Heterogeneous catalysis – Catalysts database

This is a partial list of catalysts used in some industrially important heterogeneous catalytic reactions. The list will be updated gradually.

Reaction	Catalyst	Remarks
Adsorption Separation technology	Polysiloxanes with various substitution groups Packed catalyst columns	
Adsorption Water treatment	Zeolites Activated carbon	
Adsorption Air treatment	Zeolites Activated carbon	
Alkylation Benzene----> Toluene Toluene----> Xylenes or styrene	$AlCl_3$ Zeolite-X Zeolite-Y ZSM-5 Ag/Al2O3 MCM-42 MCM-49 Pt/H-ZSM-5 La-Zeolite-X SBA-15 H-MCM-22 CeO2-MgO	
Hydroformylation $CO+C_n^{=}+H2$-----> C_{n+1} aldehyde	Rh/Al2O3 Rh/SiO2	

	Rh/SiO2-Al2O3 Pd/SiO2 Rh-Pd/SiO2 Rh-Co/SiO2 Au/Co3O4 Co/Al2O3 Co/SiO2	
Hydrotreating – HDS R-SH+H2----> R+ $R^{=}$ + H2S	Sulfided CoMo/Al2O3 Sulfided NiMo/Al2O3	Industrial catalyst
Hydrotreating – HDN R-NH2+H2----> R+ $R^{=}$ + NH3	Sulfided NiMo/Al2O3, Pd/Al2O3	
Epoxidation CH2=CH2----> $(CH_2\text{-}CH_2)O$ CH_2=CH-CH_3-----> $(CH_2\text{-}CH\text{-}CH_3)O$	Ag, Ag/Au supported on zeolites, carbonates (CaCO3, MgCO3, SrCO3, BaCO3), CaF, CaTiO2, tribasic calcium phosphate, calcium molybdate, magnesium molybdate, strancium molybdate	Catl. Lett.: 2002, 80, 93
Selective hydrogenation 1,3-butadiene α,β-unsaturated aldehydes Crotonaldehyde----> Crotyl alcohol 3-methyl crotonaldehyde----> 3-methyl crotyl alcohol	Lindlar catalyst Pd/CaCO3 with Pb/Bi or Amine/Sulfur Al2O3 supported catalysts of Fe, Co(10%), Ni, Cu(10%), or Pd(5%) Al2O3 supported catalysts of Cu, Ni, Fe Ru, Re, Os supported on ZnO	Pharma, Perfumes, Flavors Batch reactors

	Pt (promoted by Fe or Sn)/SiO_2 with Pt:Sn 4:1 Cu or Cu(sulfidation) /Al_2O_3 Cu/SiO_2 Cu-Pd (3:1) Pt/TiO_2	
Selective oxidation Propylene glycol----> acids aldehydes, ketones Glycerol oxidation	Pt, Pd (promoted by Bi or Pb) Supported on C or Al_2O_3 Also: Cd, Co, Cu, Se, Ce, Te, Sn, Au, Ru serve as promoters Pt, Pd, Au, or Ag supported on C, graphite, pumice Also: PdAg/Pumice	
CO oxidation **Water gas shift reaction** **DeSox** **Complete oxidation of CH_4** **Selective partial oxidation of propene** **Olefin hydrogenation** **NO reduction with hydrocarbons**	All these reactions utilize: Au/CeO Au/TiO_2 Au/TiC (Ceria, oxides, carbides titania serve as goos supports)	
Enantio selective reaction	Adams Pt catalyst Pt/Cinchona 2.5%Pt/SiO_2 Pt/Al_2O_3	

DeSOx Decomposition of SO2 SO2+2H2S-----> 2H2O+3S	Au/TiO2	
Fischer Tropsch (FT) process CO+H2--> Hydrocarbons C-C compounds In general: nCO+nH2----> (-CH2-)n + nH2O	Fe and Co based catalysts with Ru, Cu, Ni and K2O promotion (Sasol reaction) Fe/ZrO2 Fe/K/ZrO2 Co/SiO2 (FT Catalyst) Fe-H-ZSM-5 0.5%La promoted using La2O3 On 15%Co/Activated carbon Co/Al2O3 Ru/Co/ZrO2-Al2O3 CoRe/Al2O3	Low Temp FT uses Co High Temp FT uses Fe Promotes alcohol formation
Methanol synthesis CO/CO2/H2-----> CH3OH CO+2H2------> CH3OH	Cu/ZnO/Al2O3 Cu-Zn Cu/SiO2-Zr Cu/ZrO2 Cu/ZnO Pd/SiO2 Pd/ZrO2 Pd/TiO2	EtOH product (C-C product formation) Hydrocarbons (HC) formation EtOH formation C2 oxygenates

