N·A·N·O HUB

Innovative solutions for the fruit&vegetable sector and the conservation of products

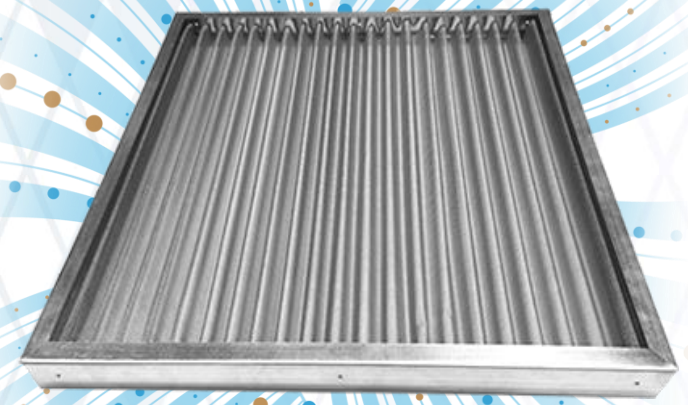
Nanohub technology

Nanohub develops solutions based on the use of nanomaterials for energy efficiency and the quality of the environment, for people well-being and for the protection and conservation of goods.

These solutions are mainly employed in the following fields:

- Treatment of buildings' surfaces and casings
- Indoor air treatment
- Groceries preservation
- Water treatment

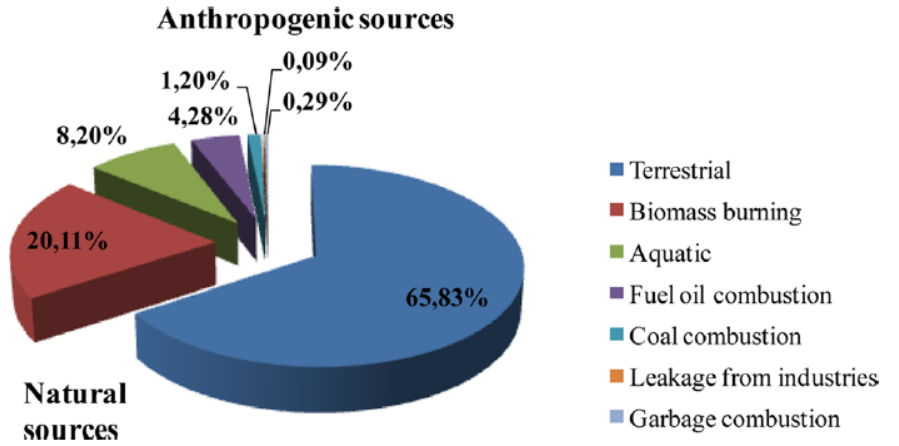
Among the developed products/solutions there are photocatalytic lamps, several devices for air treatment in closed environments, filters for air treatment in vehicles (ambulances and transport of the cold chain), systems for the fruit&vegetable sectors (in particular those of the GDO), a heat and air exchanger for domestic environments.



Ethylene and its effects on the conservation of fruit&vegetable

What is Ethylene?

Ethylene (C2H4) is a natural plant ripening hormone that has numerous effects on growth, development and conservatin of many types of fruit, vegetables and flowers. The ethylene comes from cultivation (fruit and vegetables), emissions from combustion engines, air pollution and plastics.



Why is it harmful?

Accelerates the rapid maturation that can lead to a significant **loss of the product** (between 10 and 80%).

The ethylene ethylene is superseded at extremely low concentrations (ppm to ppb).

Its reduction is useful for **climacteric fruit** in the maturation phase and for non climacteric fruit to remove the ethylene effects produced from the closeness to products with a high emission of ethylene.

