Ministero della Difesa (Segredifesa/Terrarm)
B.M.D. S.p.A.
Ce.Ri.Col.
Colorobbia Consulting

Nanotechnologies in air filtration system for CBRN applications

Overview

- Who we are
- Our goal
- Background
- Few (very) science
- Fluid dynamics
- Catalytic substrate
- Chemical tests

Who we are…

- A team composed of few Companies located and based in Italy

- With funding from Italian MoD

Who we are…

- B.M.D. S.p.A. has production capabilities in filtration business plus some key expertise within CBRNE areas
- Ce.Ri.Col. is the research center/facility of Colorobbia Consulting. Has unique expertise in many fields, including advanced materials, ceramics, catalysts and photocatalysis
- Italian MoD.. Our much appreciated sponsor!

Our goal

- Putting together knowledge and expertise in differ fields but with some key aspects we had an idea:

removal of air contaminants (chemical and biological ones) by photochemical oxidation with nano TiO_2 catalyst

Background

Ce.Ri.Col. And Colorobbia Consulting already developed:

- and patented photo-catalytizer active under UV and visible light;
- a prototype filtering unit for ColPro

Based on that we started our process..

Few (very) science

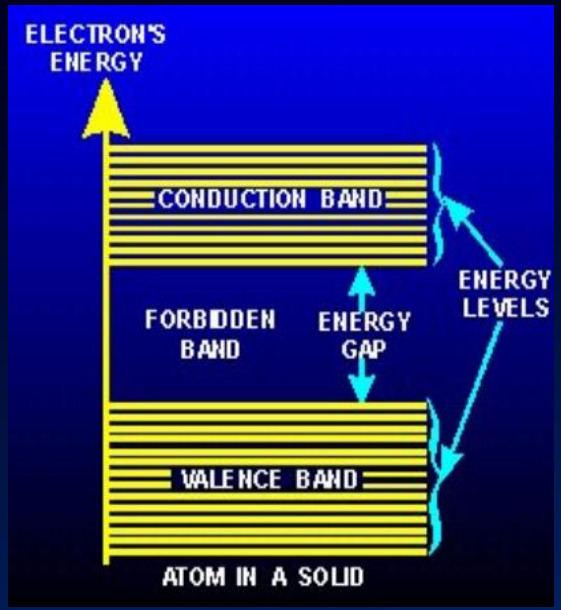
Our basic science pillars are based on:

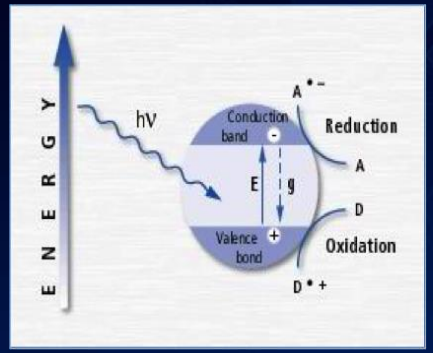
Catalysis (photo);

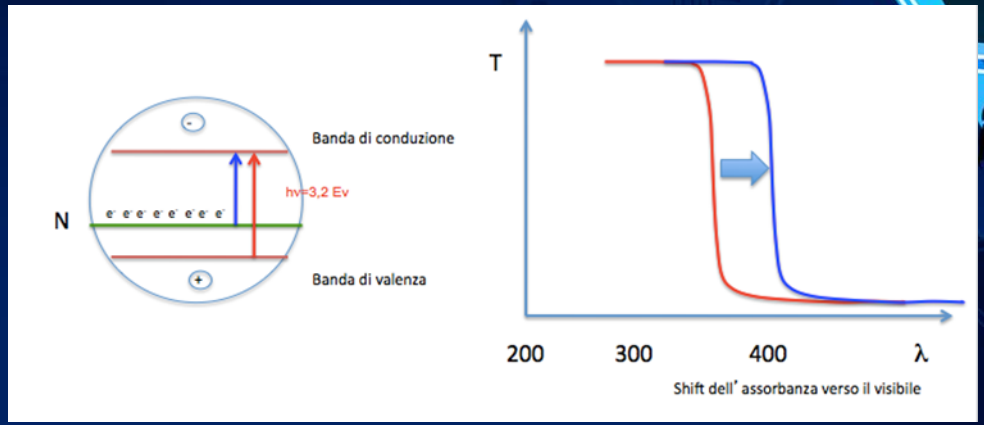
Nanotechnologies;

Fluid dynamics.