	Ca-Pd/SiO2 Cs-Cu/ZnO/Al2O3 Rh/SiO2 Rh/Al2O3 Rh/ZrO2 or TiO2 or CeO2 or MnO or La2O3 Rh/SiO2 promoted by Mn/Fe/Li or Nb	
Hydrogenation Alkene-----> alkane Acids-----> alcohols Esters-----> alcohols Oils and fats	Ru/C, Pd/C Ru/C, Pd/C, Pt/C Cu/SiO2, copper chromite, Ba promoted copper chromite Supported Ni	
Dehydrogenation Alkane dehydrogenation	Supported ZSM-5 Ga/ZSM-5 Pt/Mg(Ga)(Al)O Pt/Fe/ZSM-5 Pt/Mg(In)(Al)O V2O5/MCM-41 V/Al2O3 CrOx/SiO2 Pd/Al2O3 Supported Cr catalysts	
Oxidation Partial oxidation of alkanes	Fe/SiO2	

	PdV/TiO2 Ti-Beta V/MCM-41 Pt/Al2O3 Rh/Al2O3 Mn-Zeolite-5, 55, 58 Ti-Silicates Pt/Mg(Ga)(Al)O V2O5 V2O5/TiO2	
Ammonia synthesis	Os Ur Fe promoted with K_2O, CaO, SiO_2, and Al_2O_3 Ru/C Co/C Ba-Fe-Co/C Ru/MgO	
CO_2 hydrogenation CO2+H2-----> CO, HCOOH, HCHO, CH3OH CO2+CH4-----> 2CO+2H2	Cu-Zn-chromite H-zeoliteY ZrO2 – good support for high temperature hydrogenation Pt(Sn)/SiO2 Fe(K, Cu)/Al2O3	Dry reformation

CH4 Partial oxidation CH4-----> CH3OH or HCO species Oligomerization Dimerization Partial oxidation **Dry reforming of CH4**	Ru/TiO2 Ru/SiO2 Ru/Al2O3 Pt/CeZrO2/Al2O3 Ni or Ni-Au/MgO-Al2O3 Ni/Al2O3-aluminium nitride Ni/SiO2 Ni/Mg(Al)O Ni/MCM-41 Re/Al2O3 Mg-Al LDH Ru/SiO2 Ru/Al2O3 Ru/C Pt/Al2O3 Ni/Al2O3 PtNi/Al2O3 Rh/Al2O3 Rh/La2O3 NiCu/SiO2	
Methanol to Hydrocarbons (MTG) CH3OH-----> C2-C9 hydrocarbons	H-ZSM-5 Cu/SiO2 Raney-Ni	Dimethyl carbonate

	Cu+-zeolite-X	
Steam reforming CH4 + H2O-----> CO+3H2	Ni on Al2O3 or MgO promoted with Au, Ag, Sn, Cu, M, Fe, Ru and other transition metals Cu/ZnO	
Water gas shift (WGS) reaction CO+H2-----> CO2+H2	CuO-ZnO-Al2O3 Fe2O3-Cr2O3-MgO Au/CeO2 or TiO2 Cu/CeO2	
Hydrogen production **(Steam reforming followed by WGS process)** CH4+H2O----->CO+3H2 ΔH= + 206 kJ/mol (298K) Favored at high T and low P Then do WGS: CO+H2O-----> CO2+H2 ΔH= - 41 kJ/mol (298K)	Supported Ni catalyst (Noble metals as activators) High T shift: Fe2O3/Cr2O3 at 670K Low T shift: Cu/ZnO at 470K Ni/MgO Ni/YSZ Sn/Ni/YSZ Ni/MgO/alkali Pd/CeO2/Al2O3 Ni/MgO Ni/TiO2 Pt/TiO2 Pt/ZrO2	700 - 1250K / 30 bar TOF = 0.5 s^{-1} at 723K (with 10% CH4 conversion) Coking should be controlled Steam dissociation CO2 reforming

	Ag-Ni/Al2O3 Co-Ni/ZrO2	
Methanol to Aromatics	Impregnated Zeolites Ni/ZSM-5 Cu/ZSM-5 Zn/ZSM-5 Ga/ZSM-5 Ir/ZSM-5 Ru/ZSM-5 Pd/ZSM-5 Ag/ZSM-5	

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