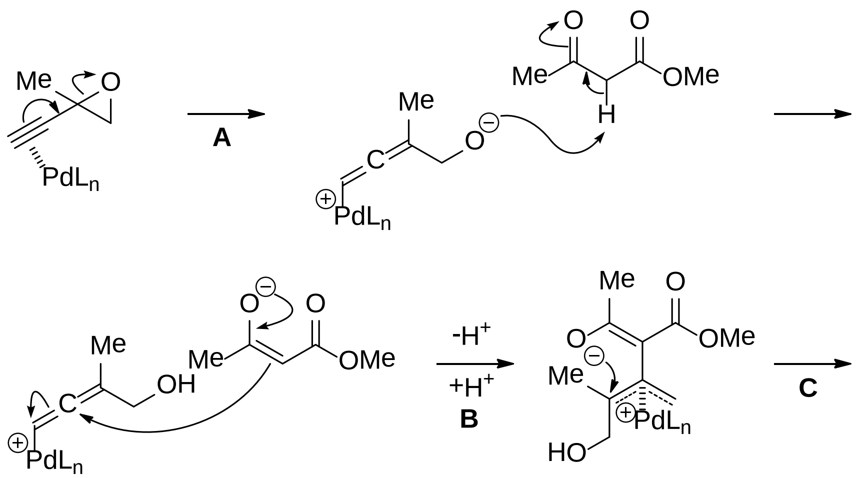
C059

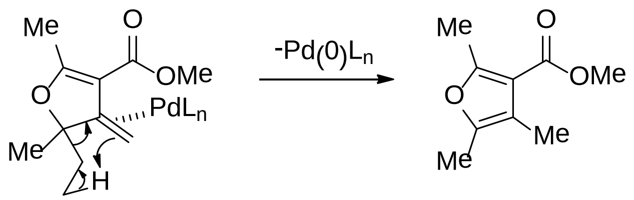


Chung, J. Y. L.; Reamer, R. A.; Reider, P. J. *Tetrahedron Lett.* **1992**, 33, 4717.

A: Friedel-Crafts acylation at the indole 3-position. **B**: Cleavage of the strained four-membered ring by chloride ion. **C**: Intramolecular electrophilic substitution by the resulting sulfenyl chloride.

C060

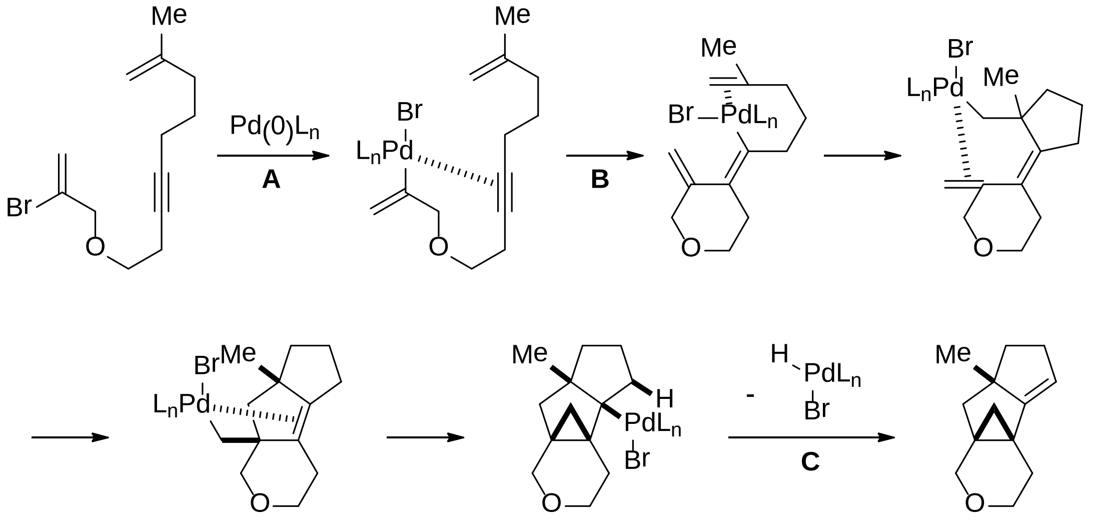




Minami, I.; Yuhara, M.; Tsuji, J. *Tetrahedron Lett.* **1987**, 28, 629.

A: Formation of an allenylpalladium species. **B**: Addition of the acetoacetate anion to generate a π-allylpalladium complex. **C**: Intramolecular nucleophilic attack to the π-allylpalladium complex.

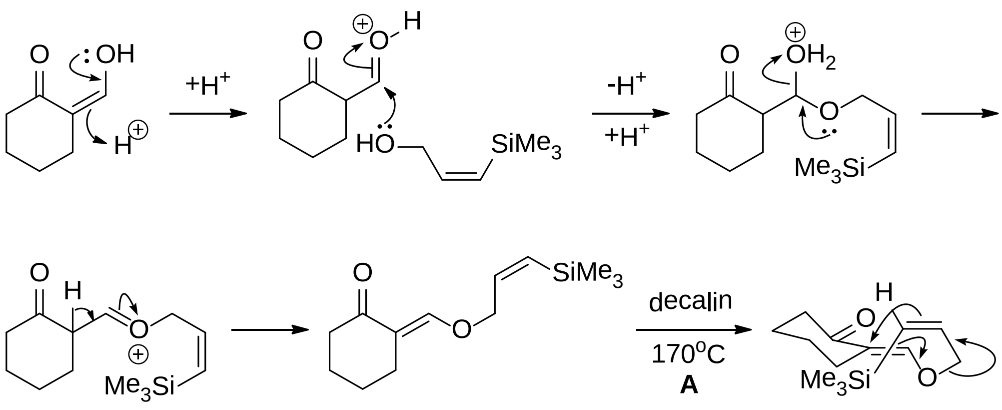
C061

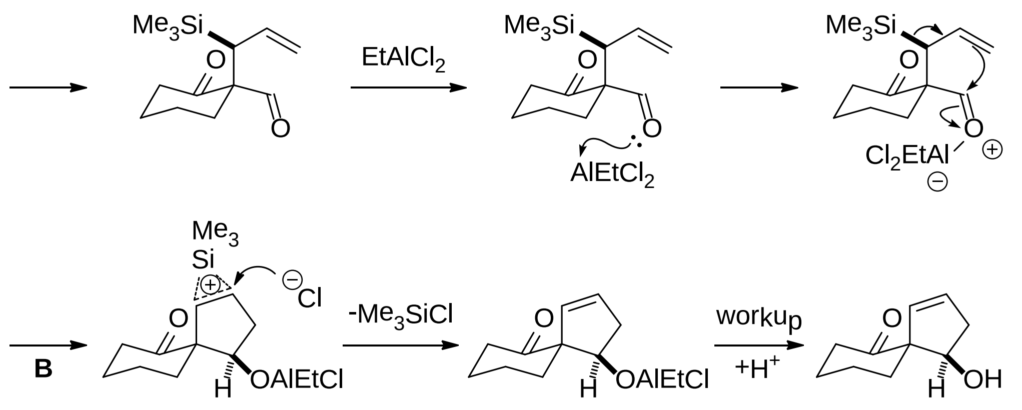


Meyer, R E.; Parsons, P. J.; de Meijere, A. *J. Org. Chem.* **1991**, 56, 6487.

A: Oxidative addition. **B**: Sequential intramolecular carbopalladation. **C**: β-Elimination.

C062

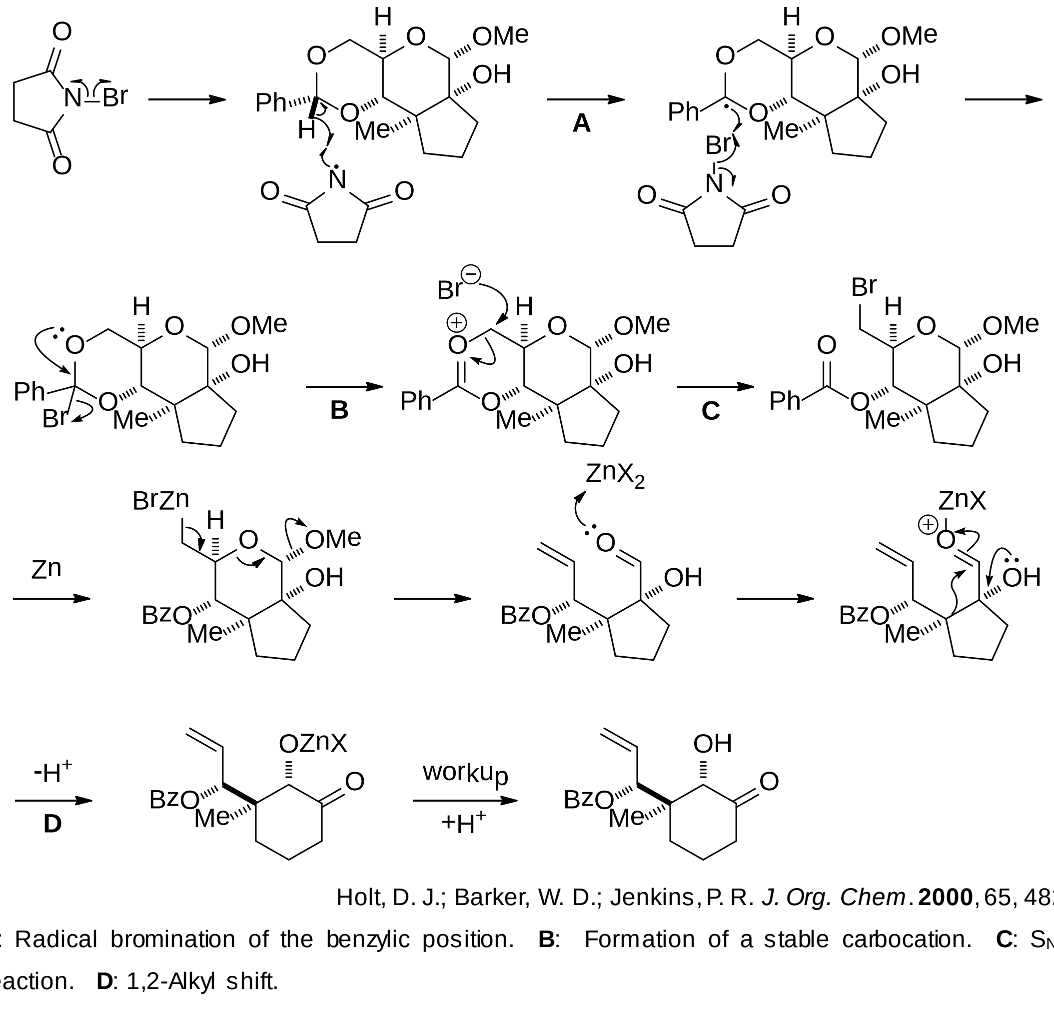




Paquette, L. A.; Ladouceur, G. *J. Org. Chem*. **1989**, 54, 4278.

A: Claisen rearrangement via a boat-like transition state. **B**: Intramolecular Hosomi-Sakurai reaction.

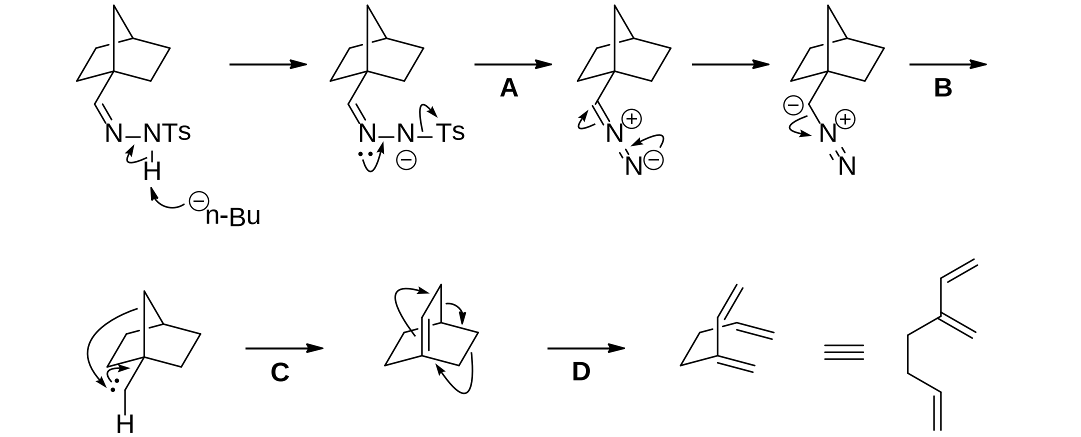
C063



Holt, D. J.; Barker, W. D.; Jenkins, P. R. *J. Org. Chem*. **2000**, 65, 482.

A: Radical bromination of the benzylic position. **B**: Formation of a stable carbocation. **C**: S_N2 reaction. **D**: 1,2-Alkyl shift.

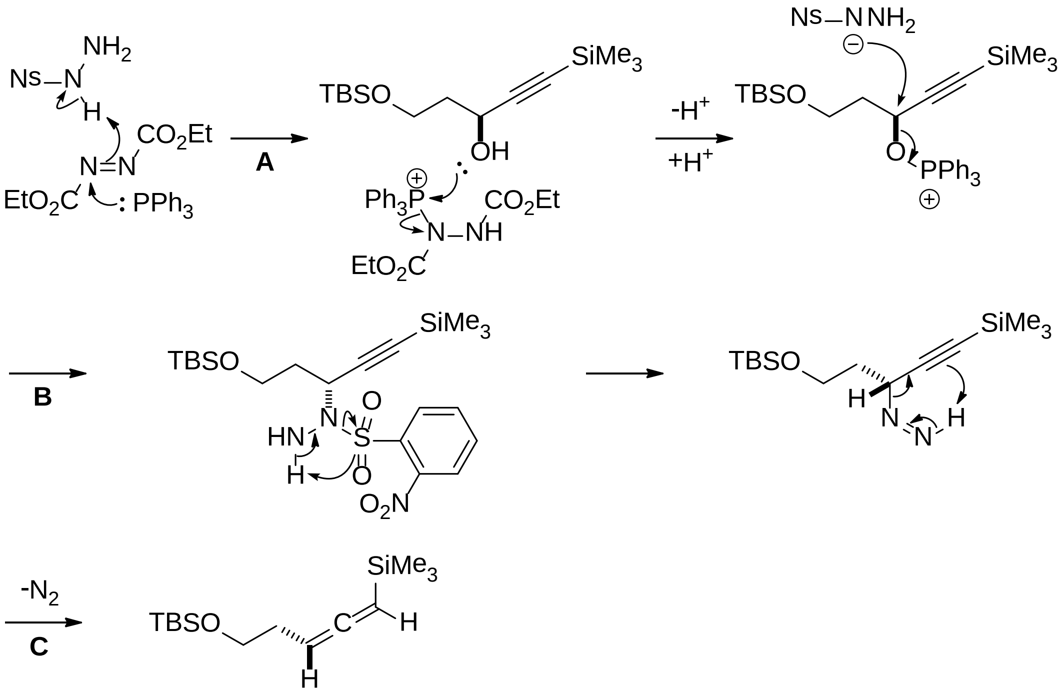
C064



Bian, N.; Jones, M., Jr. *Tetrahedron Lett.*, **1993**, 25, 3967.

A: Formation of a diazoalkane via α-elimination. **B**: Elimination of N_2 to form a carbene. **C**: Insertion of the carbene to the C-C bond. **D**: Retro Diels-Alder reaction.

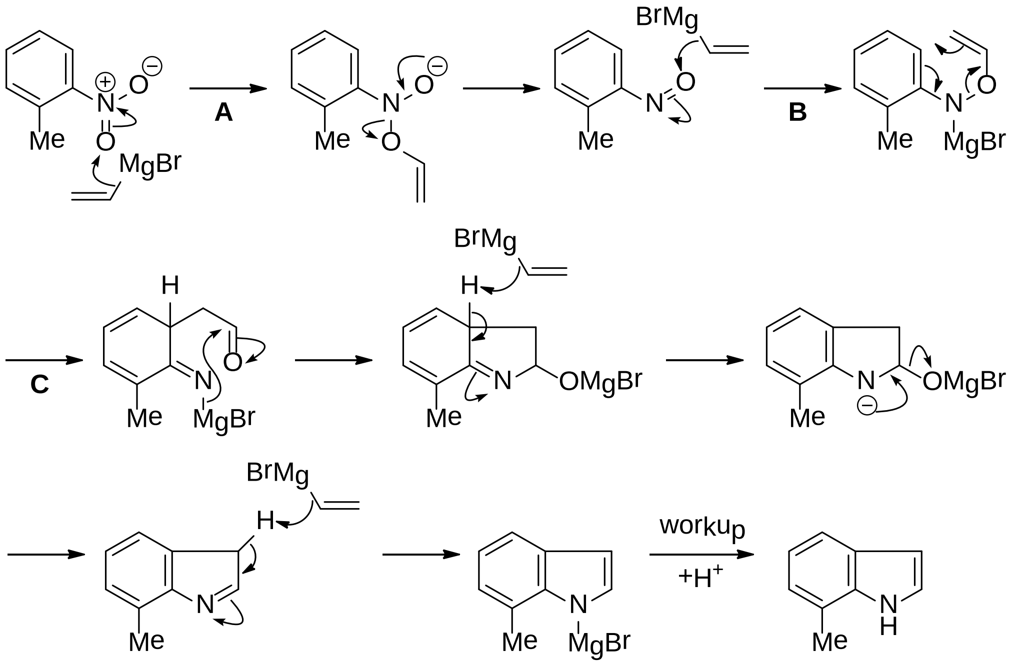
C065



Myers, A. G.; Zheng, B. *J. Am. Chem. Soc.* **1996**, 118, 4492.

A: Mitsunobu reaction (ref A045). **B**: Elimination of a sulfinic acid. **C**: Sigmatropic elimination of N_2 (stereospecific delivery of a hydride via a concerted mechanism).