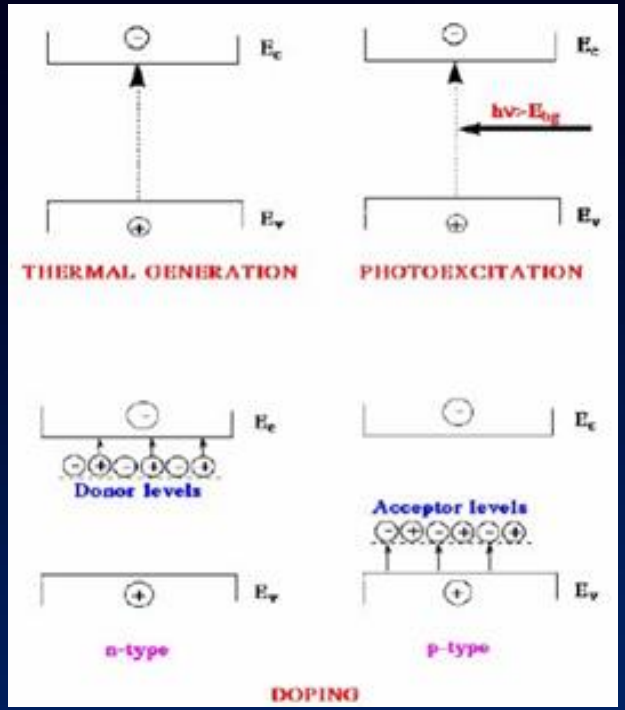
Few (very) science







Few (very) science

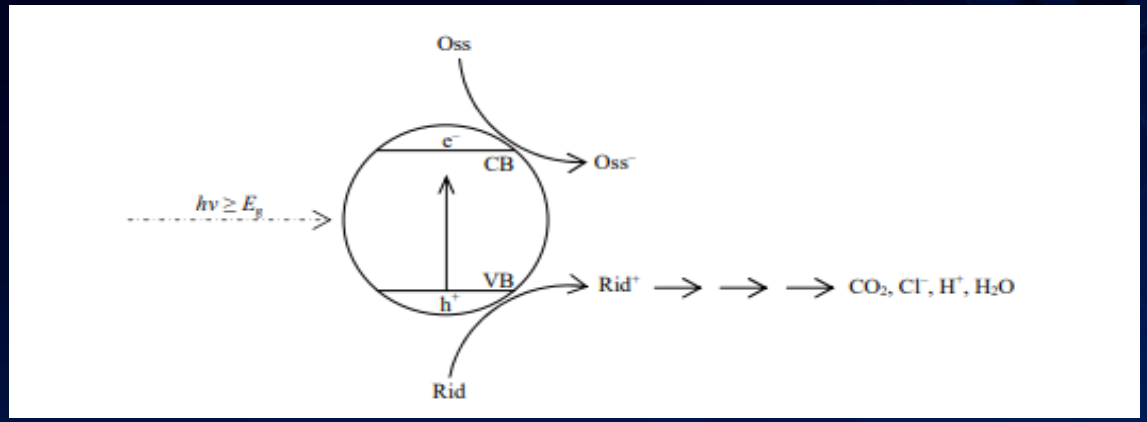


TiO_2 appears to be the ideal solution because quite cheap, widely available, easy to synthetize and manipulate, low toxic to humans, corrosion resistant and a good oxidizer.

Eg= 3,2 eV ($\lambda \leq 388$ nm)

$$TiO_2 + h\nu \rightarrow (TiO_2)\ h^+ + e^-$$

Few (very) science



$D + h^+ \rightarrow D^{\bullet} + (1)$

$A + e^- \rightarrow A^{\bullet -} (2)$

$H_2O + h^+ \rightarrow {}^{\bullet}OH + H^+ (3)$

$O_2 + e^- \rightarrow {}^{\bullet}O_2^- (4)$

$O_2^{\bullet -} + H_2O \rightarrow HO_2 + OH^- (5)$

$HO_2 + e^- \rightarrow HO_2^- (6)$

In other words:

Generated electrons (e-) are going to reduce acceptors (A) while generated lacunes (h+) are going to oxidize donors (D)