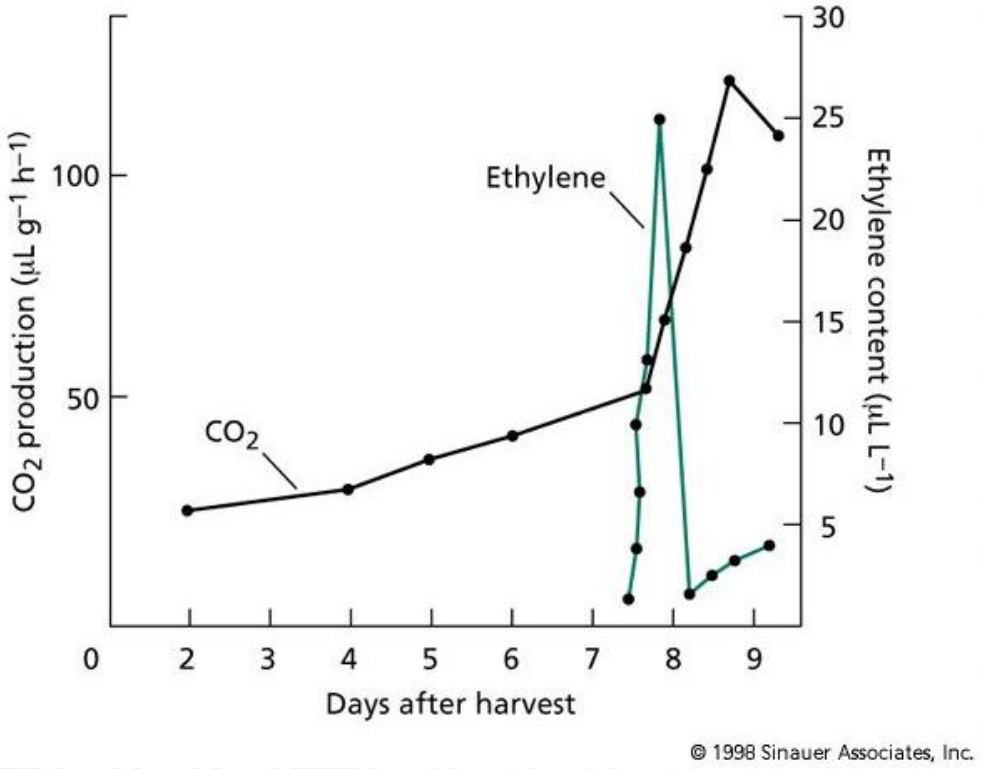
The control and reduction of ethylene are capable of **extending the shelf life** and **improve the quality** of fruit&vegetables and of cut-flowers.

Ethylene in the ripening phase of fruit&vegetable

In the post-harvest phase, all the fruit and vegetables undergo several alterations due to the change of natural environmental, physical and chemical conditions.

The most common effects observed are the different appearance and taste – namely decrease in weight, freshness, aroma and flavour, the colour, the degree of ripening, and the presence of moulds and pathogens.

The main causes of these phenomena are due to the natural physical properties of the air and to the intrinsic characteristics of these products, which produce ethylene (natural ripening hormone) in the post- harvest phase. Ethylene triggers the ripening process of the products, provoking an over-ripening and deterioration if not adequately controlled.



Several fruits have a peak production of ethylene of autocatalitic type. Breathing increases (O_2 consumption and CO_2 production).