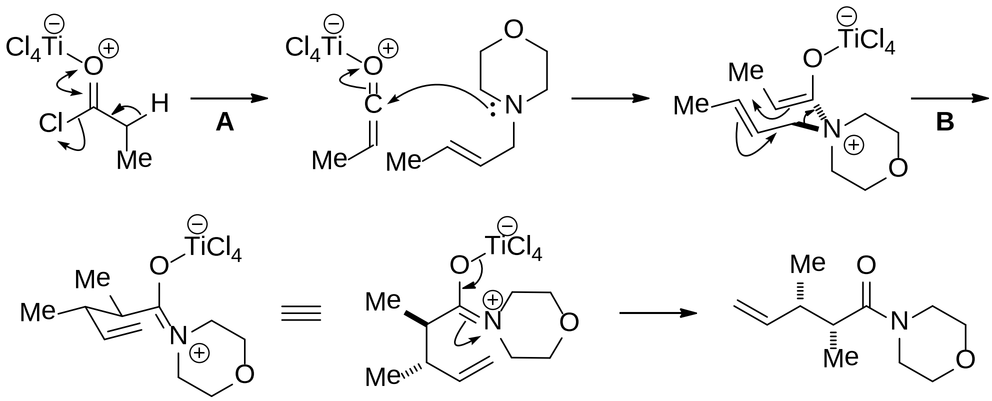
C066



Bosco, M.; Dalpozzo, R.; Bartoli, G.; Palmieri, G.; Petrini, M.
J. Chem. Soc., Perkin Trans. 2 **1991**, 657.

Bartoli indole synthesis. **A**: Reduction of the nitro group by means of addition of CH_2=CHMgBr and elimination of an enolate to form a nitroso compound. **B**: Addition of CH_2=CHMgBr to the nitroso group. **C**: [3,3] Sigmatropic rearrangement.

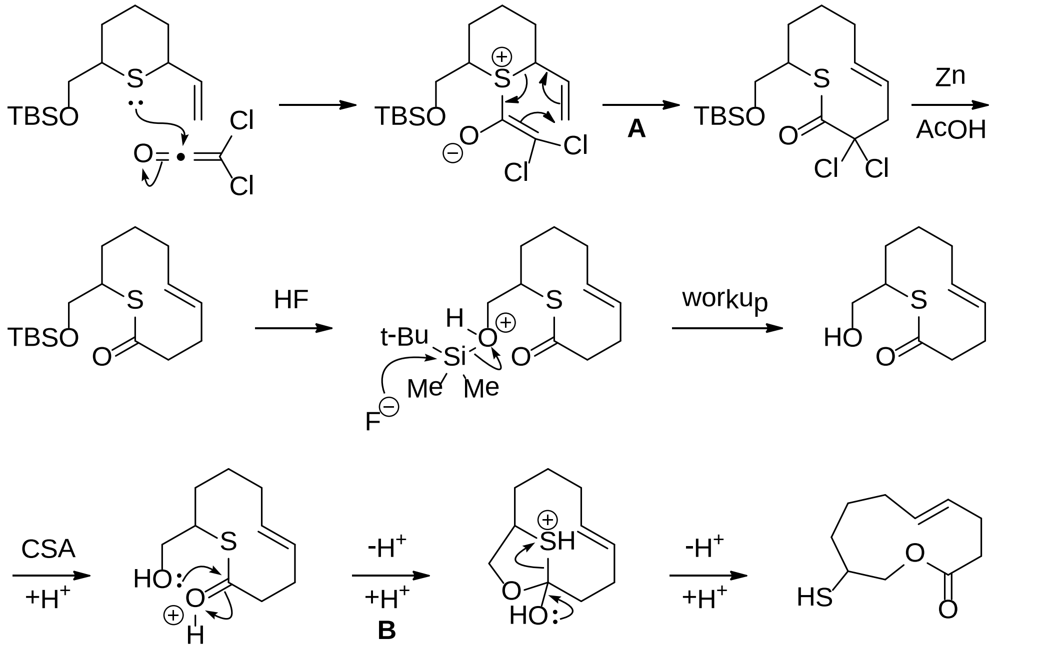
C067



Yoon, T. P.; Dong, V. M.; MacMillan, D. W. C. *J. Am. Chem. Soc.* **1999**, 121, 9726.

A: Formation of a ketene. **B**: Aza-Claisen rearrangement through a chair-like transition state.

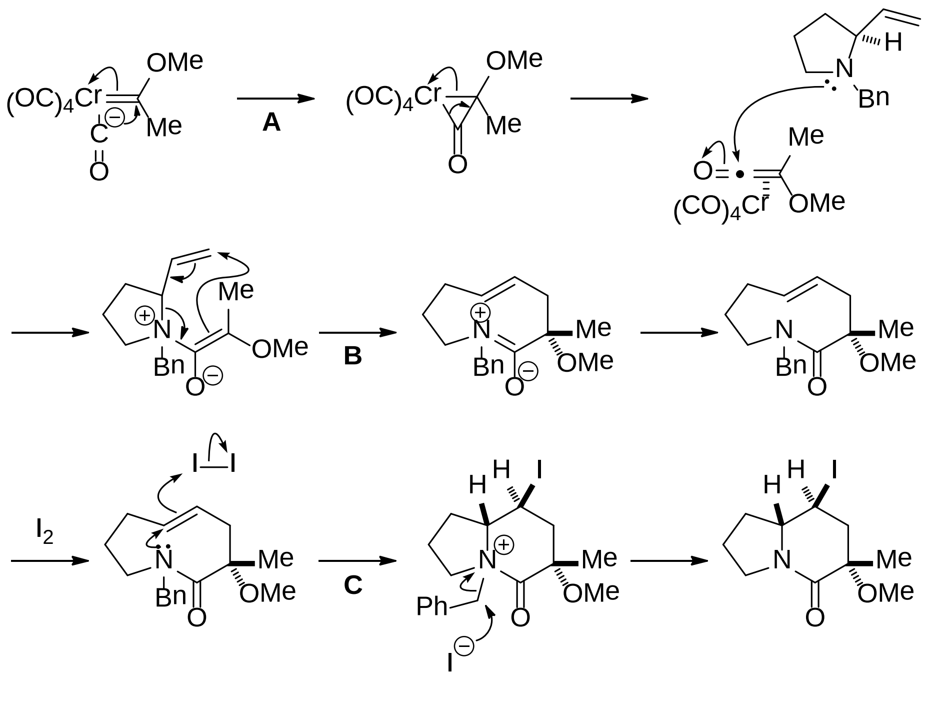
C068



Vedejs, E.; Buchanan, R. A. *J. Org. Chem*. **1984**, 49, 1840.

A: [3,3] Sigmatropic rearrangement. **B**: Intramolecular acyl transfer reaction.

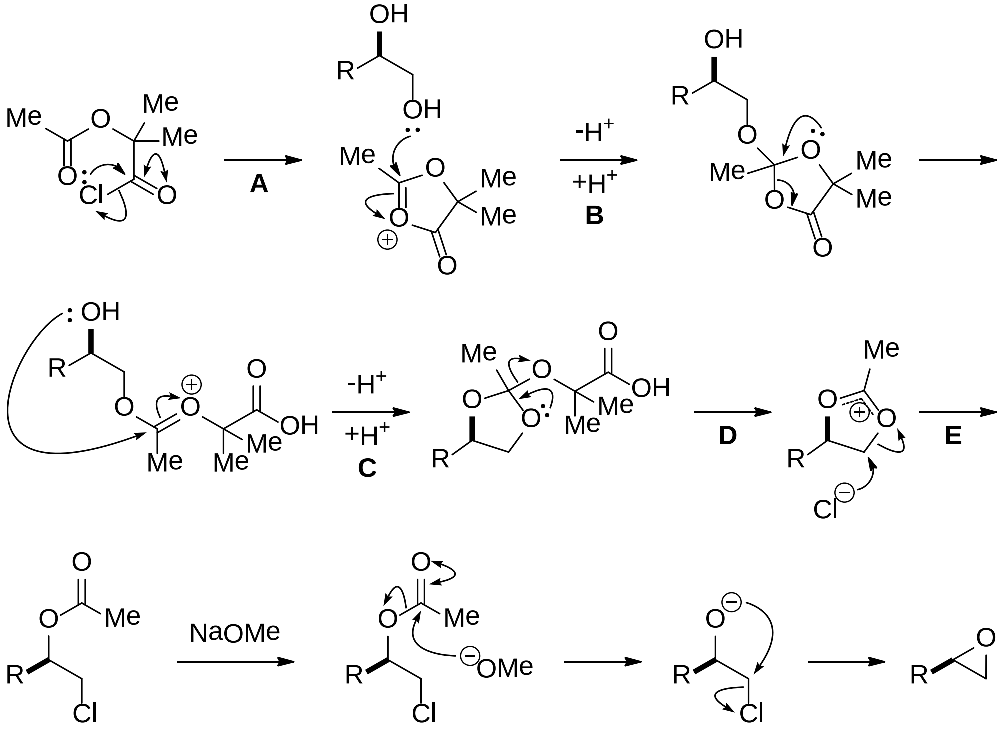
C069



eur, C. J.; Miller, M. W.; Hegedus, L. S. *J. Org. Chem*. **1996**, 61, 2871.

A: Photo-induced insertion of CO to form a ketene. **B**: Aza-Claisen rearrangement. **C**: Intramolecular iodoamidation followed by debenzylation in an S_N2 fashion.

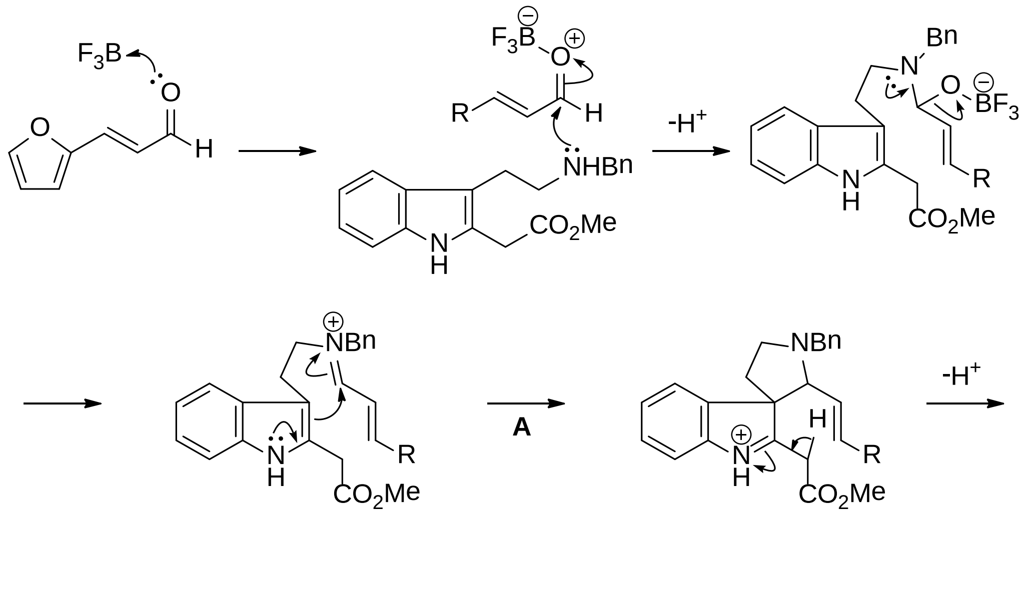
C070

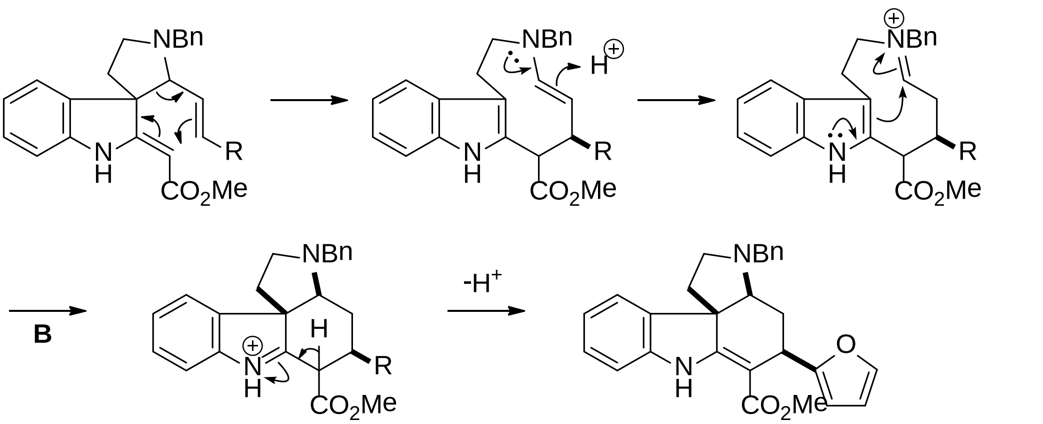


Schreiber, S. L.; Sammakia, T.; Uehling, D. E. *J. Org. Chem*., **1989**, 54, 15.

A: Activation by cyclization. **B**: Formation of an orthoester followed by cleavage of the five-membered lactone. **C**: Intramolecular interception of the stable carbocation by the secondary alcohol. **D**: Cleavage of the resulting orthoester. **E**: S_N2 reaction at the less hindered carbon with chloride ion.

C071

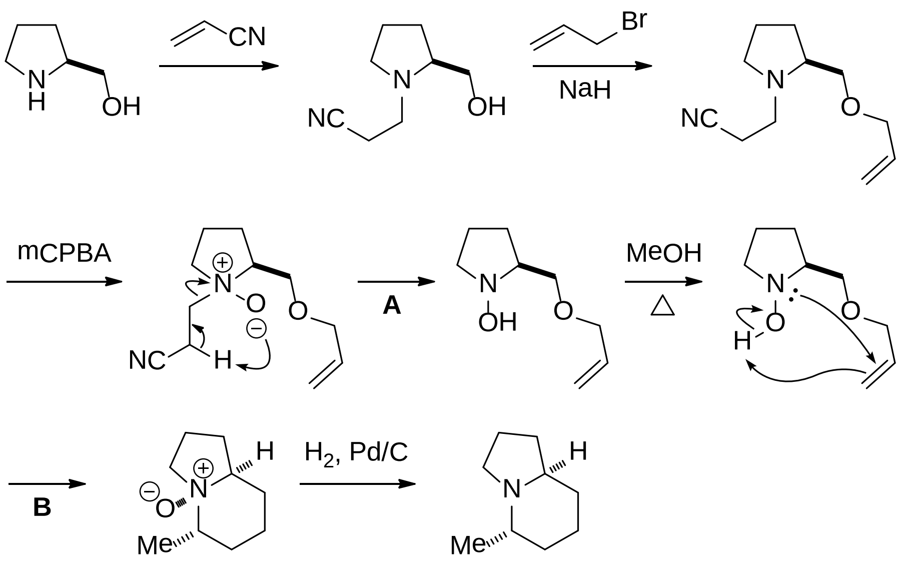




Parsons R. L.; Berk J. D.; Kuehne M. E. *J. Org. Chem*. **1993**, 58, 7482.

A: Mannich reaction followed by [3,3] sigmatropic rearrangement. **B**: Mannich reaction.

C072

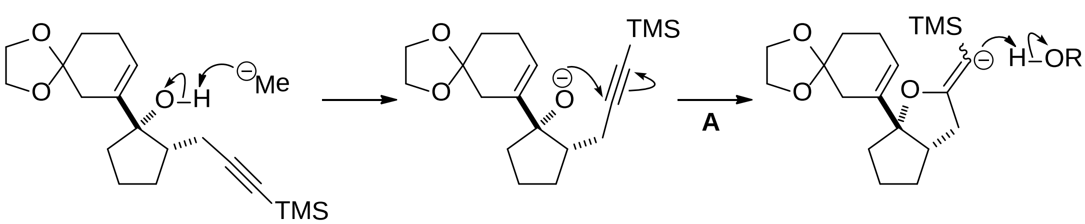


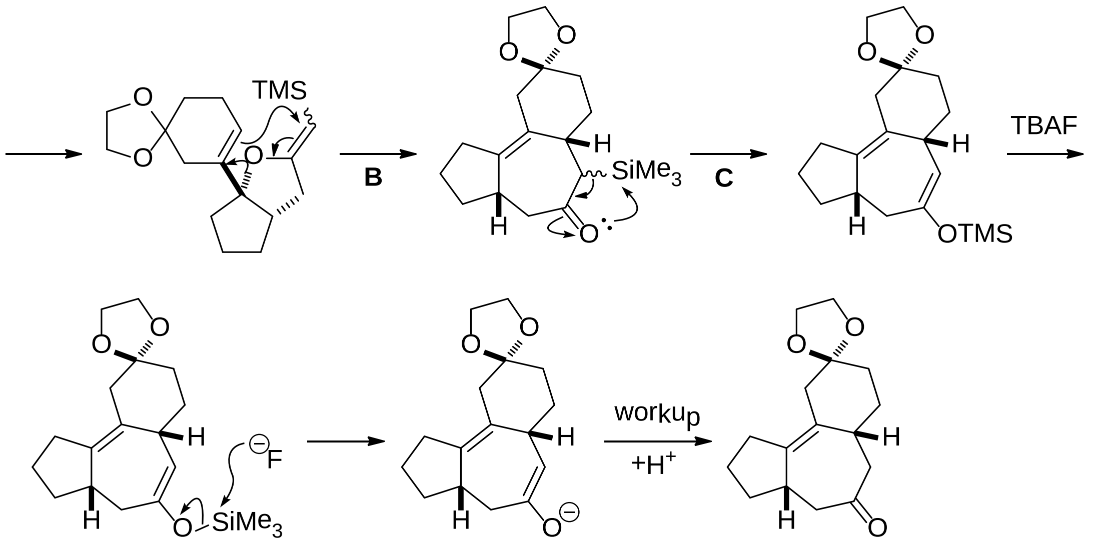
O'Neil, I. A.; Cleator, E.; Ramos, V. E.; Chorlton, A. P.; Tapolczay, D. J.

Tetrahedron Lett. **2004**, 45, 3655.

A: Cope elimination. **B**: Retro Cope elimination.