Few (very) science

$$TiO_2 + hv \rightarrow e^- + h^+ \quad (1)$$

$$(O_2)_{ads.} + e^- \rightarrow (O_2^{\cdot -})_{ads.} \quad (2)$$

$$Ti(IV)\text{-}OH + h^+ \rightarrow Ti(IV)\text{-}OH^{\cdot} \quad (3)$$

$$Ti(IV)\text{-}H_2O + h^+ \rightarrow Ti(IV)\text{-}OH^{\cdot} + H^+ \quad (4)$$

$$Compound + h^+ \rightarrow Compound_{(oxidized)} \quad (5)$$

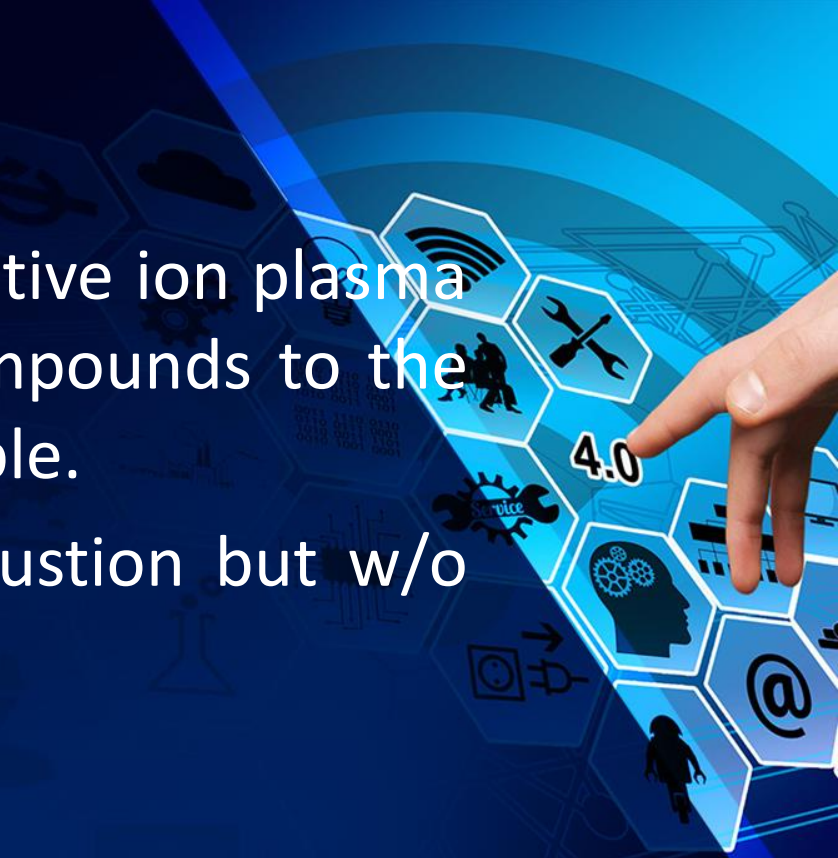
In other words:

Generated electrons (e-) are going to reduce acceptors (A) while generated lacunes (h+) are going to oxidize donors (D)

Few (very) science

We generate a sort of very reactive ion plasma able to oxidize all chemical compounds to the maximum oxidation state possible.

It is a similar process to combustion but w/o any “real flames”

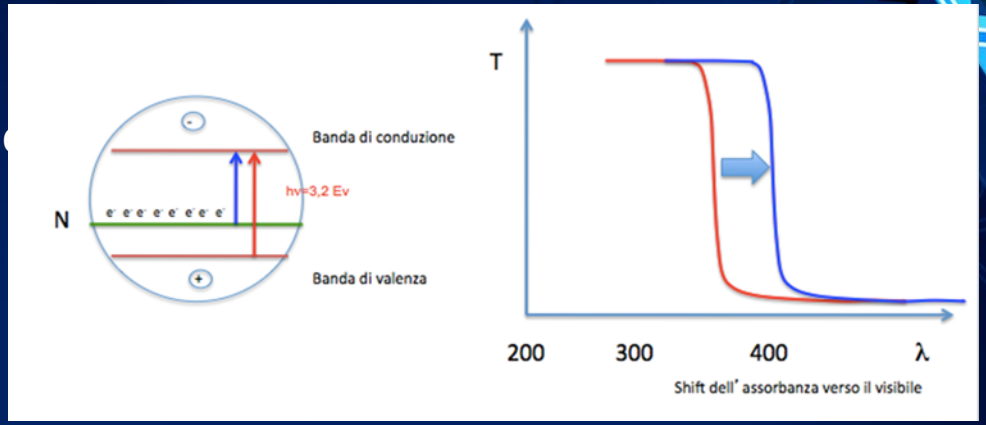


Few (very) science

Nanotech?