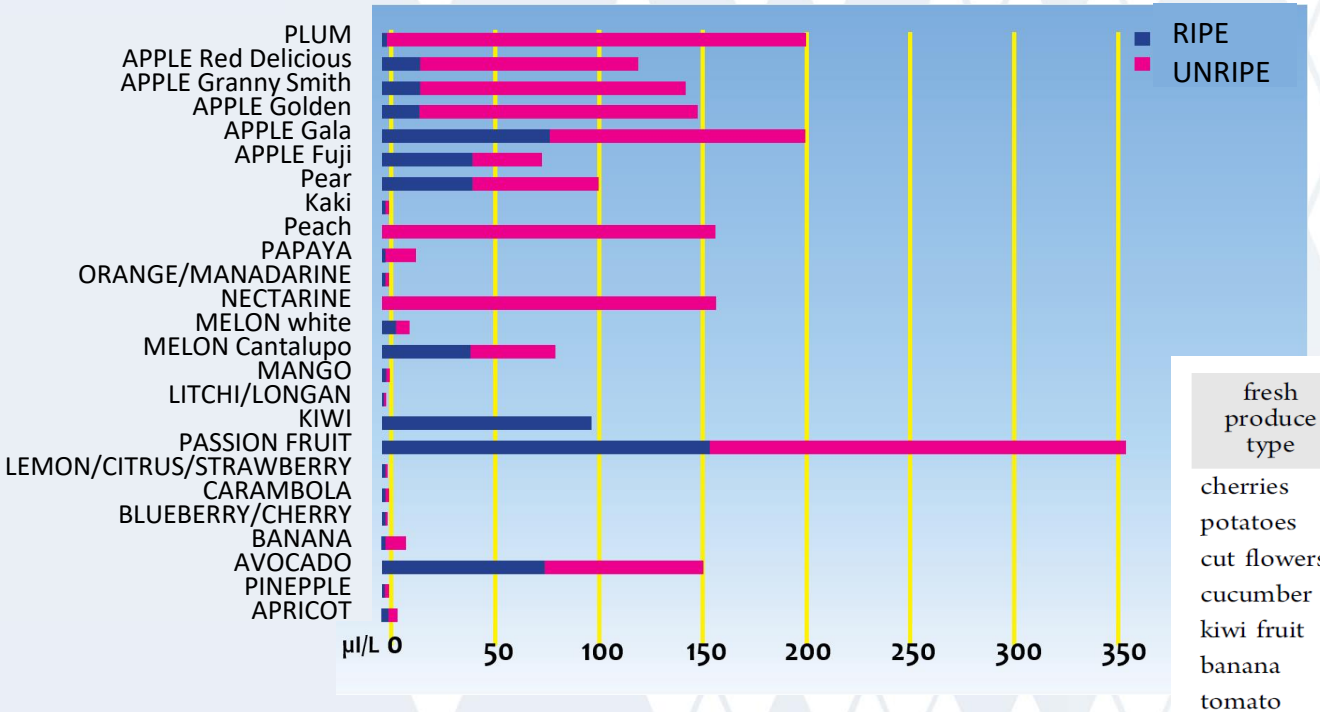
Climacteric Fruit

- Apple
- Pear
- Banana
- Kiwi
- Apricot
- Peach
- Plum
- Fig

Non-Climacteric Fruit

- Orange
- Lemon
- Strawberry
- Cherry
- Grapes
- Pineapple
- Raspberry

Percentage of ethylene produced and its sensitivity by type of fruit



fresh produce type	ethylene production rate (μL kg^{-1} h^{-1})	ethylene sensitivity[a]	principal reaction to ethylene
cherries	very low <0.1	L	softening
potatoes	very low <0.1	M	sprouting
cut flowers	very low <0.1	H	sleepiness, leaf curl
cucumber	low 0.1–1.0	H	yellowing
kiwi fruit			decay
banana	moderate 1.0–10	H	decay
tomato	moderate 1.0–10	H	shrink, decay
apricot, avocado	high 10–100	H	decay
apple	very high >100	H	scald, lose crunch
passion fruit	very high >100	H	decay

[a]Ethylene sensitivity (ppm): H = high (0.01– 0.5); M = moderate (0.5–3); L = low (3–5).

Fruit&vegetable sector in the food distribution

In developed countries the traditional retail and distribution sector for the fruit&vegetable sector produces about 10% of vegetal waste.

A relevant portion of that waste is caused by alterations generated by altering micro-organisms.