C073

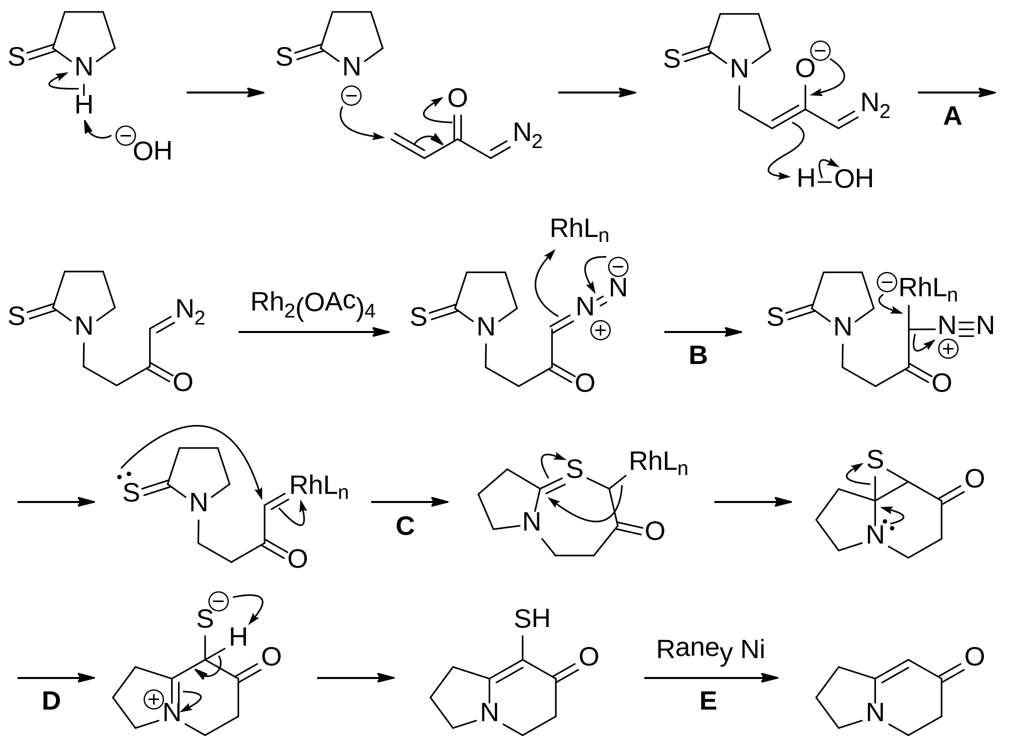




Ovaska, T. V.; Roses, J. B. *Org. Lett.* **2000**, 2, 2361.

A: 5-exo-dig Cyclization of the alkoxide ion. **B**: Claisen rearrangement. **C**: Migration of the silyl group to form a silyl enol ether.

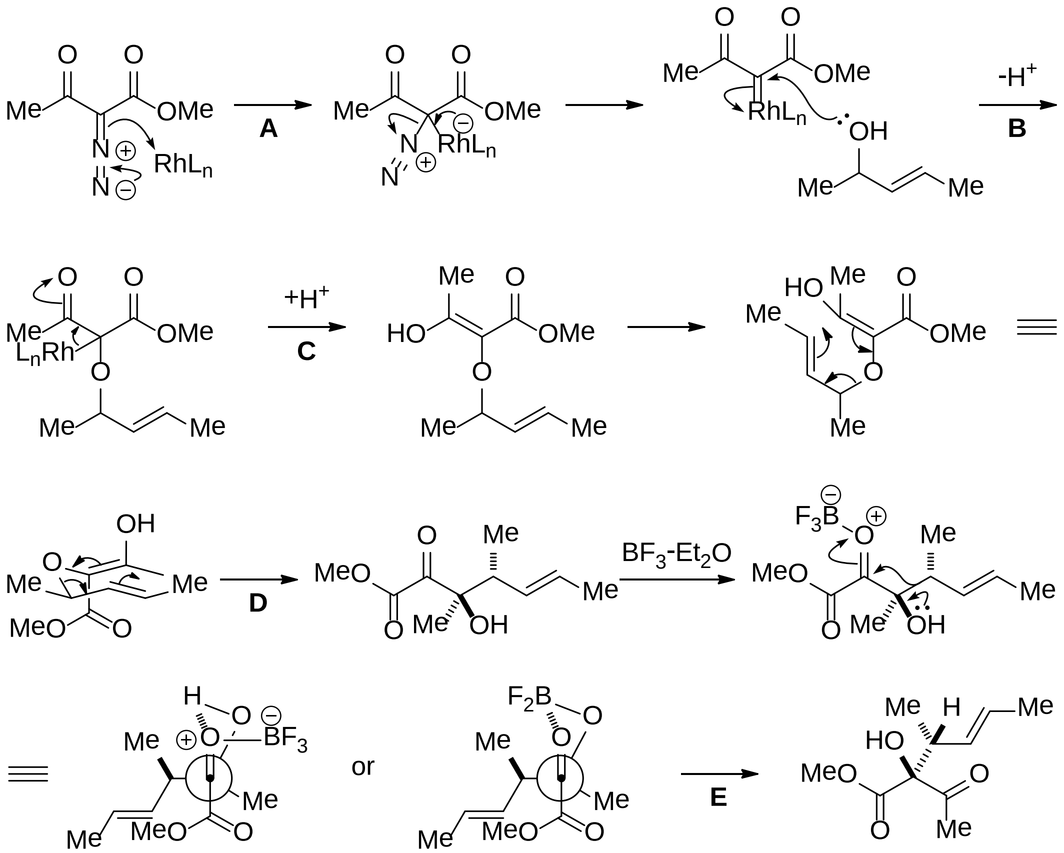
C074



Fang, F. G.; Prato, M.; Kim, G.; Danishefsky, S. J. *Tetrahedron Lett.* **1989**, 30, 3625.

A: Conjugate addition of a thiolactam anion. **B**: Formation of a rhodium carbene complex. **C**: Attack of the sulfur atom to the rhodium carbene complex followed by formation of a thiirane. **D**: Cleavage of the thiirane assisted by the nitrogen lone pair. **E**: Desulfurization.

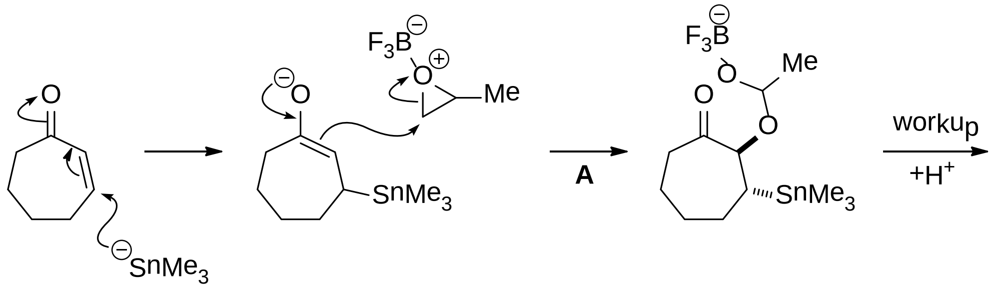
C075

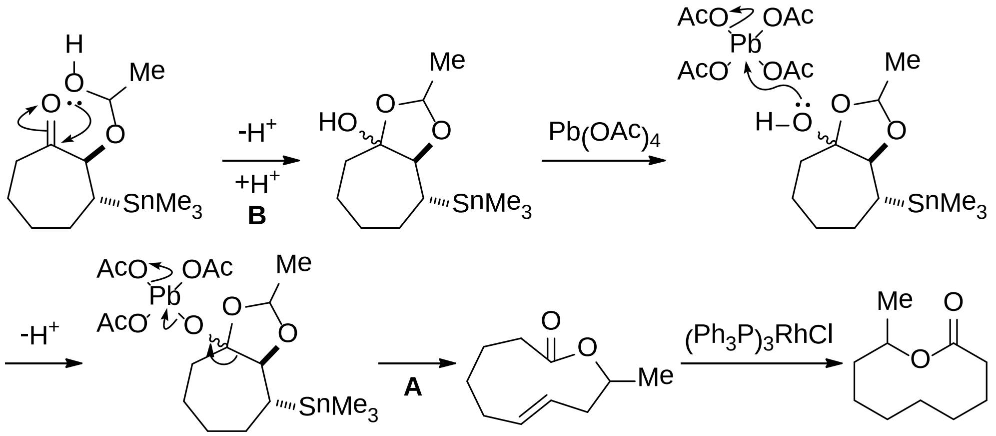


Drutu, I.; Krygowski, E. S.; Wood, J. L. *J. Org. Chem.* **2001**, 66, 7025.

A: Formation of a rhodium carbene complex. **B**: Addition of an alcohol to the carbene complex. **C**: Formation of an (Z)-enol. **D**: [3,3] Sigmatropic rearrangement via a chair-like transition state. **E**: 1,2-Migration through a synperiplanar transition state.

C076

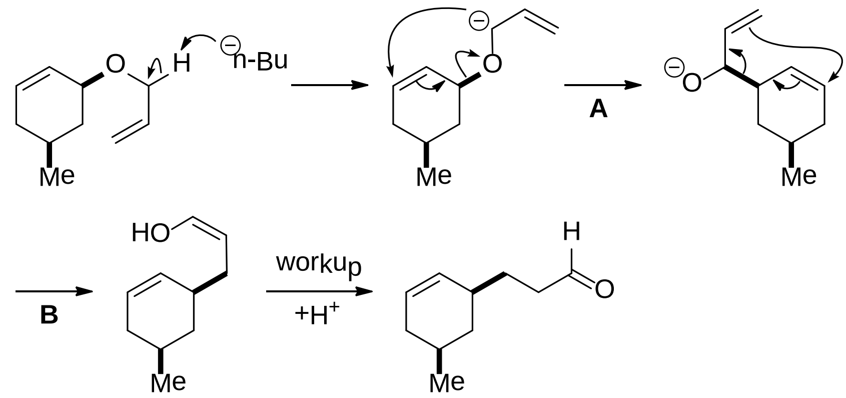




Posner, G. H.; Wang, Q.; Halford, B. A.; Elias, J. S.; Maxwell, J. P. *Tetrahedron Lett*. **2000**, 41, 9655.

A: Attack to the epoxide takes place from the less hindered side to form the trans-product. **B**: Formation of a hemiacetal. **C**: Oxidative fragmentation induced by $Pb(OAc)_4$.

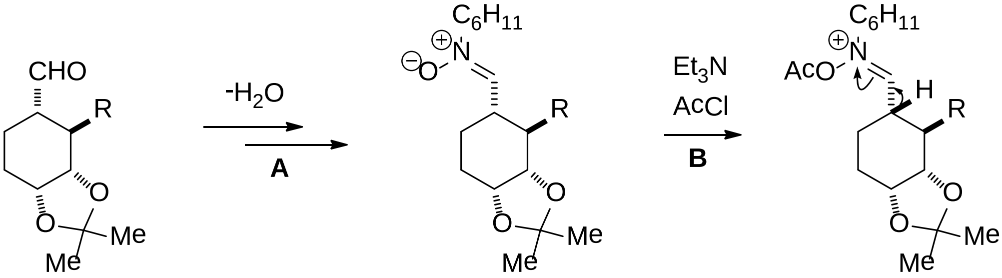
C077

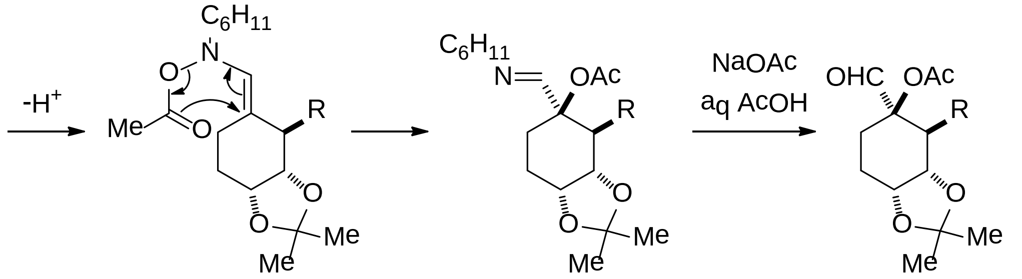


Sayo, N.; Kimura, Y.; Nakai, T. *Tetrahedron Lett*. **1982**, 23, 3931.

A: [2,3] Wittig rearrangement. **B**: Oxy-Cope rearrangement.

C078

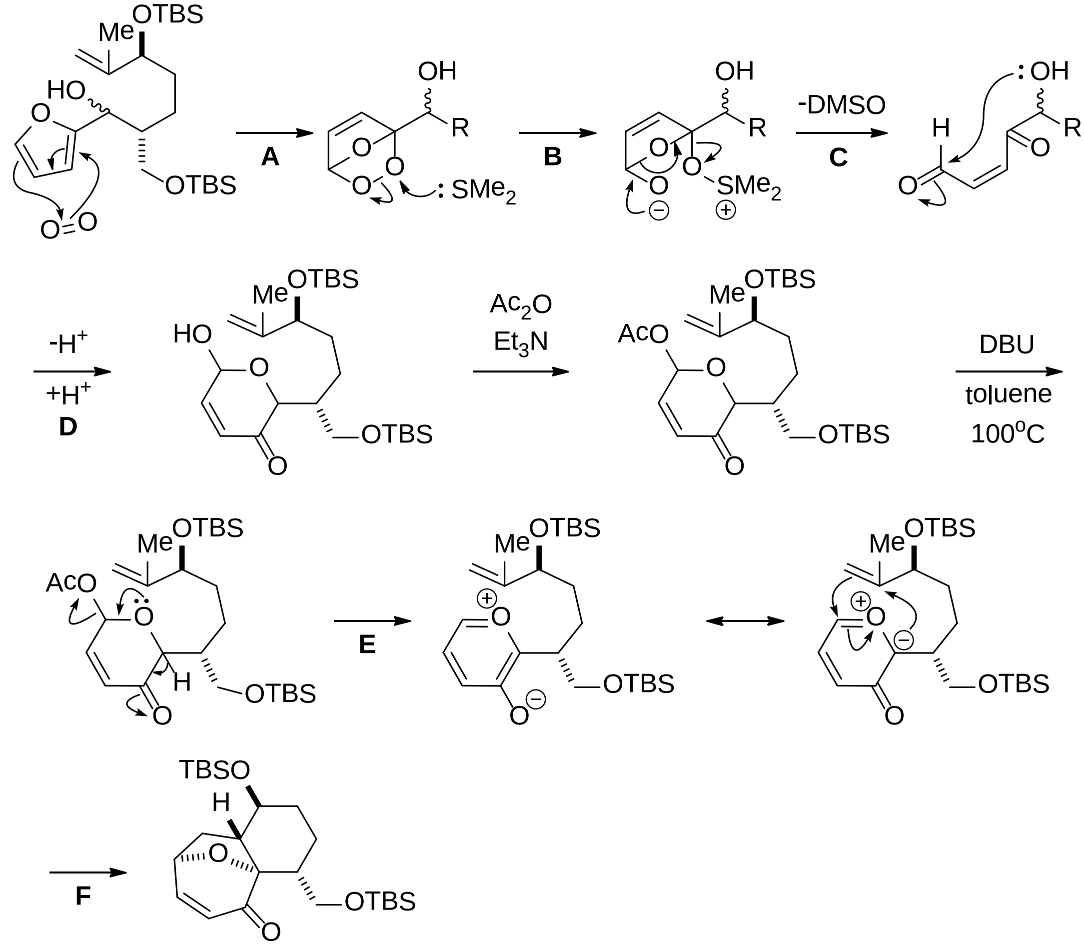




Vosburg, D. A.; Weiler, S.; Sorensen, E. J. *Angew. Chem. Int. Ed.* **1999**, 38, 971.

A: Formation of a nitrone. **B**: Acetylation followed by [3,3] sigmatropic rearrangement.

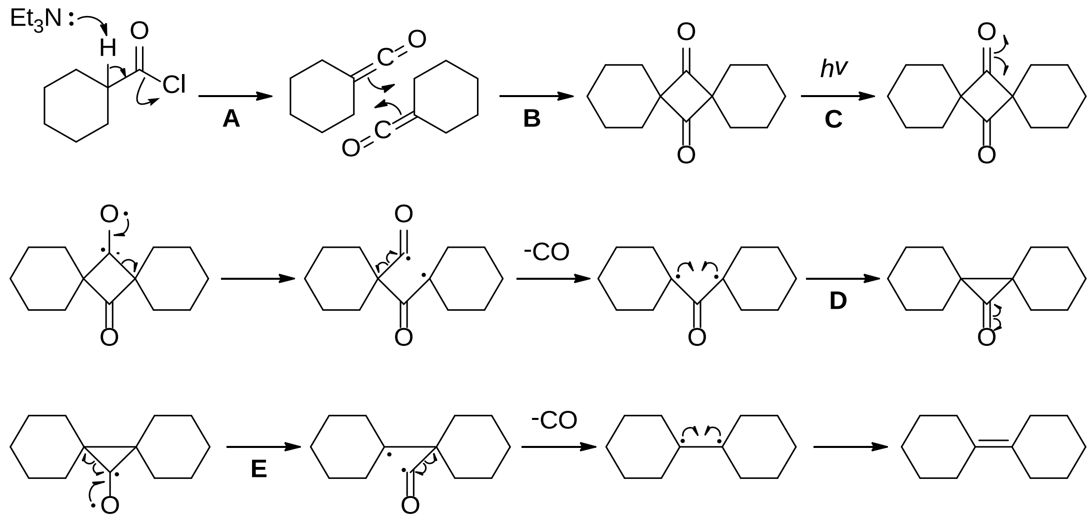
C079



Bauta, W. E.; Booth, J.; Bos, M. E.; DeLuca, M.; Diorazio, L.; Donohoe, T. J.; Frost, C.; Magnus, N.; Magnus, P.; Mendoza, J.; Pye, E; Tarrant, J. G.; Thom, S.; Ujjainwalla, F. *Tetahedron.* **1996**, 52, 14081.

Achmatowicz reaction (A-D). **A**: Diels-Alder reaction of singlet oxygen. **B**: Reductive cleavage of the endoperoxide with Me_2S. **C**: Elimination of DMSO to form cis-enal. **D**: Cyclization to form a lactol. **E**: Generation of a pyrylium ion (or a carbonyl ylide). **F**: 1,3-Dipolar cycloaddition.