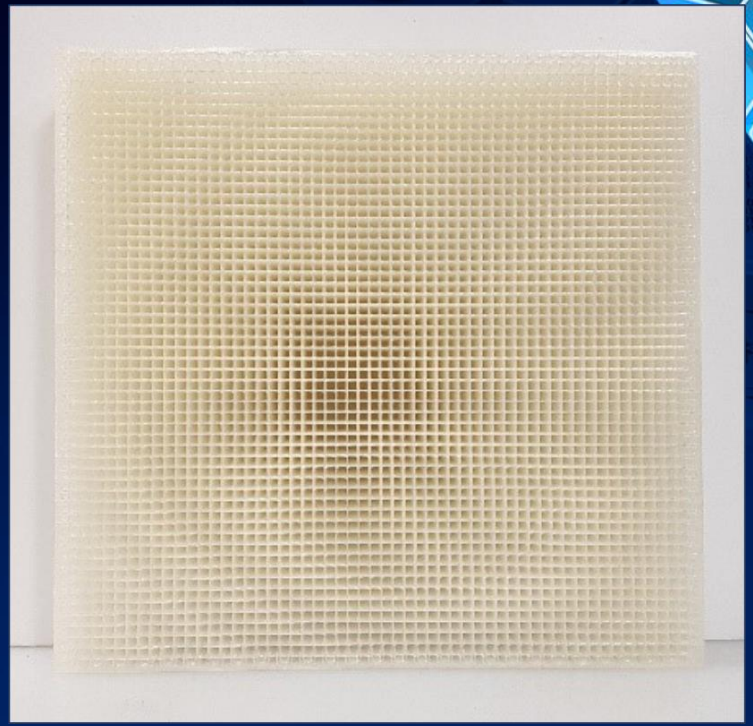
TiO_2 was properly treated with N agents yielding to N-TiO_2 (special patented ingredient!).

This catalyst is able to work (
needs).



Catalytic substrate

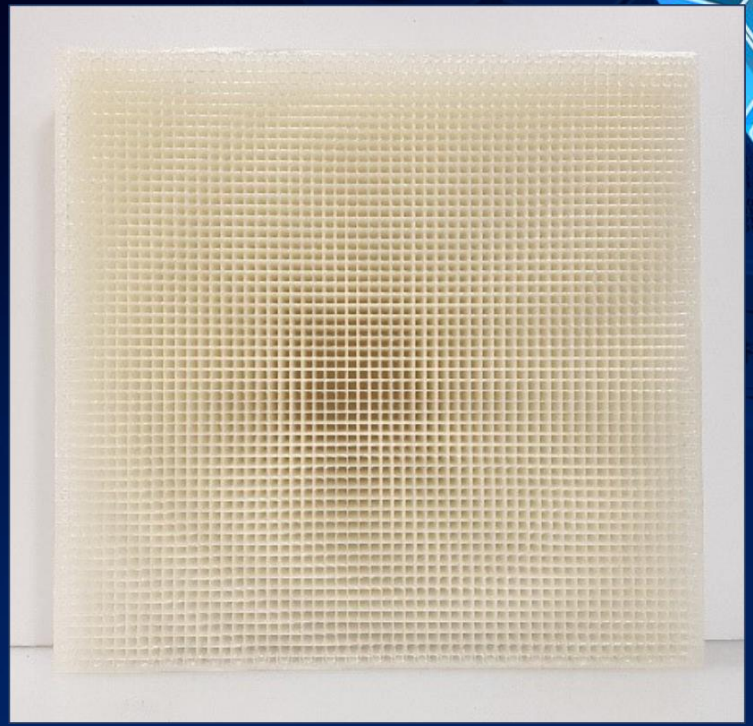
Started from a mineral honeycomb (+/-) were tested polymeric ones, while keeping same basic geometry.