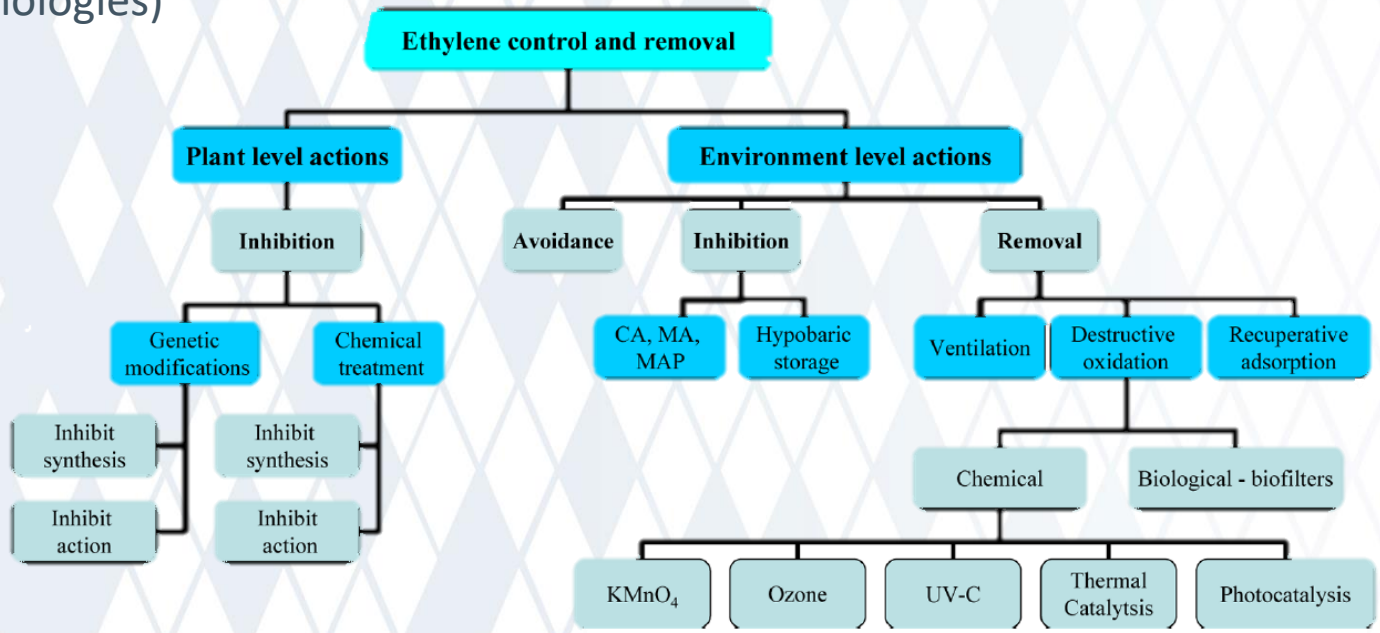
Since browning and rots are commonly caused by species capable of growing at refrigeration temperatures, the control of both the microbial load during the refrigerated storage and of the ethylene production, represents a key-factor in obtaining groceries of good microbiological quality and with a longer shelf life.

N·A·N·O HUB developed an interesting system to control this issue by means of photocatalysis.

Approaches for the control and elimination of ethylene

Two approaches exist for the protection of fruit&vegetable products in the post-harvest phase, against the ehtylene effects of products deterioration:

- Plant level actions, to inhibit both the synthesis and the action of ethylene (genetic and chemical approach)
- Conservation environment level actions, with ethylene control and removal from the athmosphere through its oxidation or adsorption (approach with destructive or recuperative technologies)



The Solution: Nano Photocatalytic Oxidation

What is Photocatalysis?

Photocatalysis is the natural phenomenon in which a substance, called a photocatalyst through the action of light (natural or artificial) changes the speed of a chemical reaction.