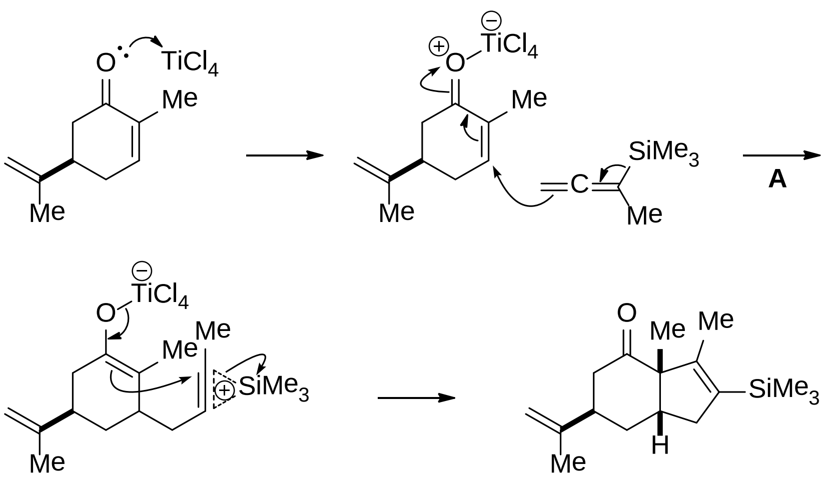
C080



Turro, N. J.; Leermakers, P. A. Vesley, G. E *Org. Synth., Coll*. Vol Ⅴ **1973**, 297

A: Formation of a ketene. **B**: [2+2] Head-to-tail dimerization of a hindered ketene. **C**: Norrish type I cleavage of the ketone followed by decarbonylation to form a diradical. **D**: Recombination of the diradical.

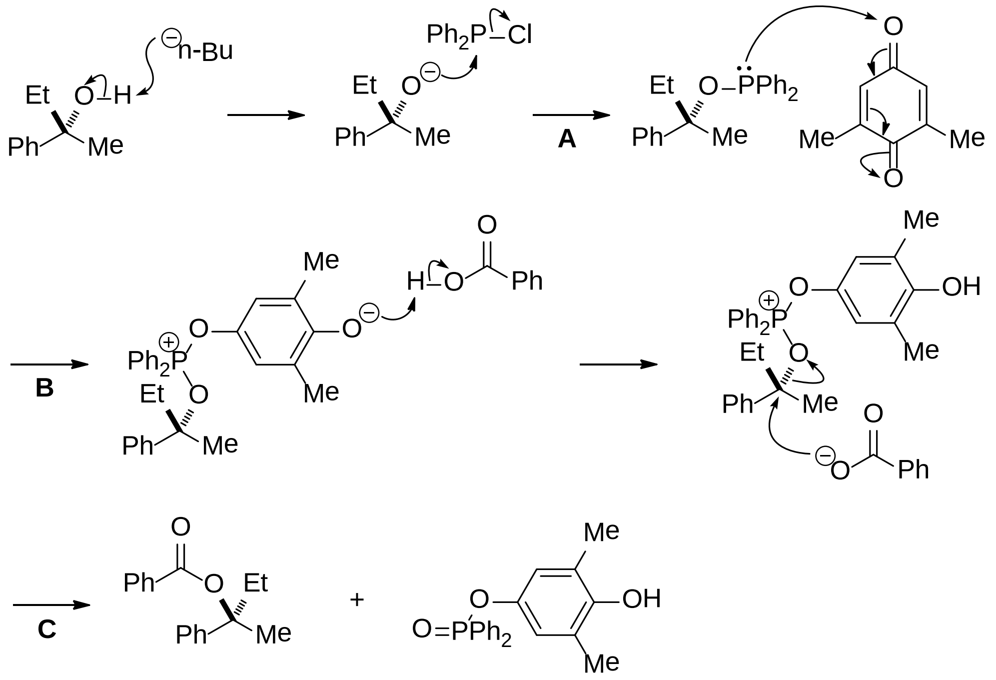
C081



Danheiser, R. L.; Fink, D. M.; Tsai, Y.-M. *Org. Synth., Coll*. Vol. Ⅷ **1993**, 347.

Danheiser annulation. **A**: Conjugate addition of the allenylsilane to form a carbocation stabilized by the silicon atom.

C082

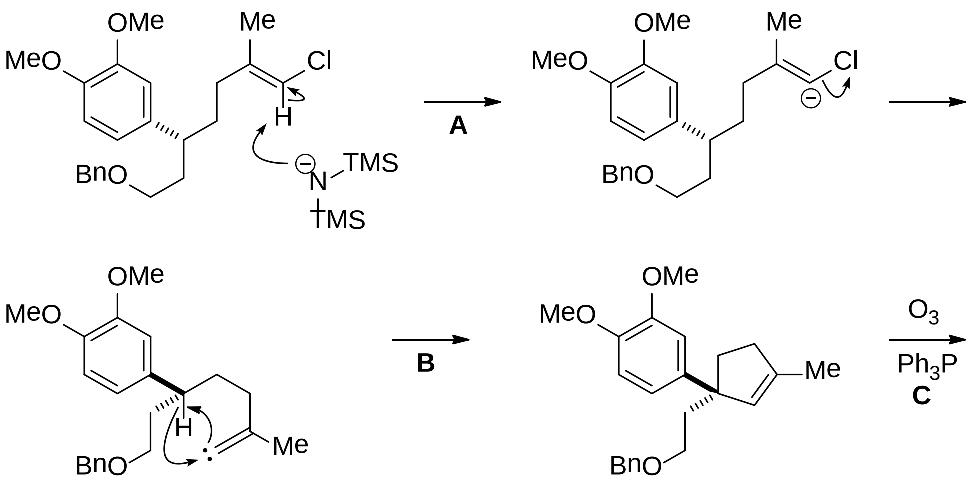


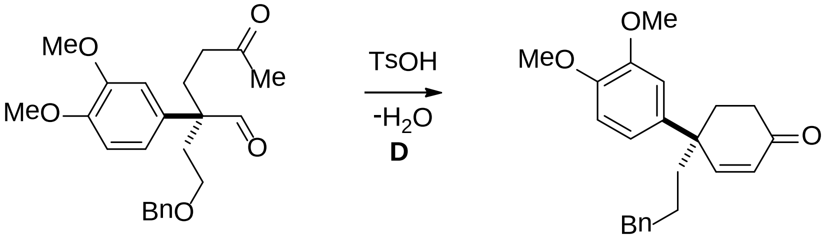
Mukaiyama, T.; Shintou, T.; Fukumoto, K. *J. Am. Chem. Soc.* **2003**, 125, 10538.

A: Formation of a phosphinite ester. **B**: Addition of the phosphinite to the electron-deficient quinone.

C: S_N2 reaction with inversion of configuration.

C083

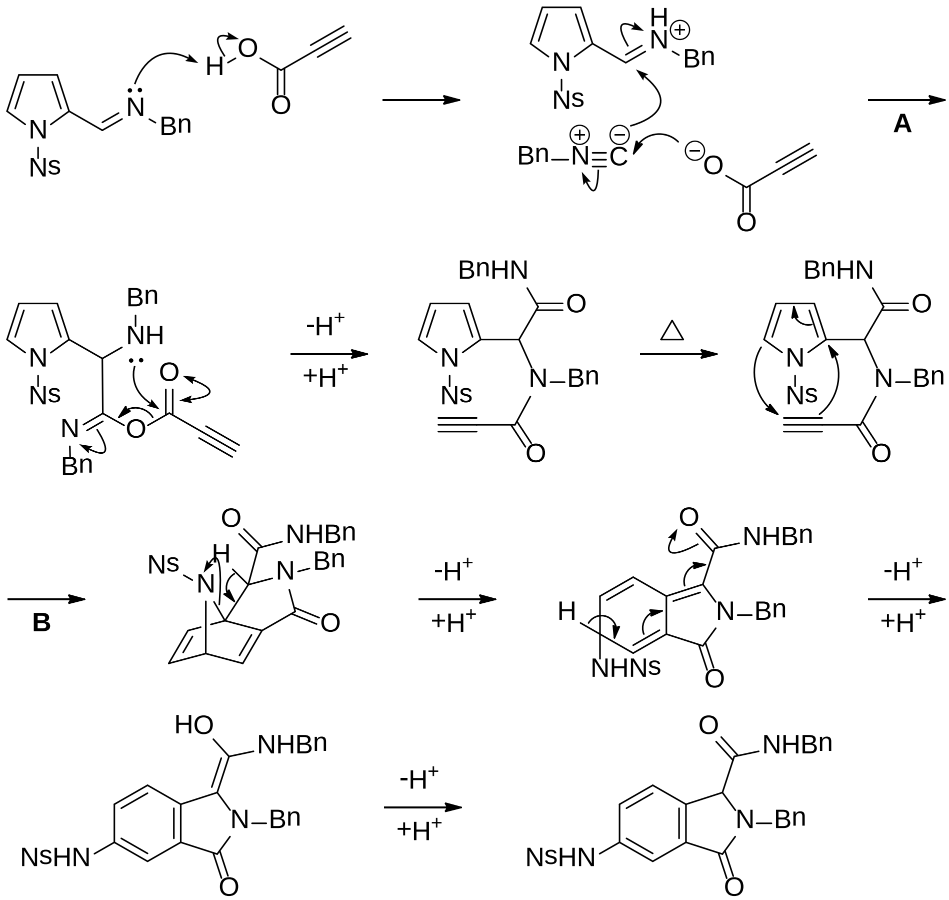




Taber, D. E; Neubert, T. D. *J. Org. Chem*. **2001**, 66, 143.

A: α-Elimination to form an alkylidene carbene. B: C-H insertion at the kinetically favored position. **C**: Ozonolysis. **D**: Intramolecular aldol reaction.

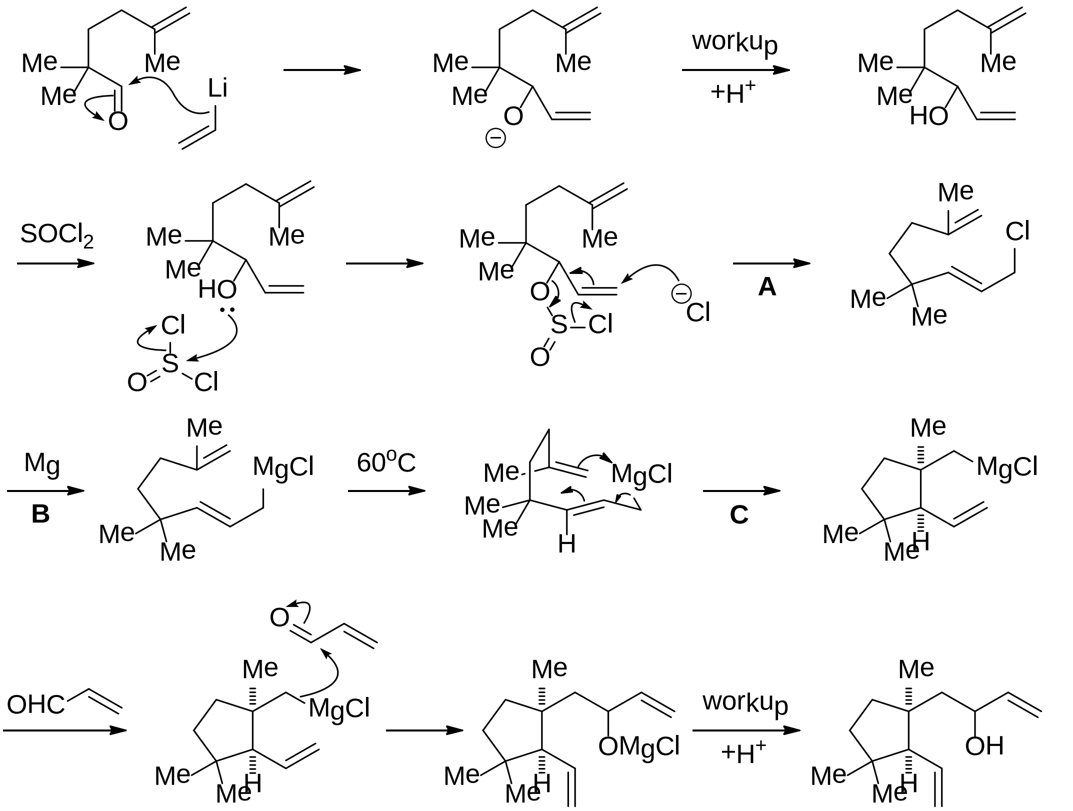
C084



Paulvannan, K. *J. Org. Chem*. **2004**, 69, 1207

A: Ugi reaction (ref C007). **B**: Intramolecular Diels-Alder reaction followed by β-elimination to release the ring strain.

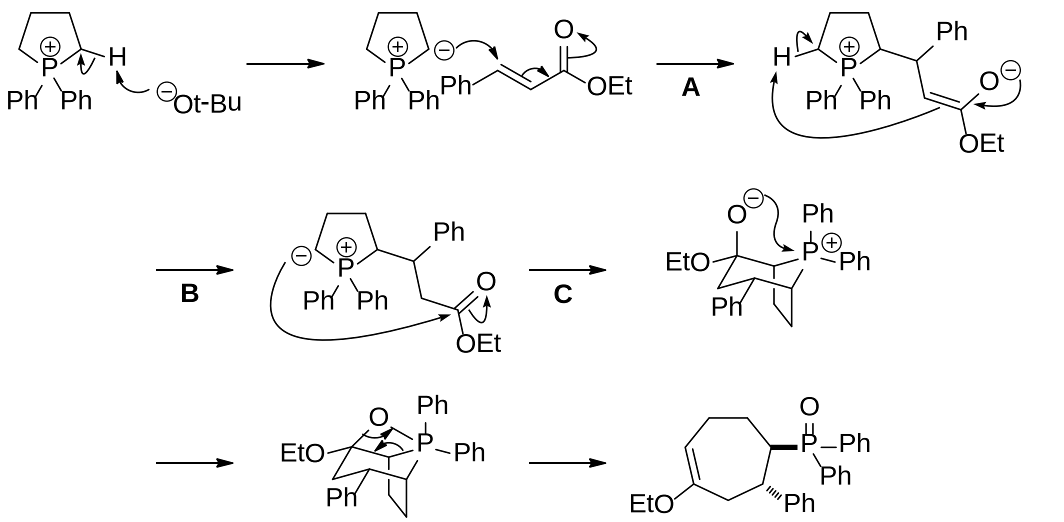
C085



Oppolzer, W.; Bättig, K. *Tetrahedron Lett.* **1982**, 23, 4669.

A: Formation of an allyl chloride via S_N2' reaction. **B**: Formation of a Grignard reagent. **C**: Magnesium-ene reaction through a chair-like conformation.

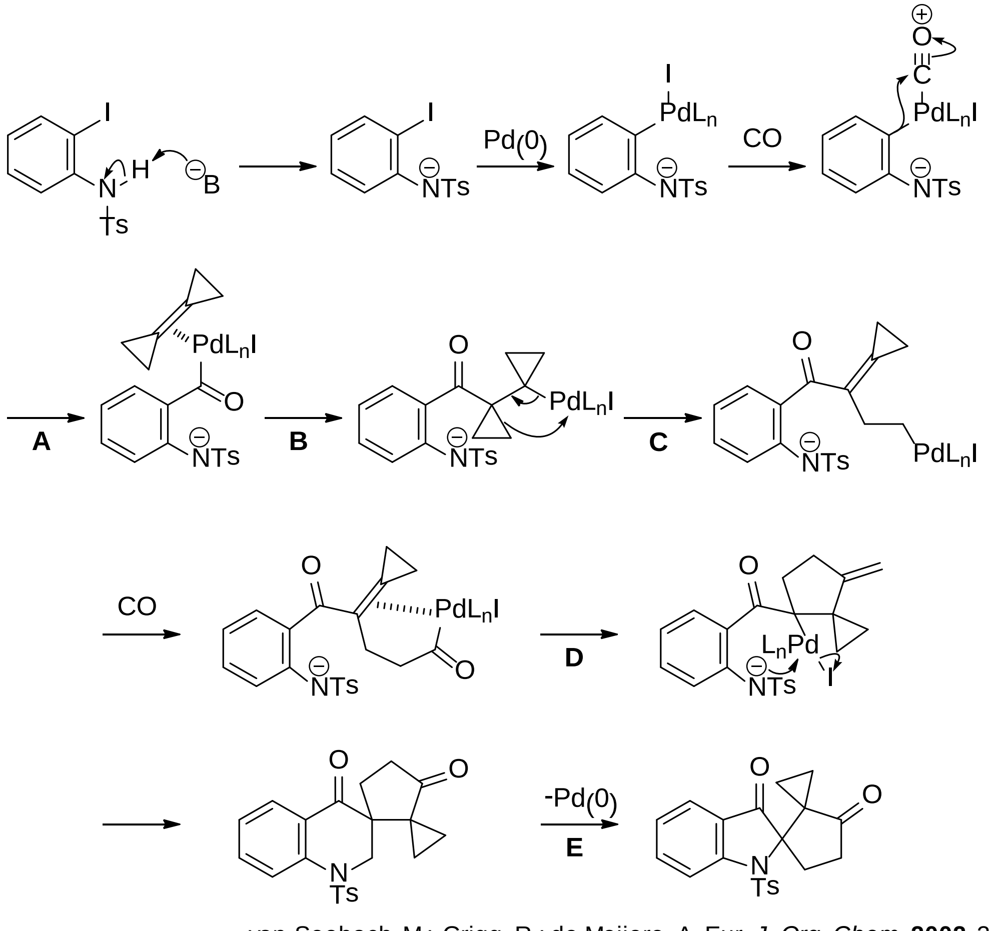
C086



Fujimoto, T.; Kodama, Y.; Yamamoto, I.; Kakehi, A. *J. Org. Chem.* **1997**, 62, 6627.

A: Conjugate addition of an ylide. **B**: Intramolecular proton transfer to generate an ylide. **C**: Intramolecular Wittig reaction.