Catalytic substrate

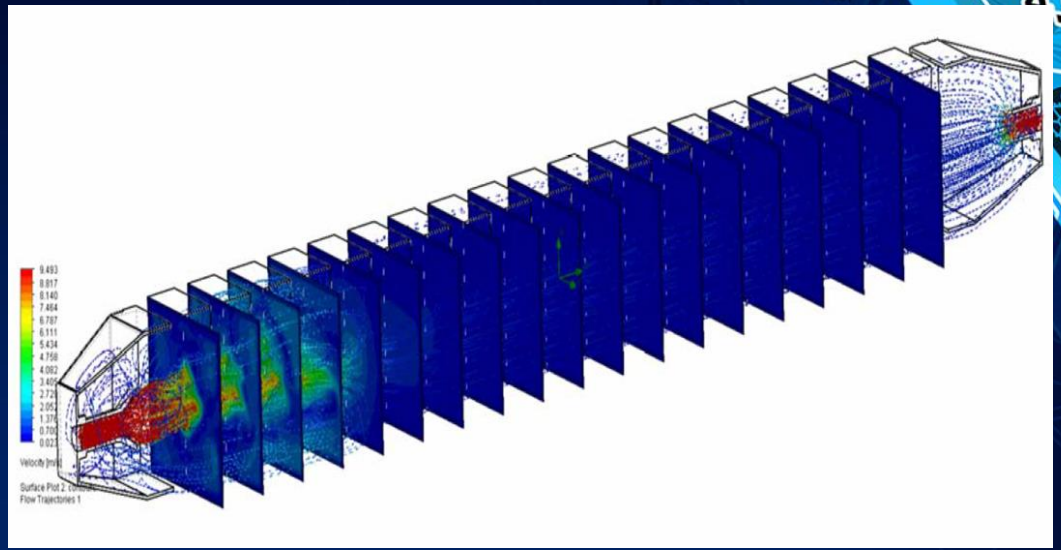
Latest version is based on a poly mix made with 3D printing.

The catalyzer was applied using the flow coating technique.



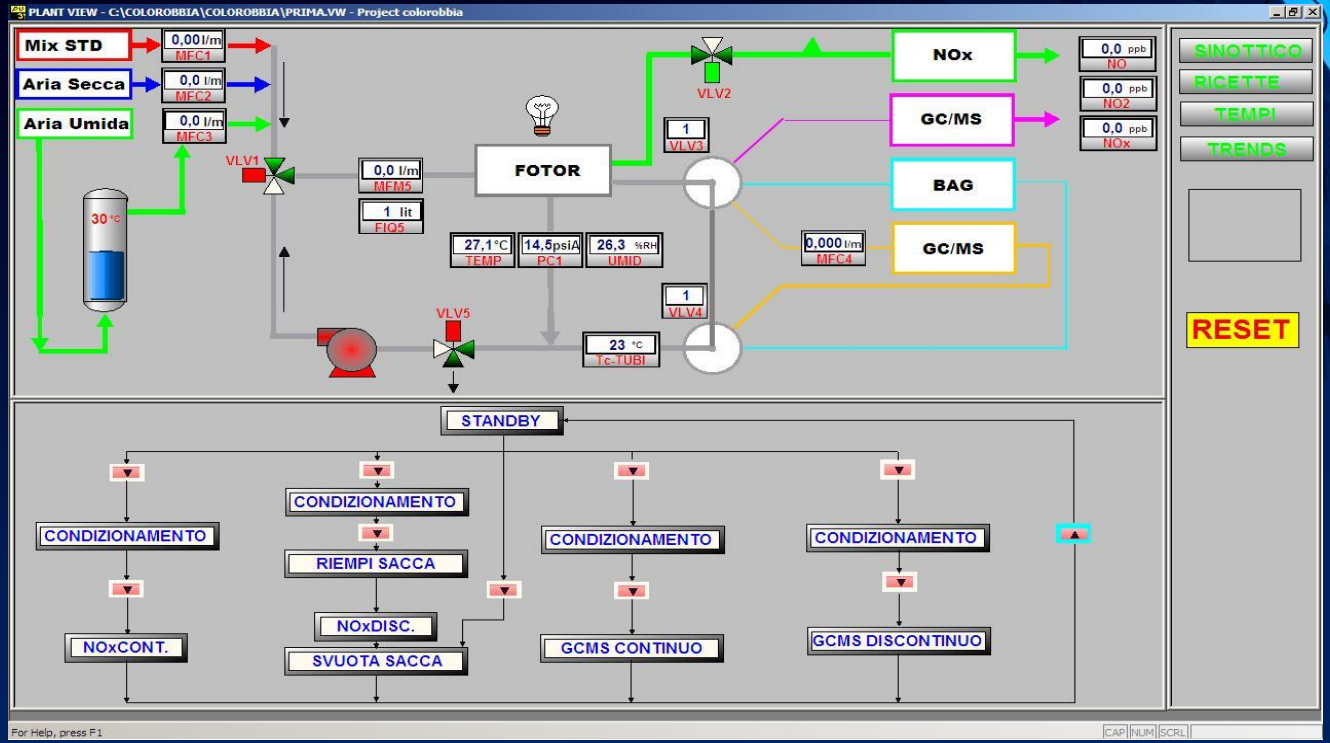
Fluid dynamic studies

- An elementary filter module was designed using CAD software.
- The system consists of 19 functionalized honeycombs, the plexiglass envelope that allows the passage of light radiation, and a peripheral LED matrix lighting system.
- Fluid dynamics studies were conducted to optimize the flow inside the duct.