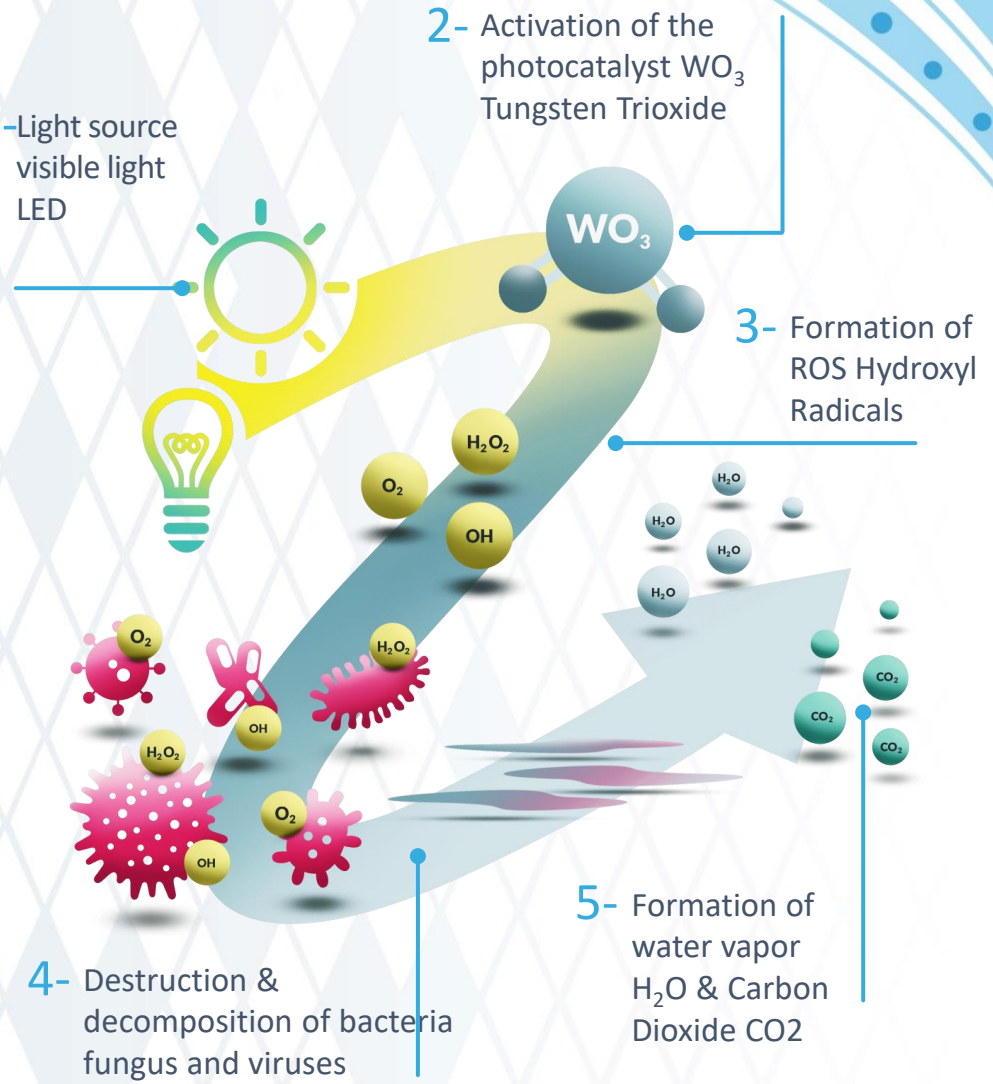
When exposed to light, Tungsten Trioxide WO_3 absorbs and converts light energy into electrons and electron holes. WO3 reacts with water (air humidity) to create hydroxyl radicals (expressed as OH-) and with oxygen to create superoxide anions (O2-).

Billions of these highly oxidizing species are created in billionths of a second and work to break down matter at the molecular level.
The result is an effective decomposition of organic and inorganic pollutants (similar to all fine dust PM2.5 - PM10), microbes, viruses, nitrogen oxides, poly condensed aromatics, sulfur dioxide, carbon monoxide , formaldehyde, methanol, ethanol, benzene, ethylbenzene, nitrogen monoxide and dioxide etc.
Photocatalysts do not lose their properties over time, as they only act as process activators, do not bind to pollutants and remain available for new photocatalysis cycles. The catalyst does not intervene directly in the reaction but favors the photocatalytic reaction by lending its electrons which it subsequently regains from the environment.

Pollutants and toxic substances are transformed, through the photocatalysis process, into:

- sodium nitrate ($NaNO_3$)
- sodium carbonates ($Na2CO_3$)
- calcium carbonate ($CaCO_3$)
- carbon dioxide (CO_2)
- water vapor

All harmless and measurable in ppb (parts per billion)



Photocatalysis for Food preservation

- The photocatalysis process can be used for the treatment of ethylene and of microbiological pollutants, main cause of the **fruit and vegetable decay.**
- Implementing the treatment in environments for food storage allows maintaining the products at a higher temperature (ex. 18° C instead of 4° C) with **relevant energy savings** and a **better fruit quality**.
- The pictures show the result of keeping two Kiwi for 3 weeks at 18° C and UR 70%, with and without photocatalytic treatment.
- Eliminating ethylene slows breathing, which implies a lower oxygen consume and reduction in CO_2 emission.

Some tests

Nanohub started a collaboration with the University of Salento on the issue of ethylene control and its effects on the fruit&vegetable conservation. Several tests and research on the application of the photocatalytic oxidation technology have been conducted.