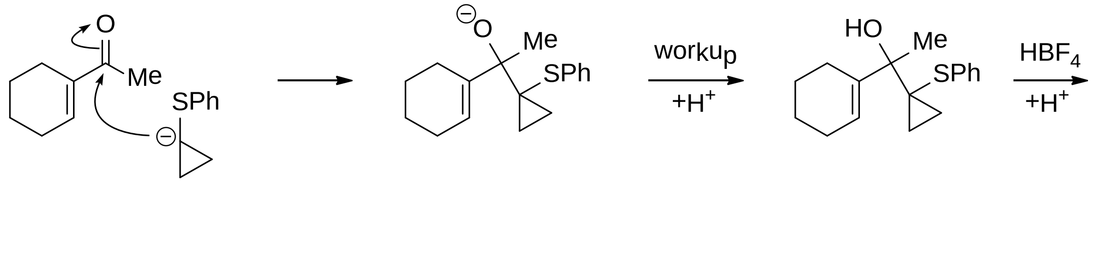
C087

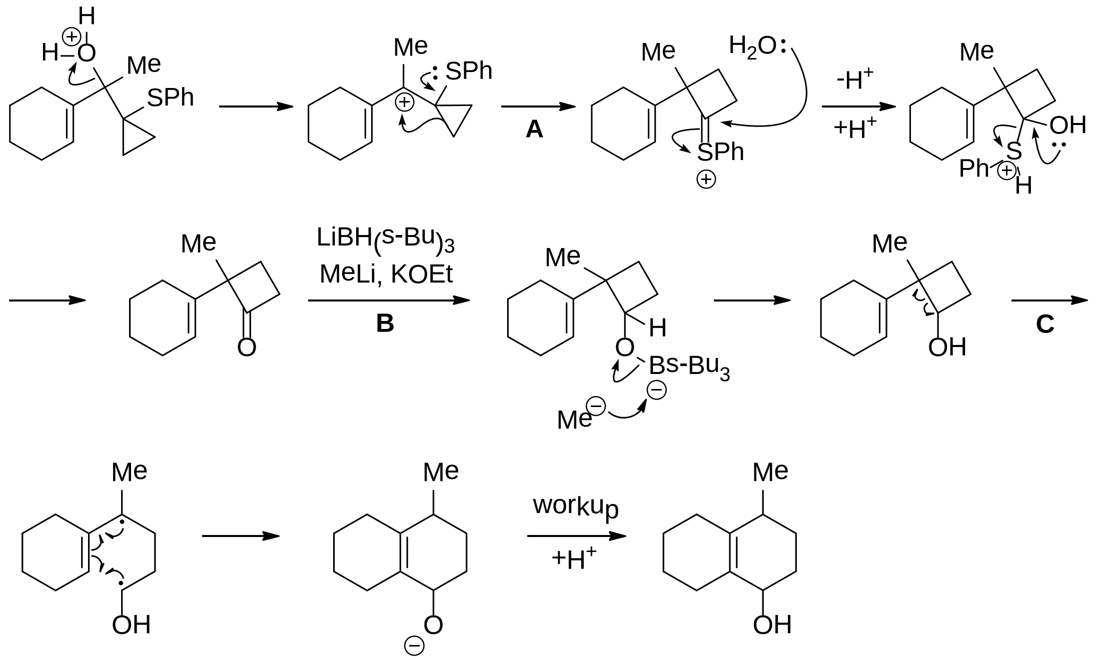


von Seebach, M.; Grigg, R.; de Meijere, A. Eur. *J. Org. Chem*. **2002**, 3268.

A: Pd-mediated carbonylation to form an acylpalladium species. **B**: Carbopalladation to a strained olefin. **C**: β-Carbon elimination. **D**: Intramolecular carbopalladation to the resulting strained olefin. **E**: Reductive elimination of the palladacycle.

C088

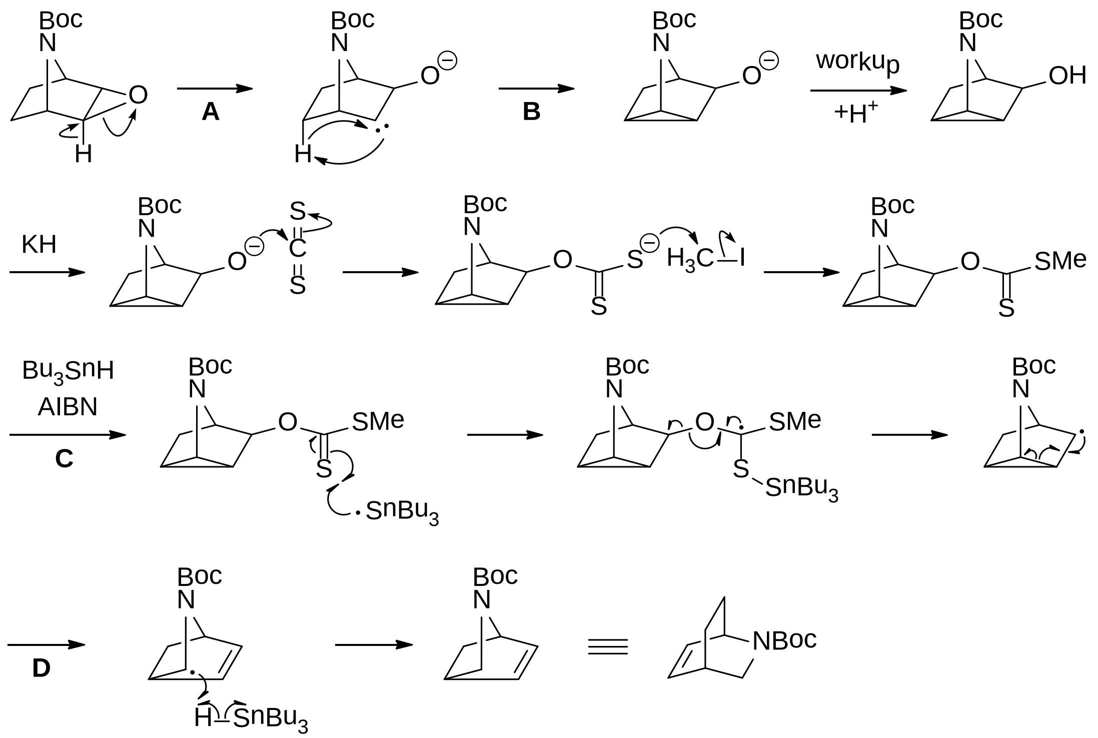




Danheiser, R. L.; Martinez-Davila, C.; Sard, H. *Tetrahedron*. **1981**, 37, 3943.

A: Pinacol-type rearrangement. **B**: Reduction of the ketone. **C**: Anion-accelerated vinylcyclobutane-cyclohexene rearrangement.

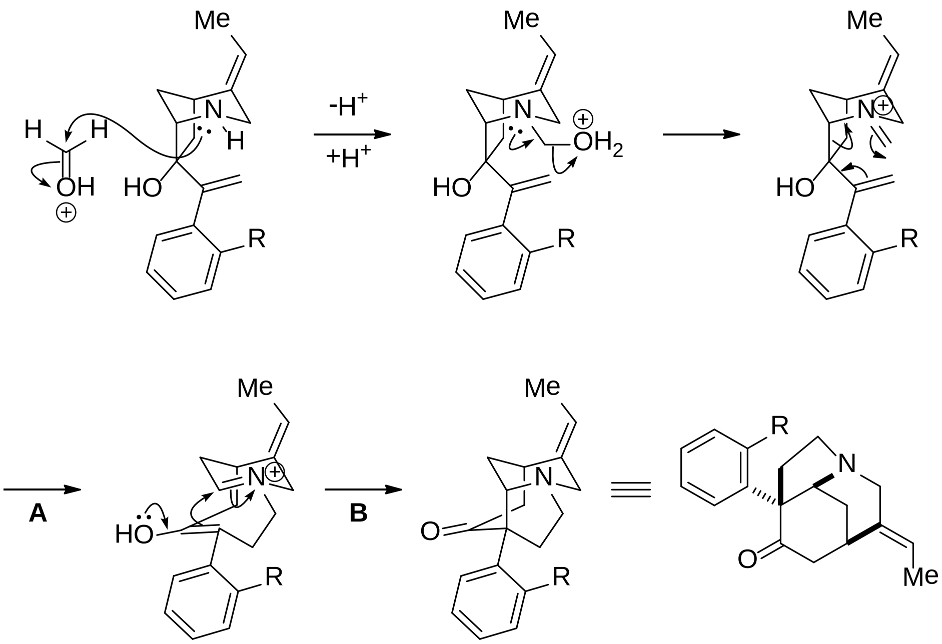
C089



Hodgson, D. M.; Maxwell, C. R.; Wisedale, R.; Matthews, I. R.;
Carpenter, K. J.; Dickenson, A. H.; Wonnacott, S.
J. Chem. Soc., Perkin Trans. 1 . **2001**, 3150.

A: α-Elimination of the epoxide to form a carbene. **B**: C-H insertion. **C**: Barton-McCombie deoxygenation of a xanthate (ref A051). **D**: Formation of a radical at a cyclopropylcarbinyl position induces cleavage of the cyclopropane ring (cf. radical clock).

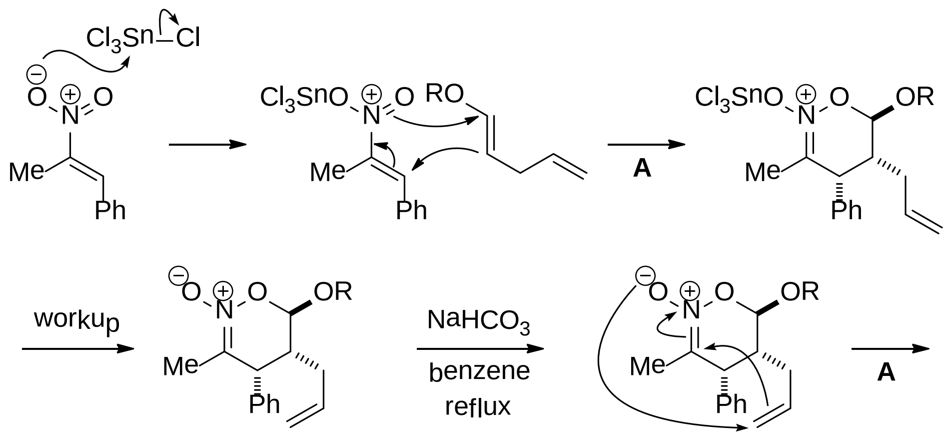
C090

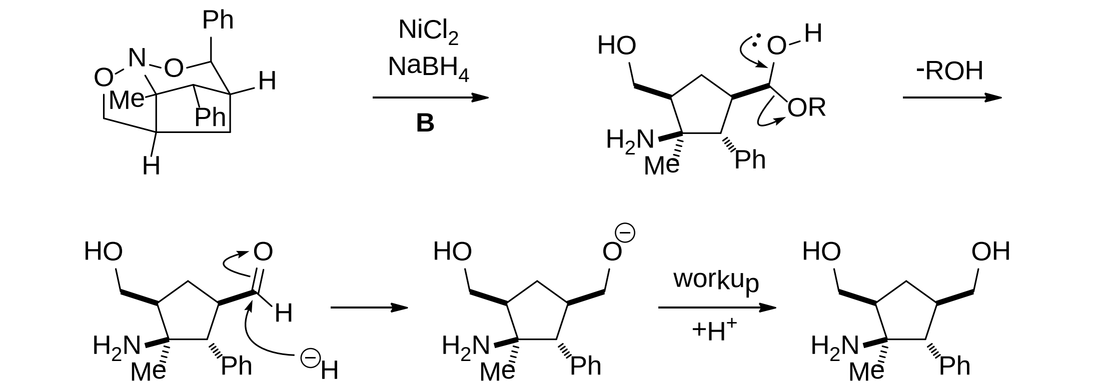


Angle, S. R.; Fevig, J. M.; Knight, S. D.; Marquis, R. W., Jr.; Overman, L. E
J. Am. Chem. Soc. **1993**, 115, 3966

A: Aza-Cope rearrangement. **B**: Mannich reaction.

C091

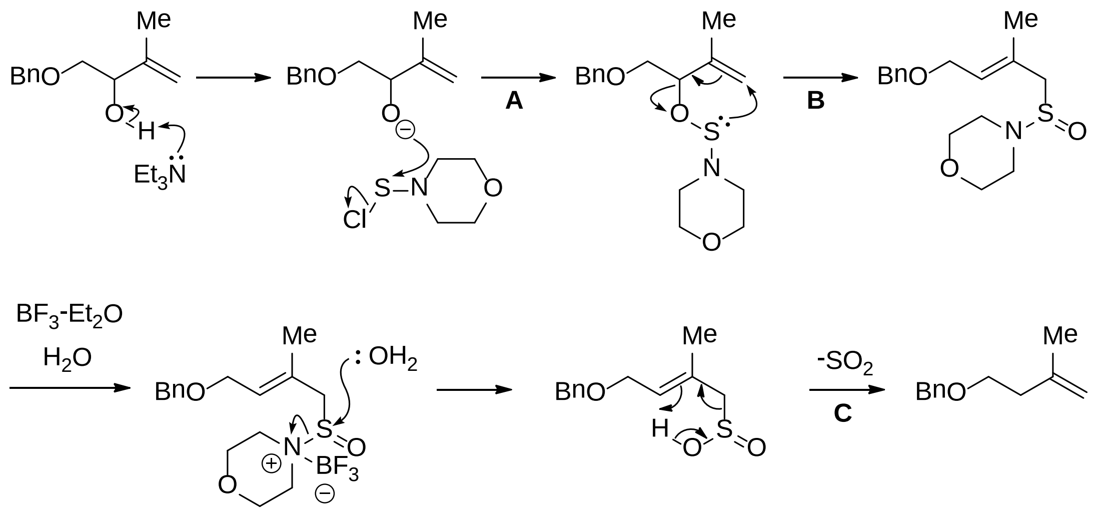




Denmark, S. E.; Dixon, J. A. *J. Org. Chem.* **1998**, 63, 6178.

A: Inverse electron demand hetero-Diels-Alder reaction. **B**: 1,3-Dipolar cycloaddition. **C**: Reductive cleavage of the N-O bonds.

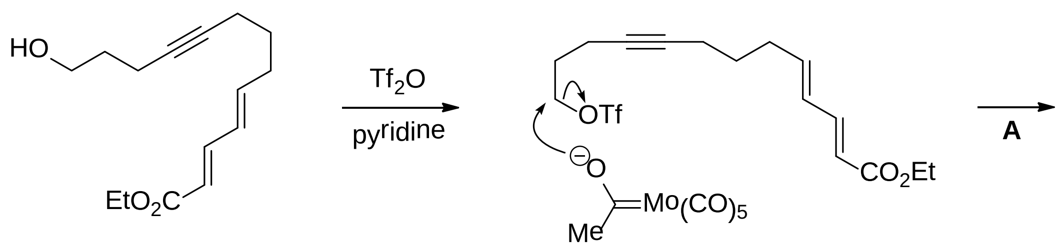
C092

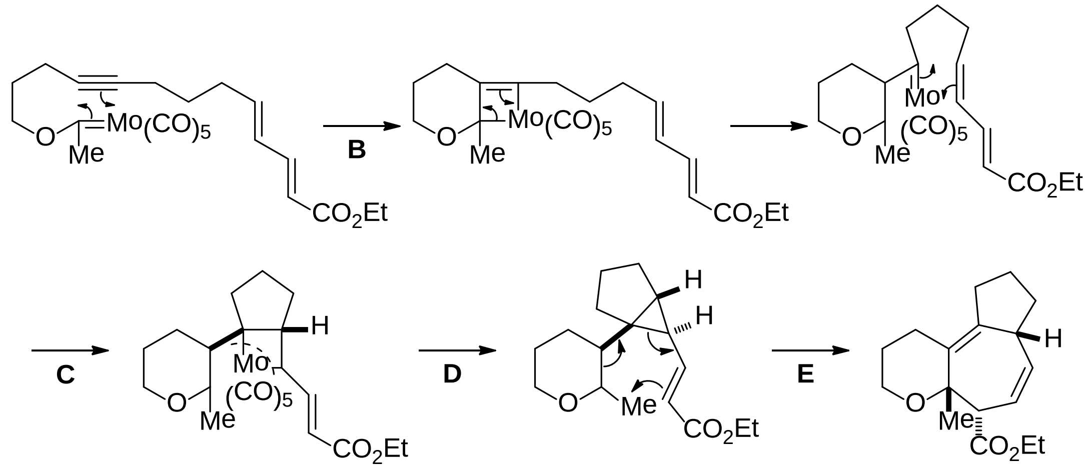


Baudin, J.-B.; Julia, S. A. *Tetrahedron Lett.* **1988**, 29, 3251.

A: Formation of a morpholinesulfenate. **B**: [2,3] Sigmatropic rearrangement. **C**: Extrusion of SO_2 through a six-membered transition state.

C093

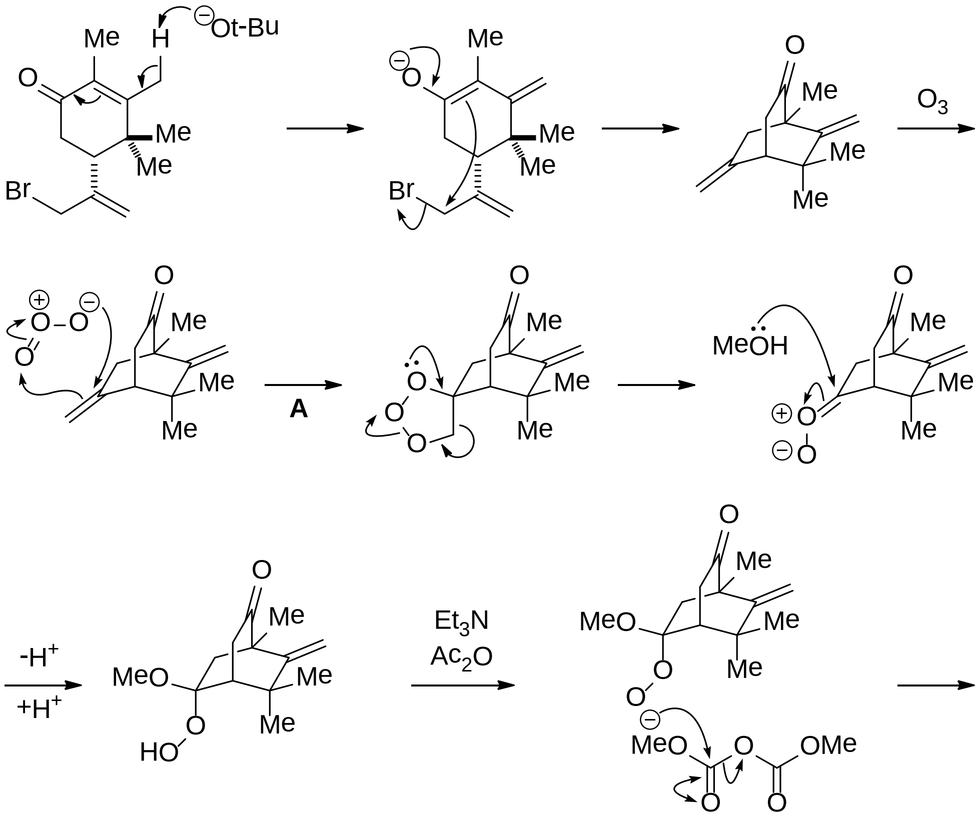


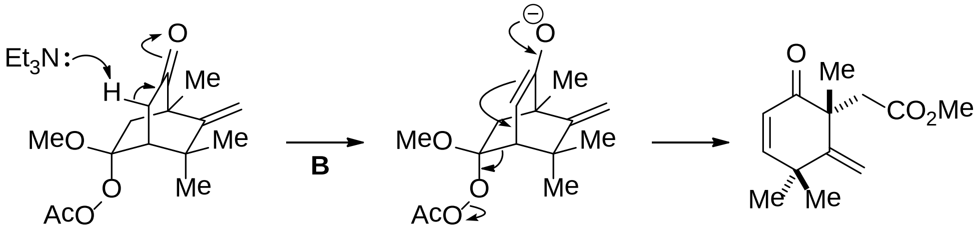


Harvey, D. E; Brown, M. F. *J. Org. Chem*. **1992**, 57, 5559.