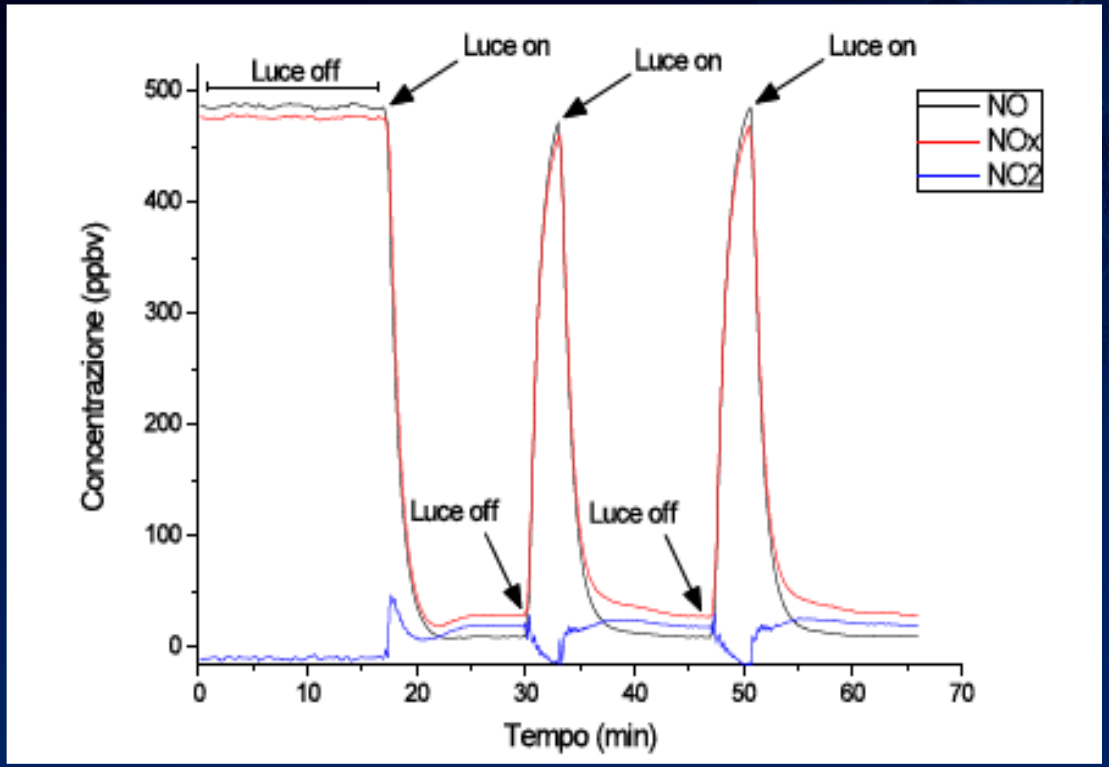


Chemical tests

Chemical tests



Chemical tests



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