In the following slides, tests are reported, conducted on:

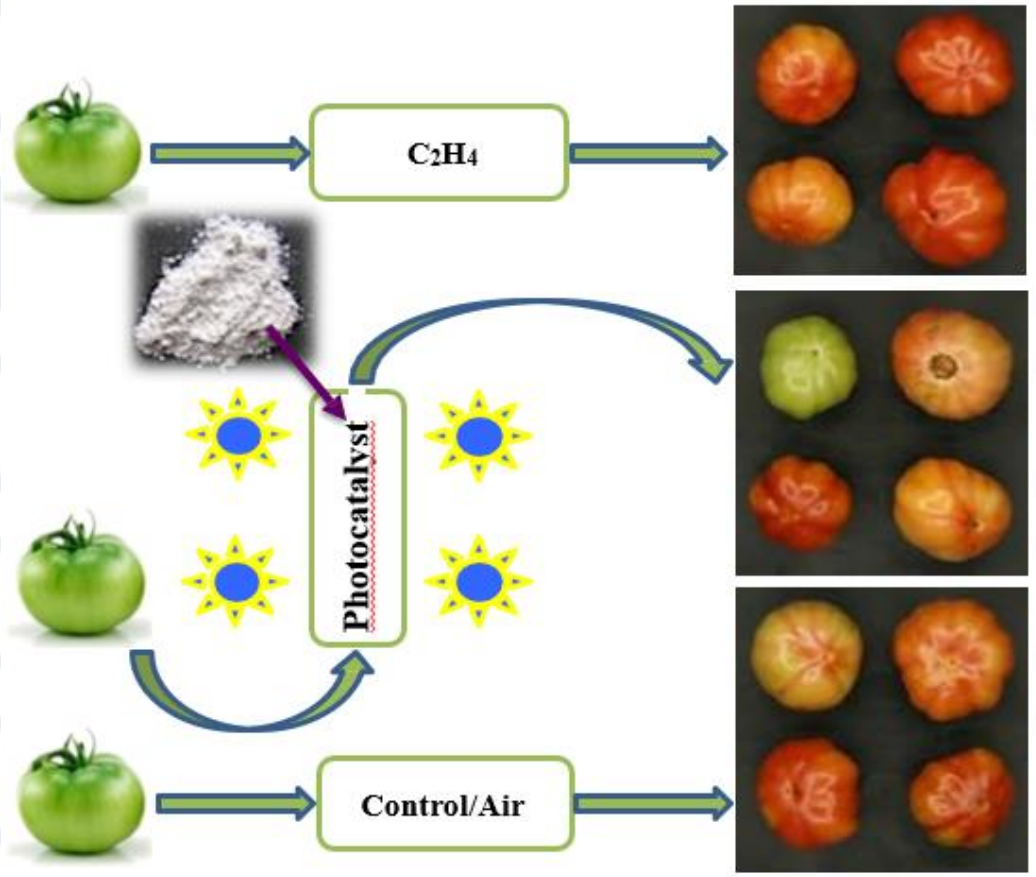
- ✓ Tomatoes
- ✓ Lettuce
- ✓ Rocket

Tomatoes

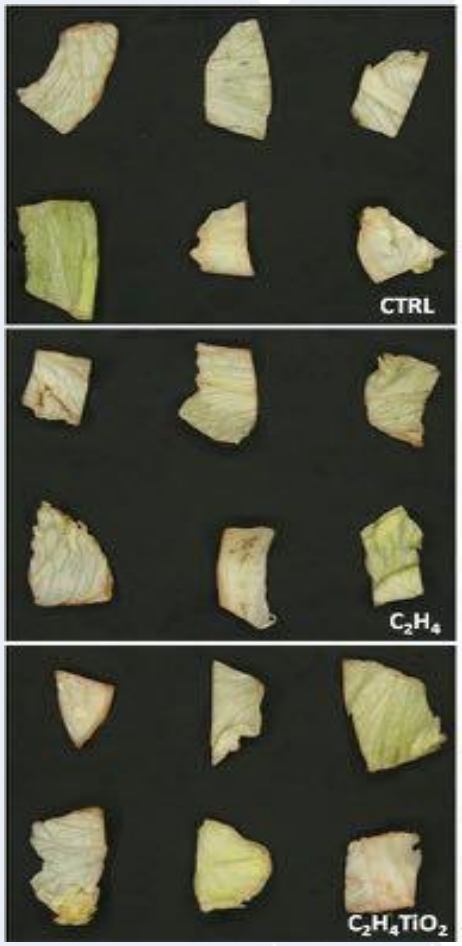
The tomatoes have been kept under C_2H_4, catalyst and ambient air.