A: Formation of a Fischer carbene complex. **B**: Intramolecular alkyne metathesis. **C**: Intramolecutar alkene metathesis. **D**: Reductive elimination to form a cyclopropane. **E**: Divinylcyclopropane rearrangement (ref A042) via a boat-like transition state.

C094

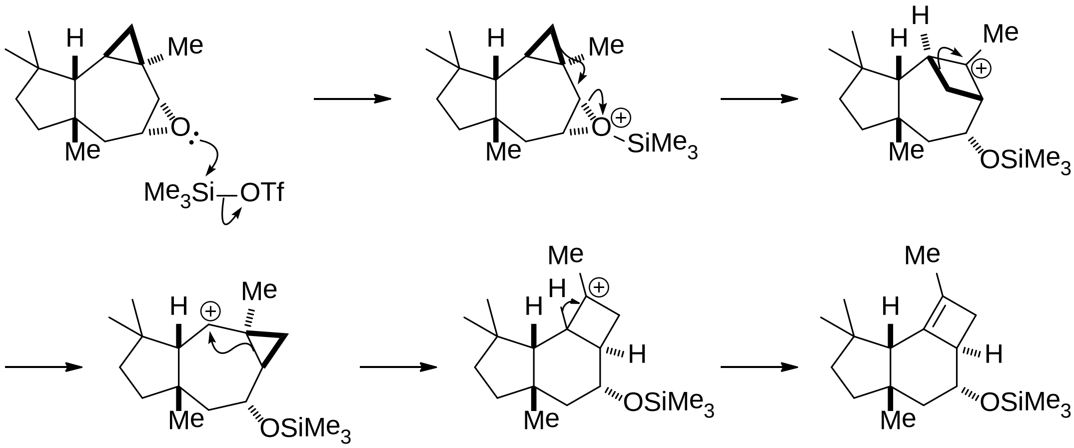




Srikrishna, A.; Anebouselvy, K.; Reddy, T. J. *Tetrahedron Lett.* **2000**, 41, 6643.

A: Ozonolysis of the less hindered olefin in MeOH to form a hydroperoxide (ref BI16, BI17). **B**: Grob-type fragmentation.

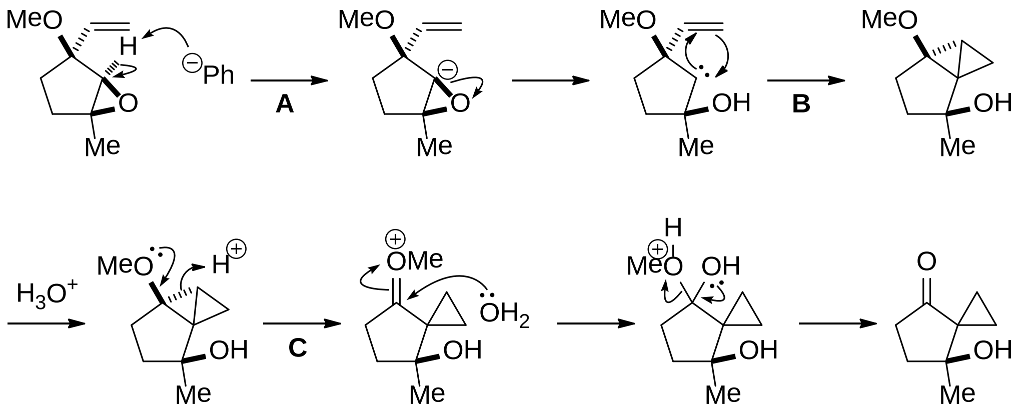
C095

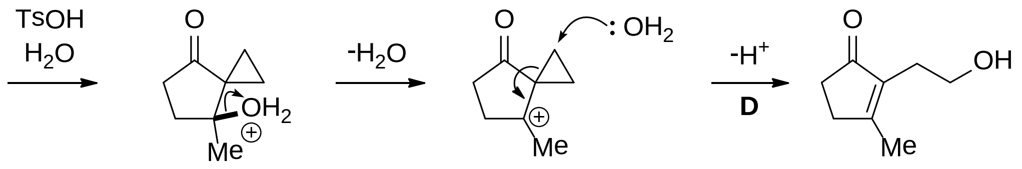


Fujita, T.; Ohtsuka, T.; Shirahama, H.; Matsumoto, T. *Tetrahedron Lett.* **1982**, 23, 4091

Wagner-Meerwein rearrangements.

C096

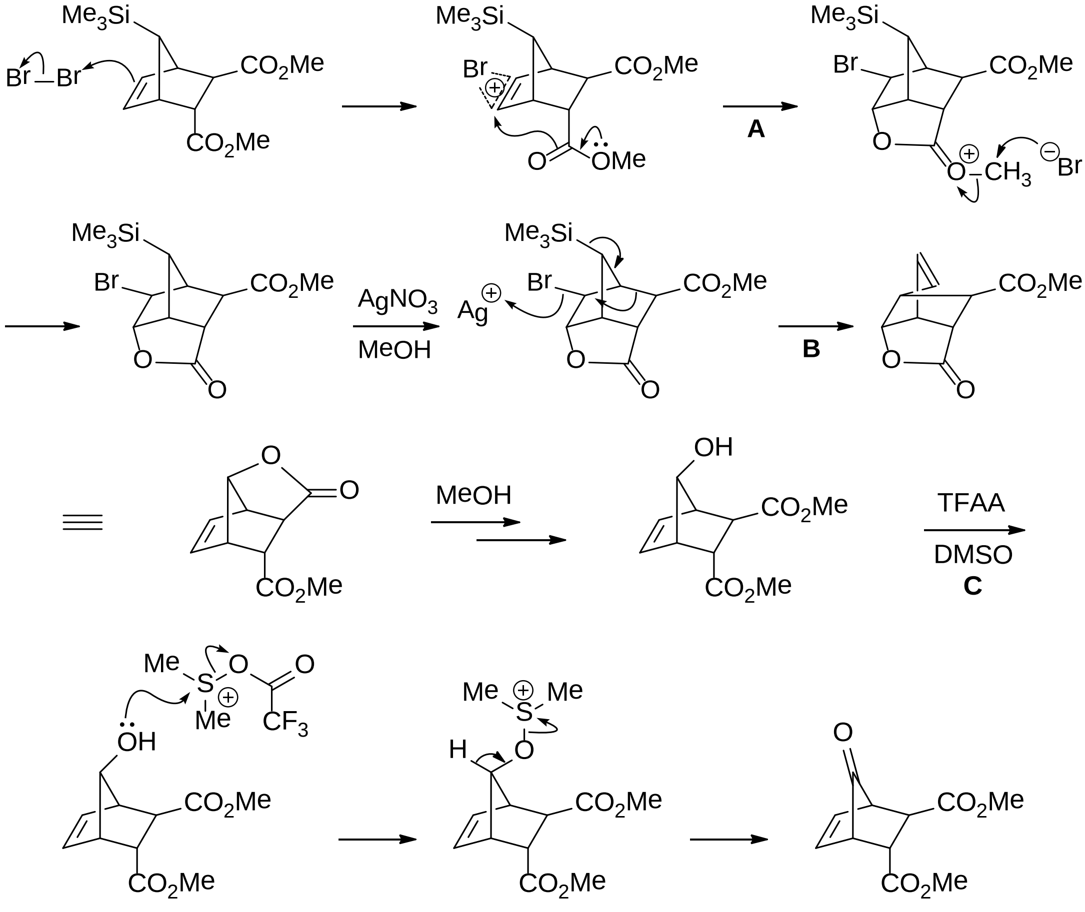




Dechoux, L.; Agami, C.; Doris, E.; Mioskowski, C. *Eur. J. Org. Chem*. **2001**, 4107.

A: α-Elimination of the epoxide to form a carbene. **B**: Cyclopropanation. **C**: Cleavage of the electron-rich cyclopropane ring. **D**: Cleavage of the cyclopropane ring.

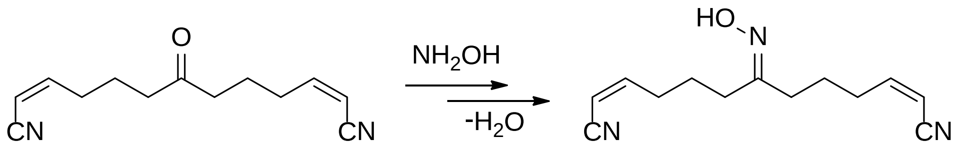
C097

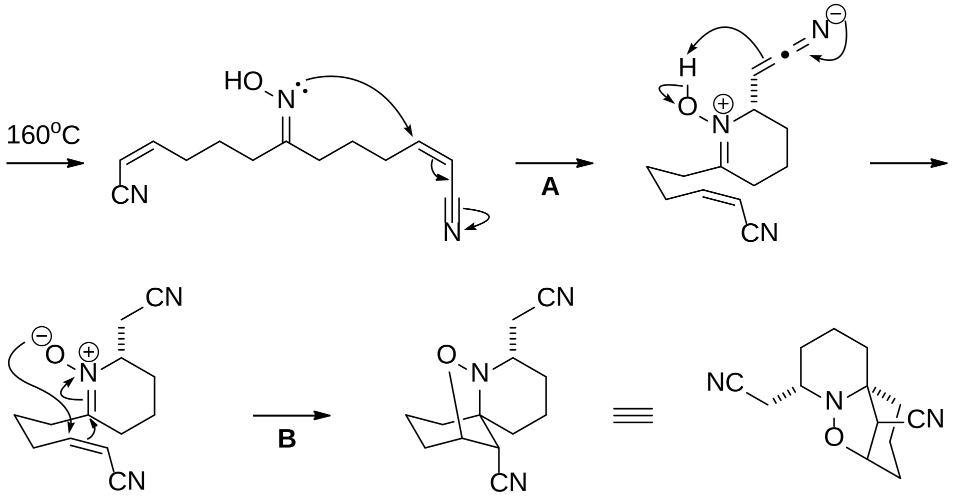


Fleming, I.; Michael, J. P. *J. Chem. Soc., Perkin Trans 1* .**1981**, 159.

A: Bromolactonization. **B**: Wagner-Meerwein rearrangement followed by desilylation. **C**: Swern oxidation.

C098



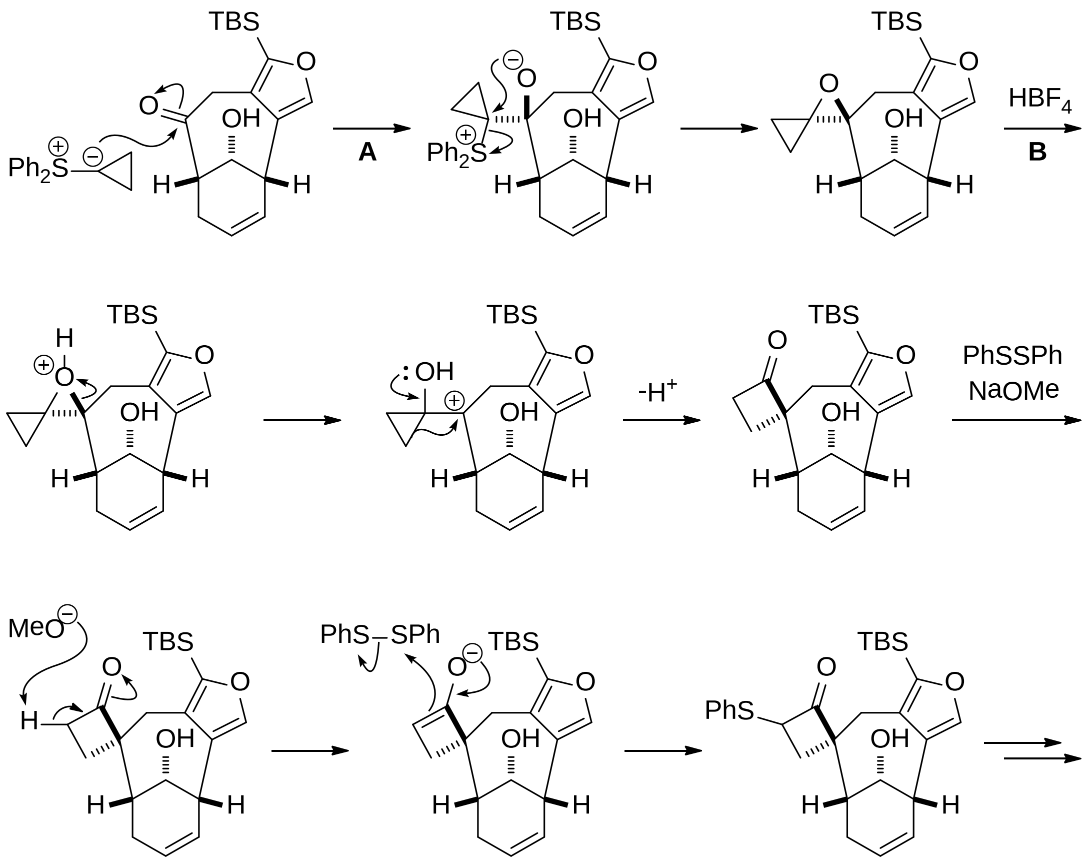


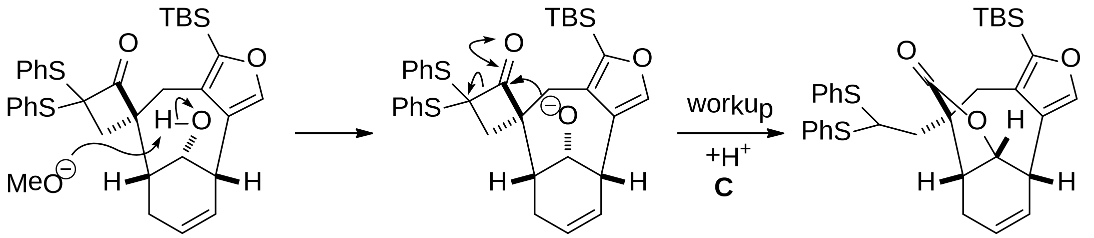
Stockman, R.A. *Tetrahedron Lett*. **2000**, 41, 9163.

A: Formation of a nitrone by intramolecular Michael addition of the oxime to the α,β-unsaturated nitrile.

B: Intramolecular 1,3-dipolar cycloaddition.

C099

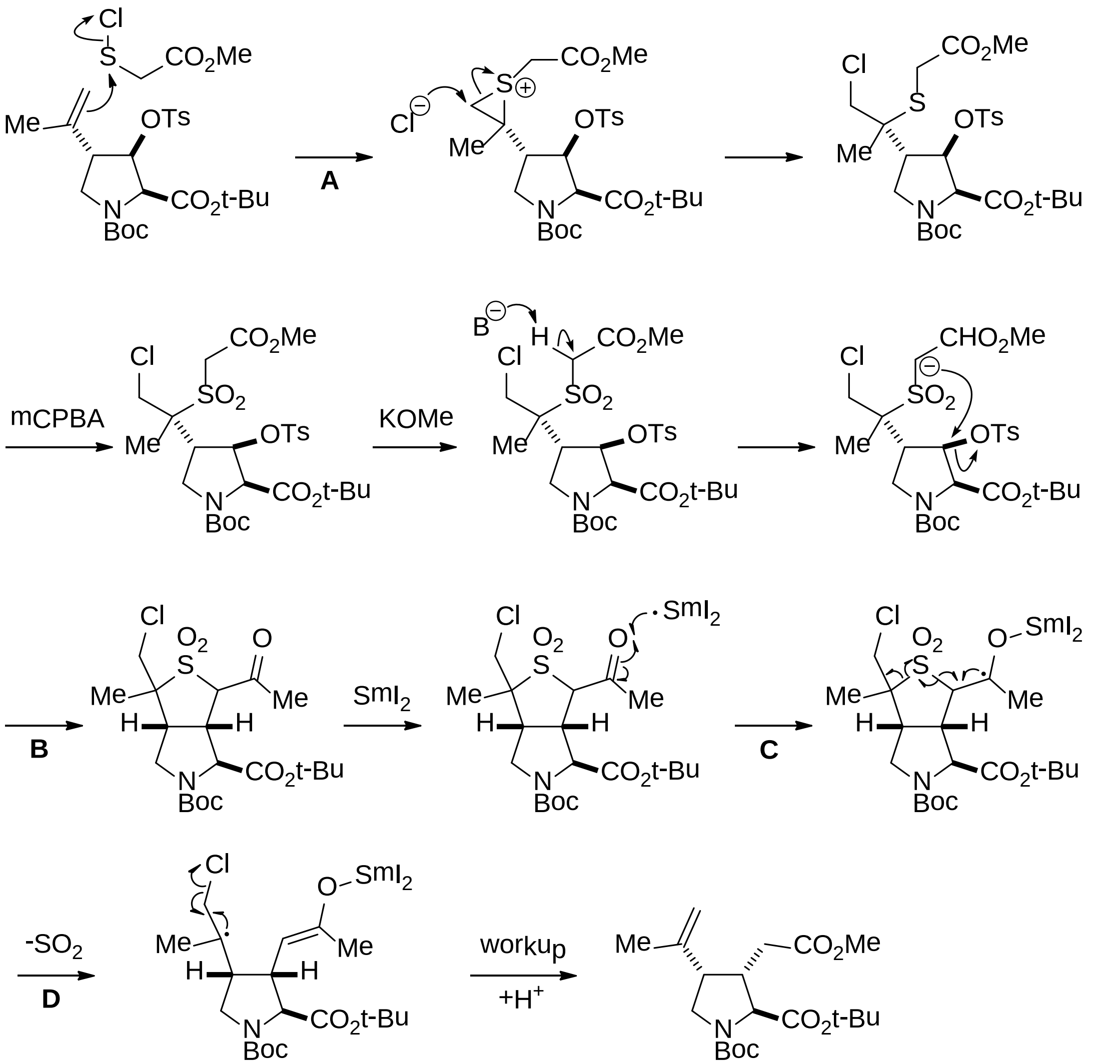




Kwon, O.; Su, D.-S.; Meng, D.; Deng, W.; D'Amico, D. C.; Danishefsky, S. J. *Angew. Chem. Int. Ed.* **1998**, 37, 1880.