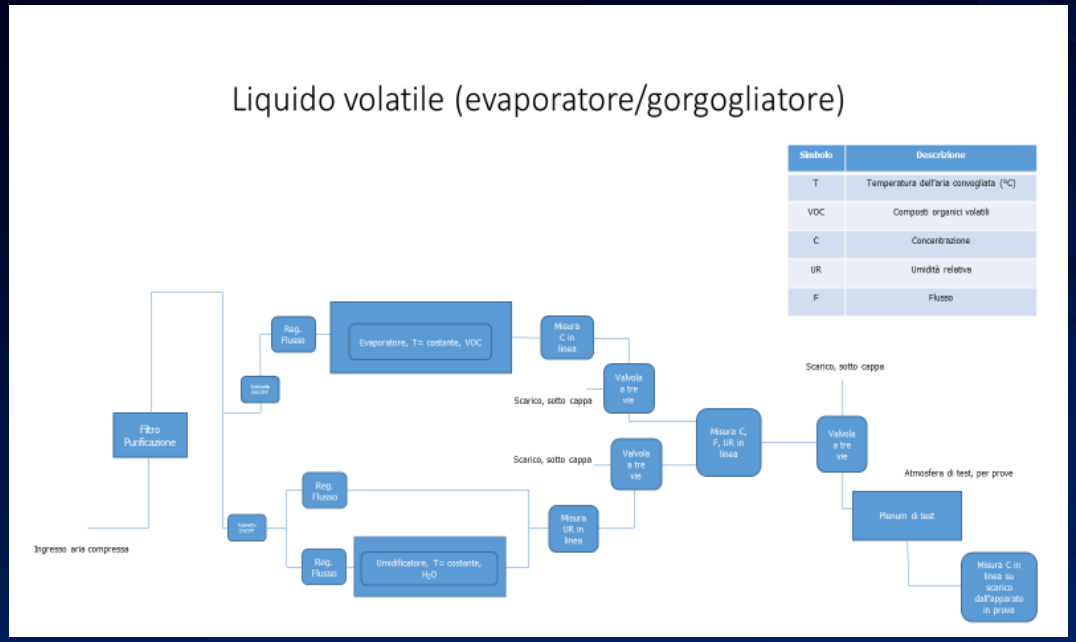
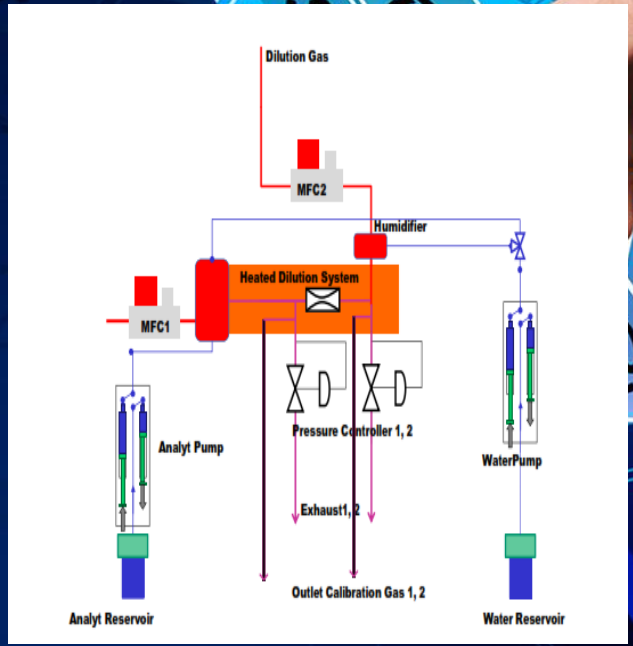
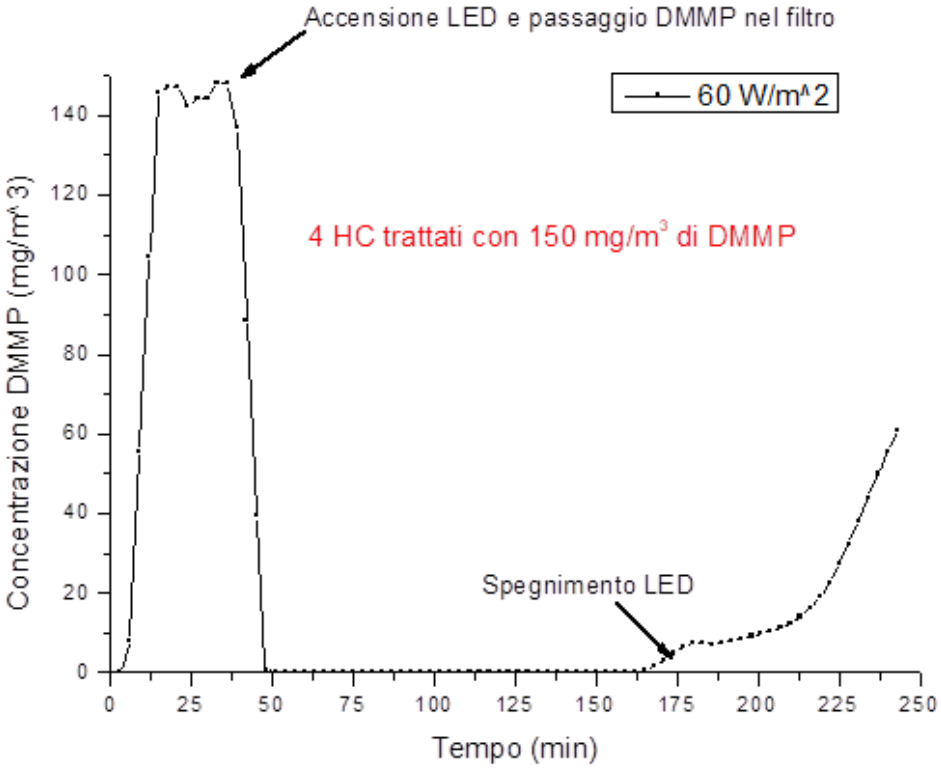