Ethylene concentration was monitored by measuring the air treated with a gas chromatograph.

Maturation was prevented after storage in the atmosphere treated with photocatalyst.



Iceberg Lettuce



Russet spotting (Ethylene phytopathology) only on lettuce leaves treated with exogenus ethylene.

Pre-treatment with photocatalyst allows the elimination of ethylene and therefore prevents the appearance of rust on plant samples.

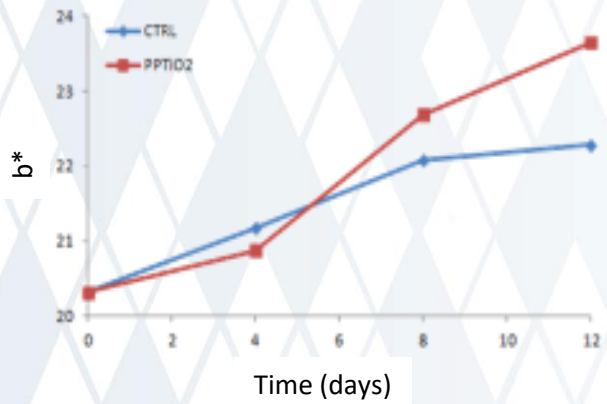
The effectiveness of the treatment, fluctuating for other products, is dependent on product sensitivity to the presence of ethylene.

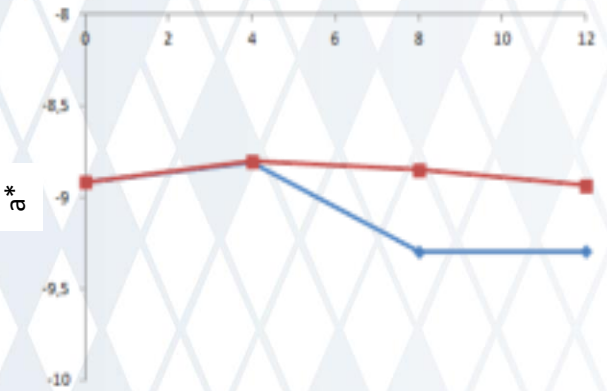
Rocket

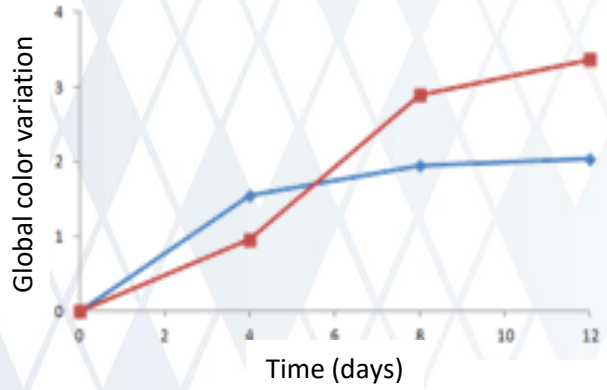
Photocatalysis slightly affects the degree of yellowing of the tissues in leaf products.

In fact, ethylene acts on the foliar tissues speeding up the loss of chlorophyll and, therefore, the yellowing.

In the graphs, the evolution of the yellow and red values and of the global variation of the rocket leaves colour di giallo e di rosso e della variazione globale di colore di foglie di rucola packaged in two different films (overall the color is tending less to yellow).