A: 1,2-Addition of the sulfur ylide followed by formation of an epoxide in an S_N2 fashion. **B**: Cleavage of the epoxide induces 1,2-migration to form a cyclobutanone via a stable tertiary carbocation. **C**: Ring opening of the cyclobutanone by the proximal alkoxide is facilitated by formation of the sulfur-stabilized carbanion.

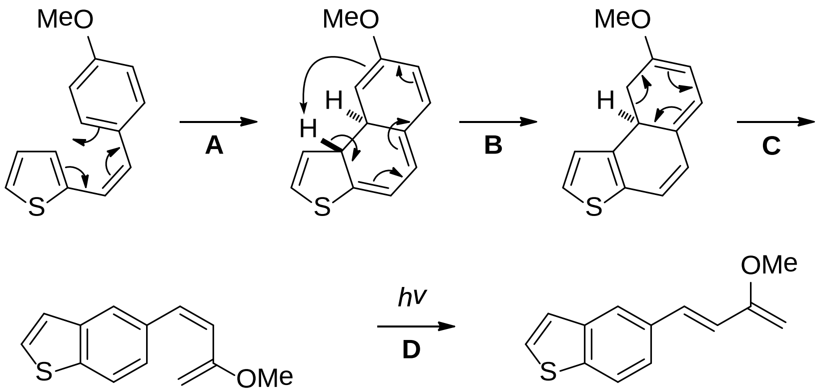
C100



Bachi, M. D.; Melman, A. *J. Org. Chem.* **1997**, 62, 1896.

A: Formation of an episulfonium salt followed by attack of chloride ion at the less hindered carbon. **B**: Cyclization proceeds by an S_N2 mechanism. **C**: SET. **D**: β-Cleavage followed by extrusion of SO_2 and elimination of a chloride radical.

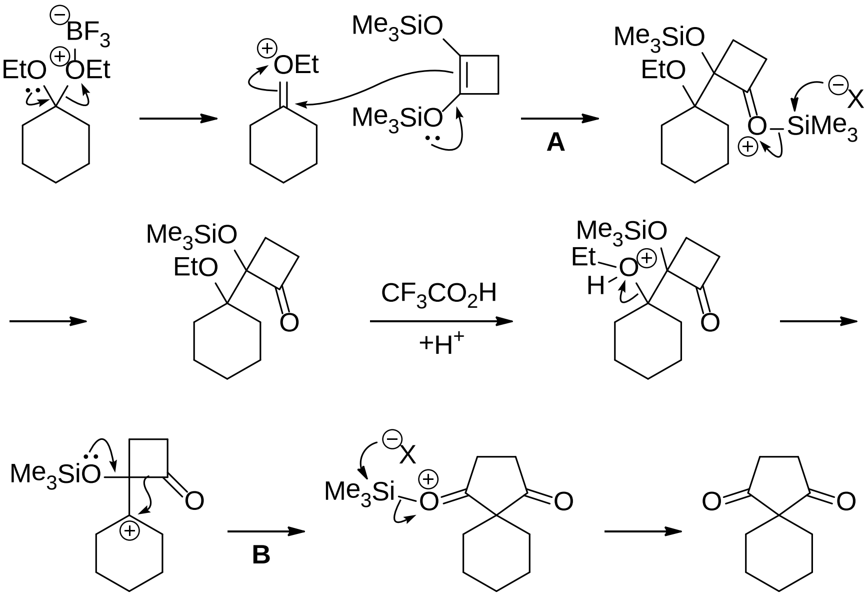
C101



Wu, J.-Y.; Ho, J.-H.; Shih, S.-M.; Hsieh, T.-L.; Ho, T.-I. *Org. Lett.* **1999**, 1, 1039.

A: Photo-induced 6e conrotatory etectrocyclic reaction. **B**: Thermally allowed suprafacial 1,9-hydrogen shift. **C**: 6e Electrocyclic reaction. **D**: Photoisomerization of the (Z)-olefin.

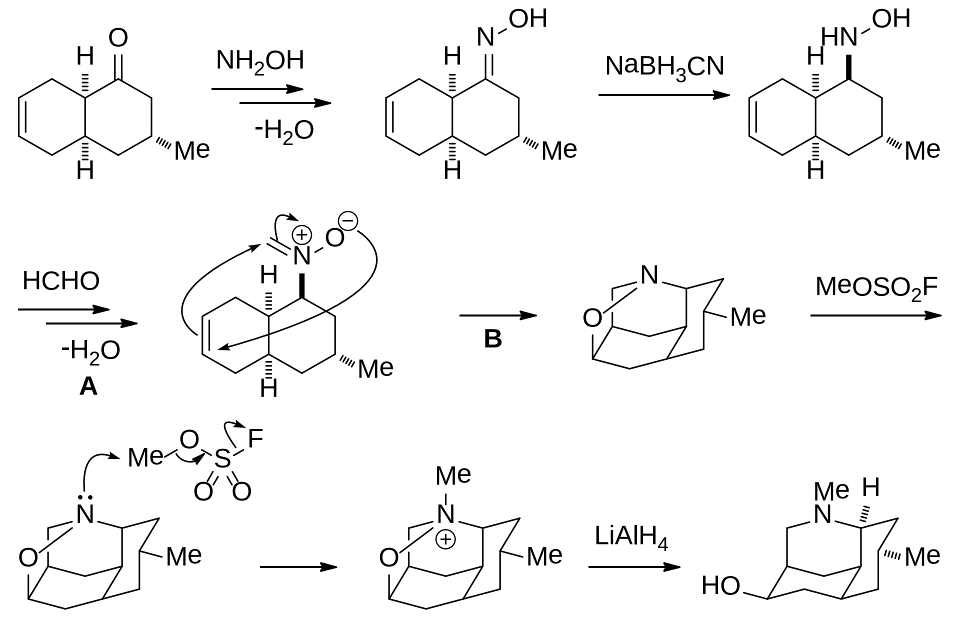
C102



Nakamura, E.; Kuwajima, I. *Org. Synth., Coll*. Vol. Ⅷ **1987**, 17.

A: Mukaiyama aldol reaction. **B**: Preferential migration of the carbonyl carbon (Pinacol rearrangement).

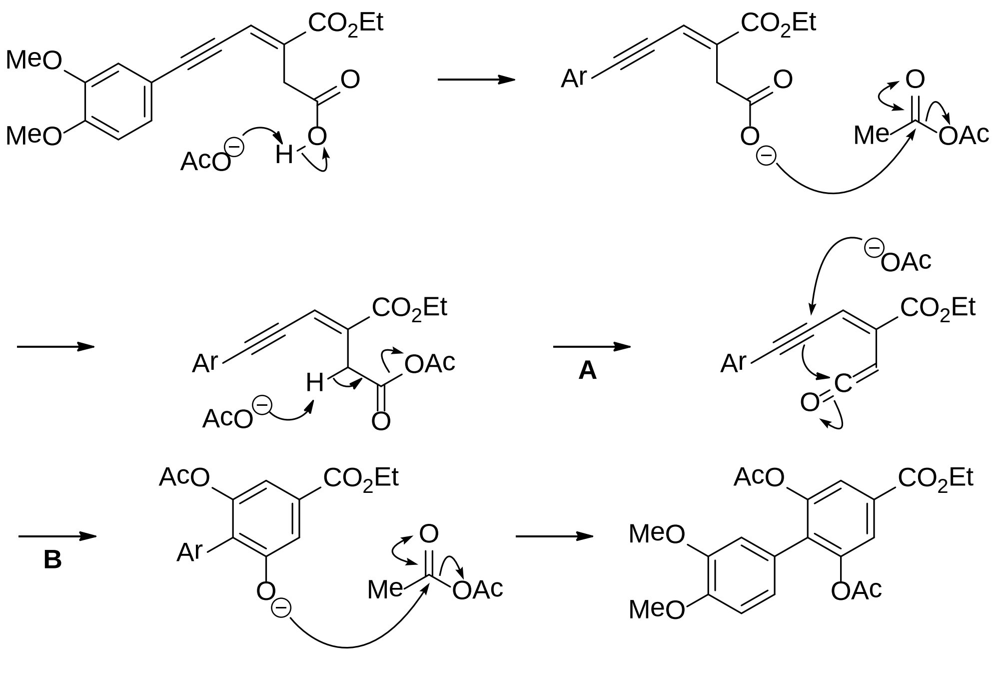
C103

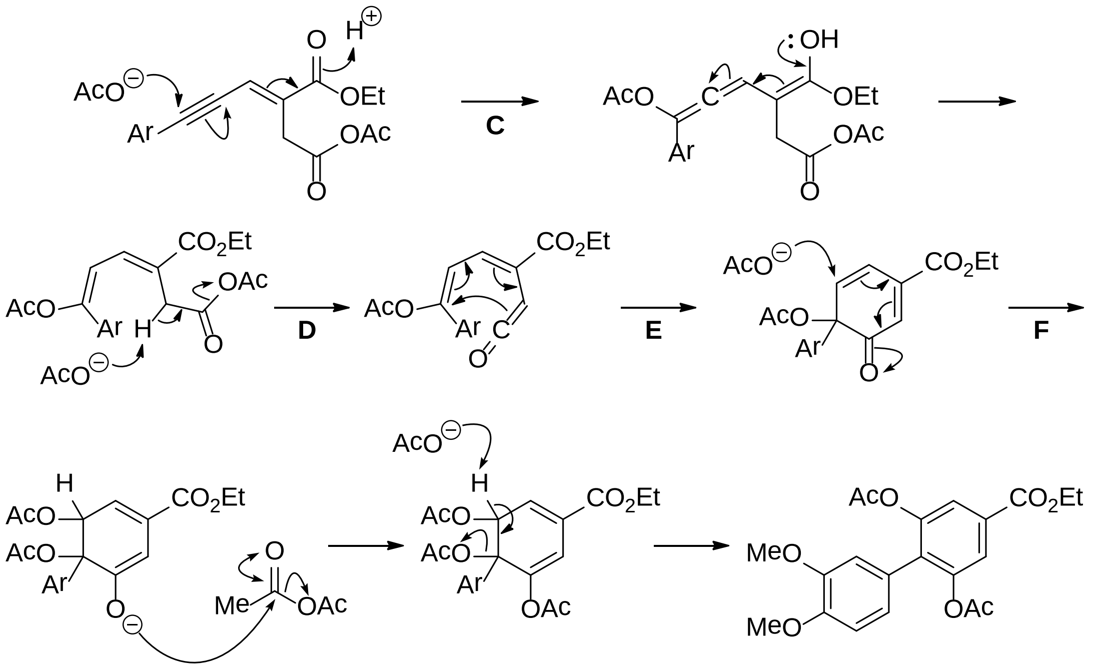


Oppolzer, W.; Petrzilka, M. *J. Am. Chem. Soc.* **1976**, 98, 6722.

A: Formation of a nitrone ref A065. **B**: 1,3-Dipolar cycloaddition.

C104

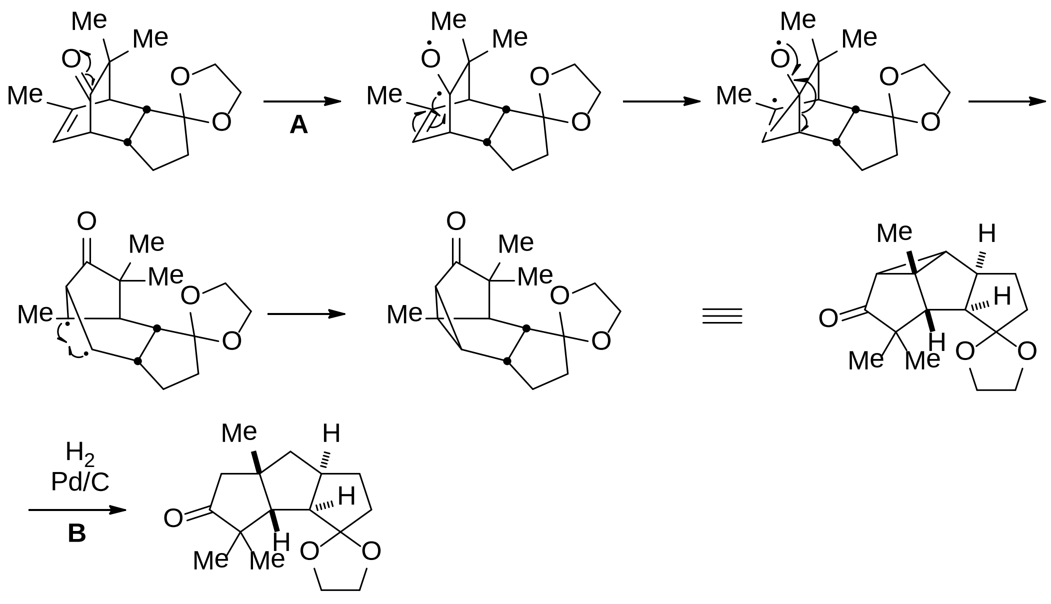




Serra, S.; Fuganti, C. *Synlett.* **2002**, 1661.

A: Generation of a ketene via a mixed anhydride. **B**: Benzannulation. **C**: Michael addition. **D**: Formation of a ketene. **E**: 6e Electrocyclic reaction. **F**: Michael addition.

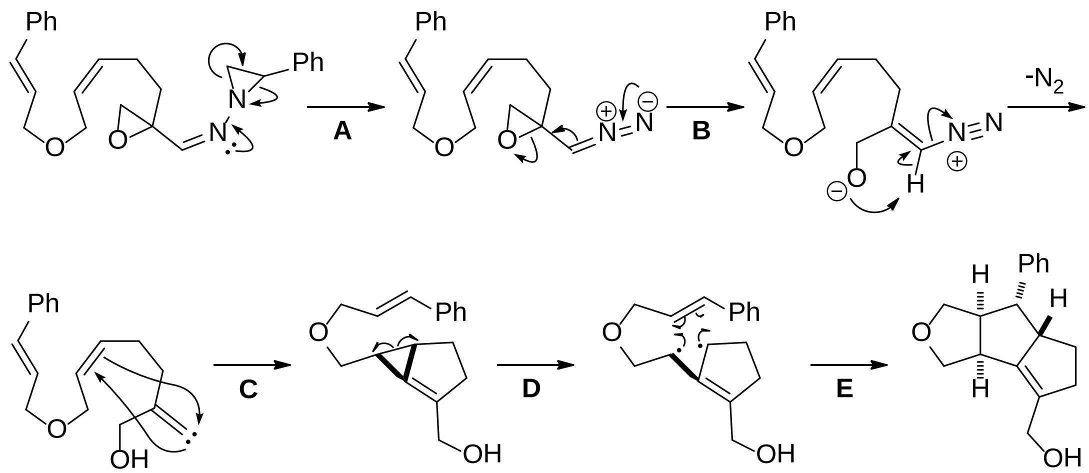
C105



Singh, V.; Prathap, S.; Porinchu, M. *J. Org. Chem*. **1998**, 63, 4011.

Oxa-di-π-methane rearrangement. **A**: n-π* Transition. **B**: Reductive cleavage of the cyclopropane ring.

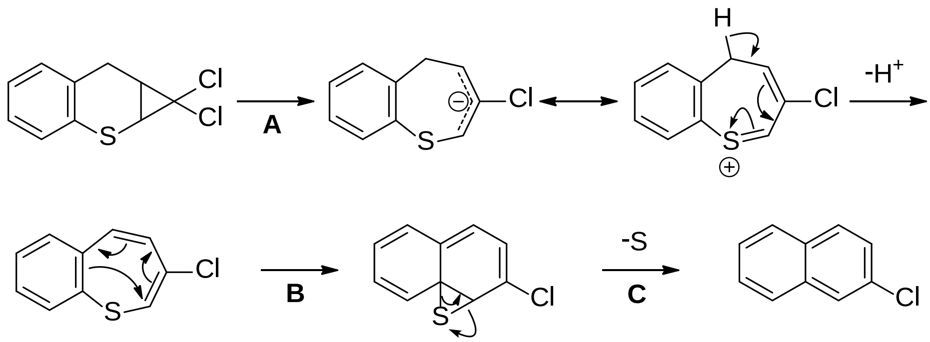
C106



Lee, H.-Y; Kim, Y. *J. Am. Chem. Soc.* **2003**, 125, 10157.

A: Thermal decomposition of an aziridinylimine to form a diazoalkane. **B**: Cleavage of the epoxide followed by elimination of N_2 to form an alkylidene carbene. **C**: Cyclopropanation. **D**: Homolytic cleavage of the strained cyclopropylidene ring to form a trimethylenemethane diradical. **E**: Radical addition.