Chemical tests

Latest chem test bench developed can generate synthetic atmospheres of VOC/TIC an SIM (DMMP). The detection apparatus can be:
In line FTIR
GC/MS
Dedicated sensors (PID/Ecs)

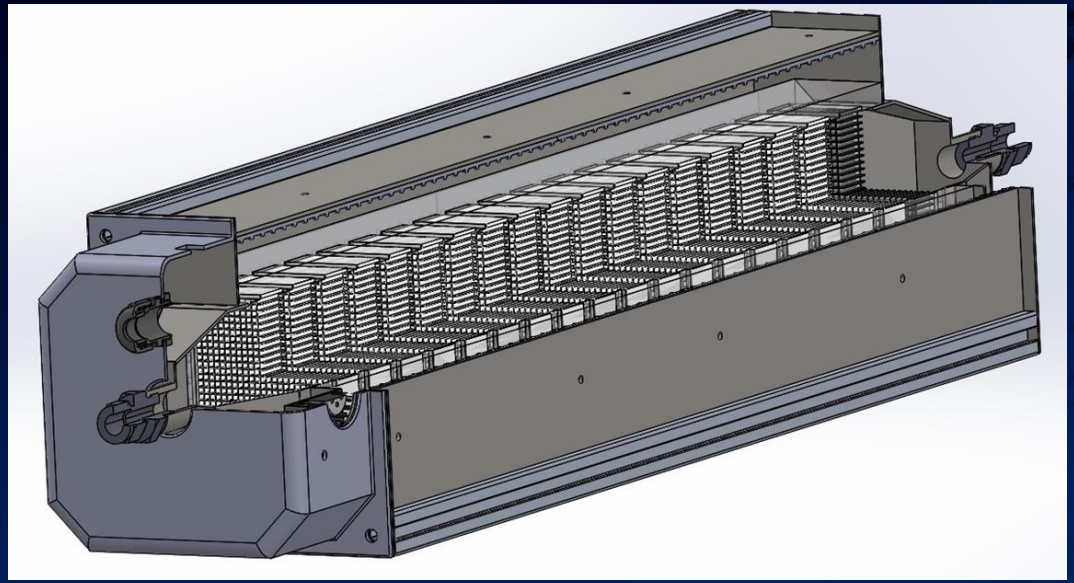
Chemical tests



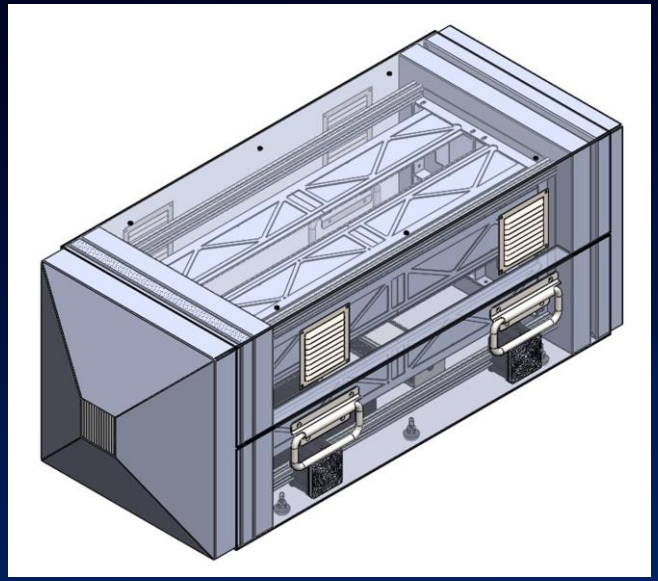
The outcome

Based on our R&D we defined the:
elemental unit (the honeycomb on previous slides);
elemental filtrating unit (on next page);
working prototype.

Elemental filtrating unit



Working prototype



Gratitude

This R&D project was only possible with the Italian MoD support (Segredifesa/Terrarm).

Also many thanks to all team members! Almost 3 years of hard work with sacrifice and dedication.

Any questions?