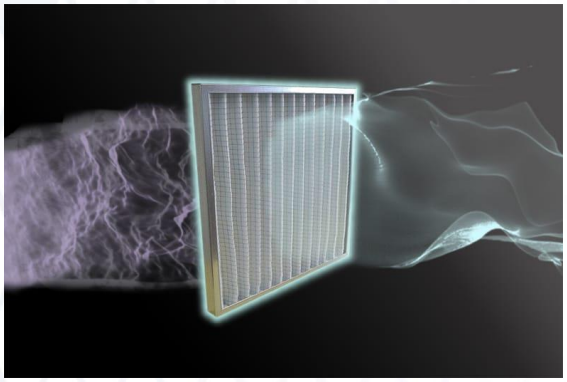


Nanohub solution for the fruit&vegetable department

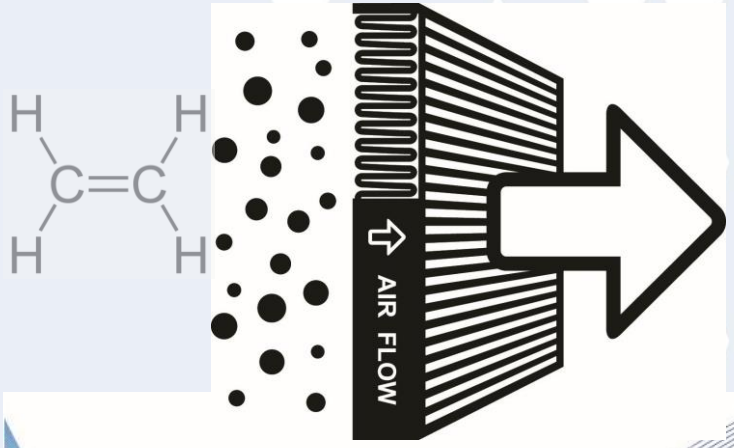
Besides the possibility of installing devices on the counters and in the fruit&vegetable cells, the proposal foresees the implementation of an intervention for air control directly in the sales area through a hooding system that filters the air and cuts down ethylene.

To obtain a better result in the conservation of goods, the department could be furnished with a night subdivision system so that the treatment focuses, in those hours, on the air most interested to the products conservation.

With this intervention it would be possible to **avoid moving the products**, once displayed on the shelves, back into the conservation cells during the night, leading to relevant benefits in terms of organization.



Devices developed by Nanohub are



Effective

- Removal of ethylene, bacteria, moulds, and micro-toxins present in the air and, indirectly, on surfaces

Economical

- Low maintenance
- Negligible power consumption
- Possibility of fruit and vegetables preservation at higher temperatures (energy saving)

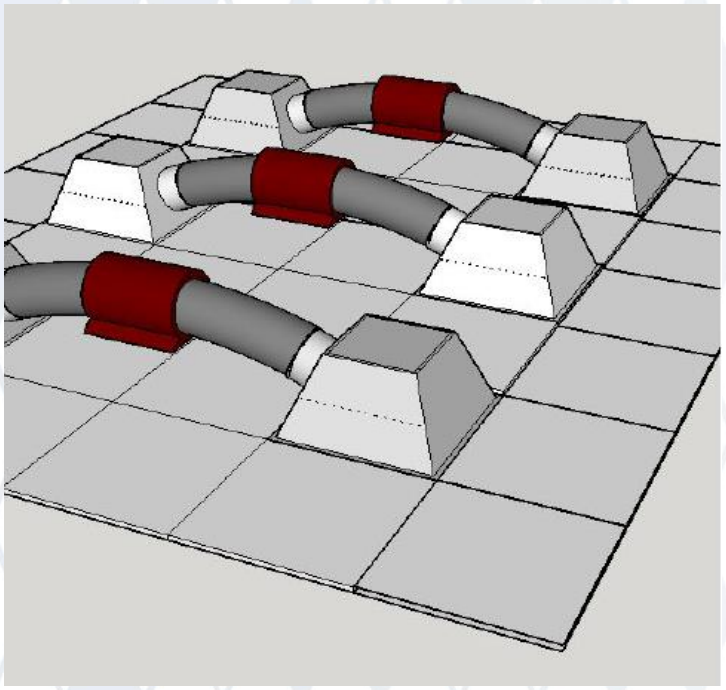
Ecological

- No chemical products are used
- Method compatible with the “Bio” productions”

Safe

- No UV rays are released from the device
- No decomposition waste
- Only an infinitesimal emission of CO2 and water vapour

Technical solutions for the preparation of the fruit&vegetable sector



Potential savings from the Nanohub solution

Reduction of staff working hours for putting back in cell the products during night (salad, celery, asparagus) beet, kaki, mushrooms, broccoli, etc.)

Estimated average time: 20 minutes for 100sqm of department.

Reduction of revenue losses on products for excessive repening counting of about 15% of the wasted products.

Average incidence of thrown away products from 3 to 5% on an average turnover value of the fruit&vegetable department of about 5.000€/smq.

Thank you for choosing Nanohub

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