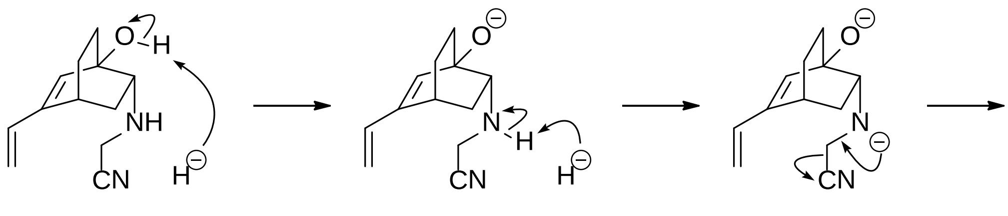
C107

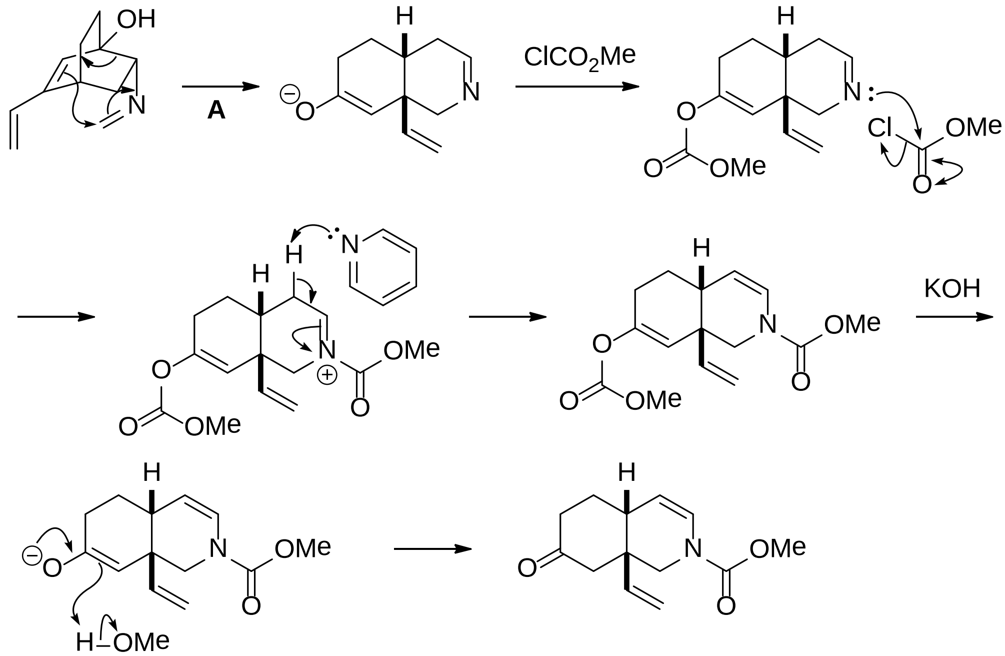


Parham, W. E.; Koncos, R. *J. Org. Chem.* **1961**, 83, 4034.

A: 2e Electrocyclic reaction. **B**: 6e Disrotatory electrocyclic reaction. **C**: Spontaneous loss of S.

C108

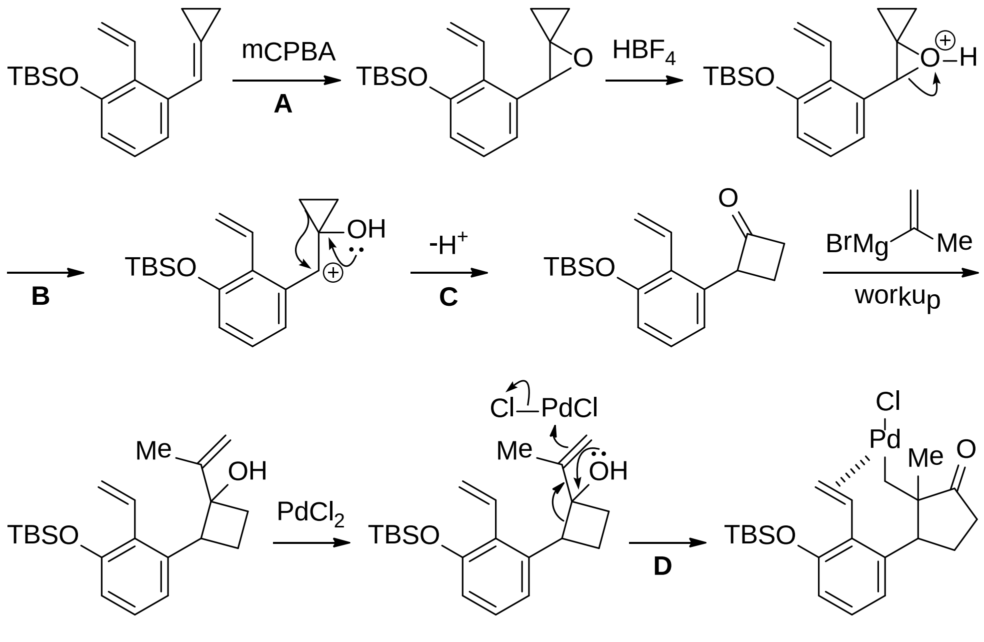


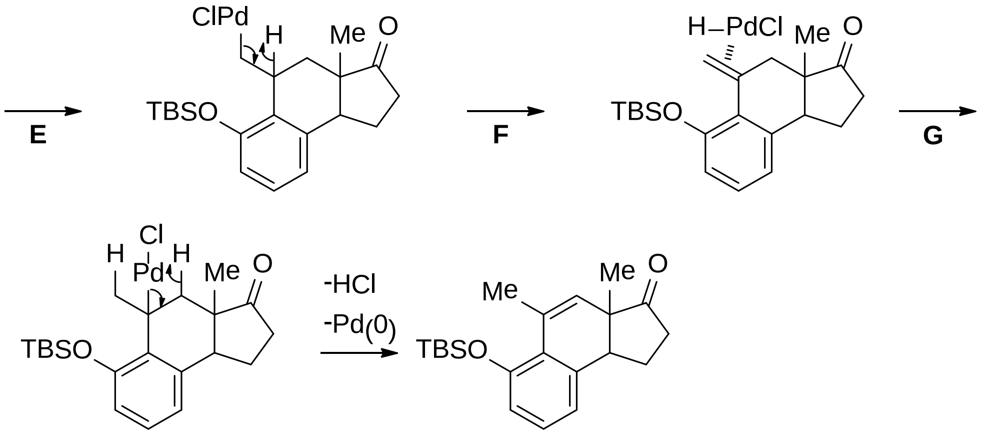


Earley, W. G.; Jacobsen, E. J.; Meier, G. P.; Oh, T.; Overman, L. E.
Tetrahedron Lett. **1988**, 29, 3781.

A: Anion-accelerated aza-Cope rearrangement.

C109





Nemoto, H.; Miyata, J,; Yoshida, M.; Raku, N.; Fukumoto, K.
J. Org. Chem. **1997**, 62, 7850.

A: Epoxidation of the strained olefin. **B**: Cleavage of the epoxide to form a stable benzylic cation. **C**: 1,2-Migration to form a cyclobutanone (ref A099). **D**: Ring expansion reaction initiated by oxidation of the olefin with $PdCl_2$. **E**: Intramolecular carbopalladation. **F**: β-Elimination. **G**: Reversible hydropalladation and 6-elimination process to give the more stable endocyclic olefin.

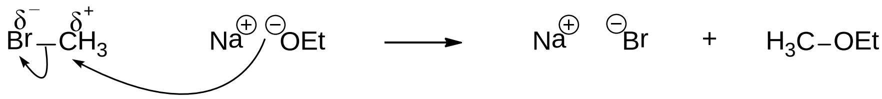
附　录

有机反应机理书写的考虑要素

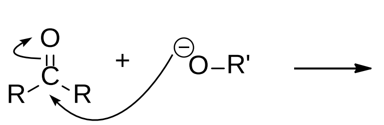
1. 考虑反应机理时重要的电负性值

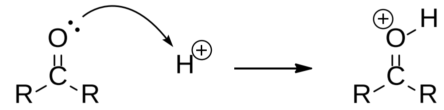
有机反应按样式可分为自由基反应，极性反应，周环反应，反应中占有比例最多的反应时极性反应，就是在反应体系中的电子的丰富的体系中，与缺乏电子的体系相互吸引，生成的化学键结合，切割的进行的反应。电子在书写时被我们用“弯箭头”介入那里，代表电子的移动。

电子从富电子体系向电子缺少体系移动。那么，如何成为判断电子如何移动的线索之一就是是电负性值。电负性值是电子吸引的内在量度，那个值越大，对电子的吸引力就越强。例如，一溴甲烷中，电子被吸引到溴原子一边，碳会部分地带正电（δ+），而溴原子会部分带负电荷的（δ-　）。一溴甲烷和乙醇钠（的NaOEt）的反应时，具有负电荷的氧原子会接近具有部分正电荷的碳原子，形成C-O键。然后C-Br键断裂，孤对电子移动到溴原子上，就产生了溴离子。



再来看看羰基化合物的反应，羰基中的电子被吸引到电负性值较大的氧原子上，碳带正电，氧带负电。富含电子的亲核试剂，像烷氧基一类的，会接近具有部分正电荷的碳原子，并生成新的键。此时，C-O键上的电子是在向氧原子移动。另一方面，羰基化合物在与盐酸那样的Brønsted酸反应时，带负电的氧原子与带正电质子（H+）发生反应，使原先带负电的结构发生极化。这样的极化导致了C-O键的分极，于是将提高对亲核基团的反应活性。





因此考虑化合物中的官能团的电荷——最具反应性的位点，是考虑反应机理的基础。

表①常用元素电负性一览表

H 2.1						
Li 1.0	Be 1.5	B 2.0	C 2.5	N 3.0	O 3.5	F 4.0
Na 0.9	Mg 1.2	Al 1.5	Si 1.8	P 2.1	S 2.5	Cl 3.0
K 0.8	Ca 1.0					Br 2.8
						I 2.5

2. 从酸度系数pKa预测反应途径

在水溶液中酸性化合物的电离方式如下。

$$HA + H_2O \rightleftharpoons A^- + H_3O^+$$

对于**HA**酸放出质子后的**A-**，叫做**HA**的共轭碱。此时测量出的它的酸性量度，就是我们常用的酸度系数。在稀的水溶液中，化合物的酸离解常数（**pKa**）定义为如下。

$$\mathrm{p}K_\mathrm{a} = -\log K_\mathrm{a} = \frac{\left[\mathrm{A}^-\right]\left[\mathrm{H_3O^+}\right]}{\left[\mathrm{HA}\right]}$$

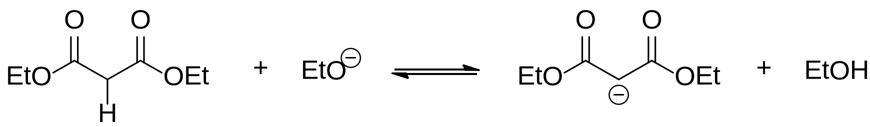
根据这个定义，pKa的值就越小，酸性越大，（由于平衡偏向右边，化合物很容易释放出质子）。同时还要考虑到共轭碱（B）在共轭酸的pKa（HB +）的值较大时，碱性就会高（平衡偏向左边，化合物难以释放质子）。

酸（**HA**）与酸根（共轭酸**HB**碱**B-**）共存时，平衡常数为**Keq**的酸和酸根的**pKa**的数值可以表示如下。

$$\mathrm{HA} + \mathrm{B}^- \rightleftharpoons \mathrm{A}^- + \mathrm{HB}$$

$$\mathrm{p}K_{\mathrm{eq}} = -\log\frac{[\mathrm{A}^-][\mathrm{HB}]}{[\mathrm{HA}][\mathrm{B}^-]} = \mathrm{p}K_{\mathrm{a}}(\mathrm{HA}) - \mathrm{p}K_{\mathrm{a}}(\mathrm{HB})$$

也就是说，只是通过计算的两种酸的pKa的差，严格意义上来说是不准确的，有可能会遗漏溶液中的平衡状态。例如，丙二酸二乙酯（EtO2CCH2CO2Et;pKa值=13），乙醇钠（乙醇钠，共轭酸乙醇0）时的pKa=16）共存，可以大致考虑平衡如下。

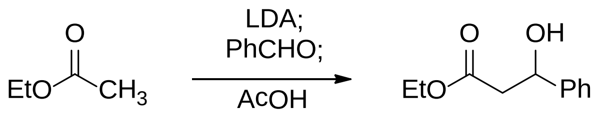


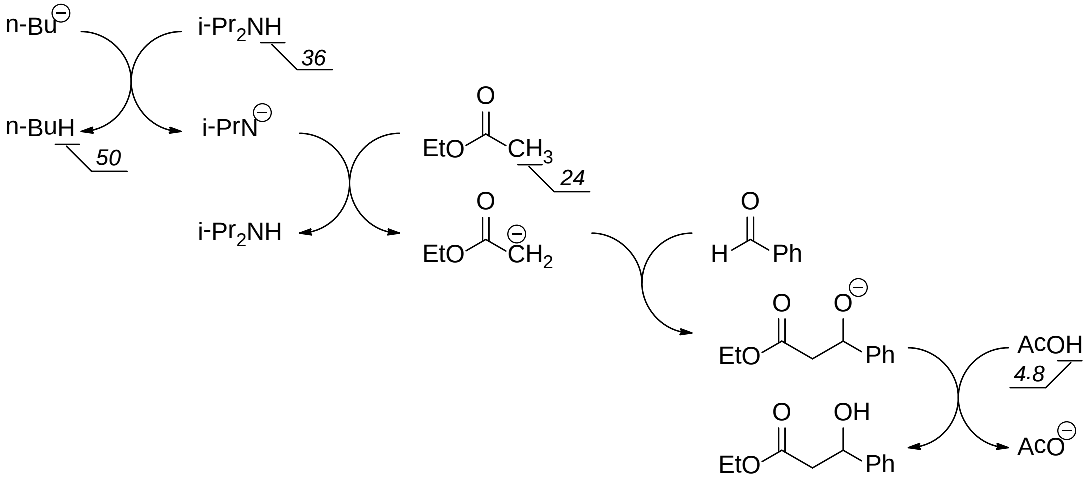
$$\mathrm{p}K_{\mathrm{eq}}=\mathrm{p}K_{\mathrm{a}}(\mathrm{malonate})-\mathrm{p}K_{\mathrm{a}}(\mathrm{EtOH})=13-16=\text{-}3$$

$$K_{\mathrm{eq}}=10^3$$

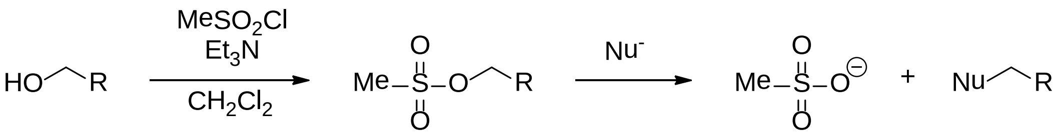
这种平衡可以看出它偏向右侧。从另一种化学的角度来看，丙二酸二乙酯是一种弱酸，乙醇钠是一个强酸根，这导致它几乎完全脱去质子。

接下来，考虑以下的反应。生成的是二异丙基氨基锂（LDA）。正丁基锂（是pKa=50共轭酸正丁烷）拔出二异丙胺的质子（pKa值=36），以生成LDA。然后LDA是拉出的酯的α碳的质子（pKa值=24），以生成酯的阴离子。将这种阴离子和苯甲醛缩合，得到的产物共轭酸的pka变小了（pKa值=17）。在后面的反应里加入乙酸（pKa值=4.8），醇盐被质子化，产生了具有乙酸阴离子的产物，反应才结束。如下所述，pKa值高的试剂不断反应生成pKa值低的试剂，使反应顺利进行。





另外，pKa值也是共轭碱的脱去能力的量度。虽然不能直接表示基团的脱去能力——它们只是pKa为酸电离的平衡状态的数字表示，但是pKa值和脱去能力之间有很多的相关性。例如，一个羟基的取代反应，通过正常的亲核基团，羟基的取代反应几乎不能进行，但由于甲磺酰基的作用，反应可以很轻易地引入亲核基团。这可以从水（pKa值= 15.7）和甲磺酸（pKa值= -6）的pKa的比较中来理解。



事实上反应机理是由各种因素决定的，而不是仅仅是由pKa决定反应如何进行，从pKa值的大小来观察也可能进行逆向的去质子化反应。从酸度系数的定义严格地来说，它不能准确描述反应的状态。但是，从pKa值的大小来比较出反应的结果，是考虑反应机理时非常有效的方法。在卷末对pKa值有一个总结表，一定要好好利用。

表② 酸度系数

pKa	酸	酸根	pKa	酸	酸根
−10	$HO-SO_2-OH$	$HO-SO_2-O^{-}$	−1. 4	$^{-}O-N^{+}(=O)-OH$	$^{-}O-N^{+}(=O)-O^{-}$
−9	$RC(=\overset{+}{O}H)Cl$	$RC(=O)Cl$	−0. 5	$RC(=\overset{+}{O}H)NH_2$	$RC(=O)NH_2$
−8	$RC(=\overset{+}{O}H)H$	$RC(=O)H$	0. 5	$F_3C-C(=O)OH$	$F_3C-C(=O)O^{-}$
−7	$RC(=\overset{+}{O}H)R$	$RC(=O)R$	1. 5	$Ph-S(=O)-OH$	$Ph-S(=O)-O^{-}$
−6. 5	$Ar-SO_2-OH$	$Ar-SO_2-O^{-}$	2. 0	$HO-SO_2-O^{-}$	$^{-}O-SO_2-O^{-}$
−6. 4	$Ar\overset{+}{O}H_2$	$ArOH$	2. 2	$HO-P(=O)(OH)-OH$	$HO-P(=O)(OH)-O^{-}$
−6	$Me-SO_2-O^{-}$	$Me-SO_2-OH$	2. 9	$ClH_2C-C(=O)OH$	$ClH_2C-C(=O)O^{-}$
−6	$RC(=\overset{+}{O}H)OH$	$RC(=O)OH$	4. 2	$PhC(=O)OH$	$PhC(=O)O^{-}$
−6	$Ar-\overset{+}{O}(H)-R$	$Ar-O-R$	4. 8	$MeC(=O)OH$	$MeC(=O)OH$
−3. 5	$R-\overset{+}{O}(H)-R$	$R-O-R$	6. 4	$(HO)_2C=O$	$(^{-}O)(HO)C=O$
−2. 4	$Et\overset{+}{O}H_2$	$EtOH$	10. 0	$PhOH$	PhO^{-}
−1. 7	H_3O^{+}	H_2O	11. 6	$HO-OH$	$HO-O^{-}$
−1. 5	$ArC(=\overset{+}{O}H)NH_2$	$ArC(=O)NH_2$	12. 2	$Me_2C=NOH$	$Me_2C=NO^{-}$

A

B

C

D

F~H