



# HARMLESS



## Imogolites for agriculture & environmental plant protection

Advanced High Aspect Ratio and Multicomponent materials: towards comprehensive intelligent Testing and Safe by design Strategies

[www.harmless-project.eu](http://www.harmless-project.eu)



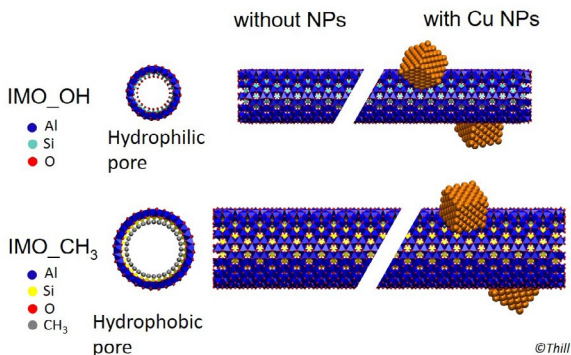
HARMLESS project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 953183.

## Material: Modified imogolites

The **modified imogolites**, aluminosilicate nanoclays with a hollow tubular structure, are included in HARMLESS case studies as advanced nano-enabled materials. They are in the form of powder after drying or dispersed in water as suspension (typical birefringence properties with increasing concentration). Their functionality depends on chemical functions on the inner or outer surfaces and dopants in the tube wall. In HARMLESS, we focus on two inner functionalities (OH or CH<sub>3</sub> group in the tube) and one outer by copper nanoparticles.

### Functionality and Application

Plant protection and action against phytopathogenic fungi or bacteria (patent WO2024002971). Action mode comes for the specific redox properties of imogolites.



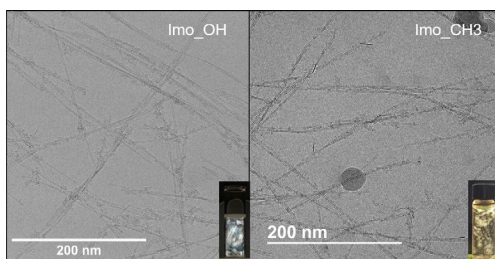
### Objective of the Case Study

Following a safe and sustainable by design (SSbD) Innovation approach in HARMLESS, imo<sub>OH</sub> (hydrophilic inner tube), imo<sub>CH<sub>3</sub></sub> (hydrophobic inner tube) and imogolites functionalized by copper/copper oxide nanoparticles were synthesized by CEA in order to optimize the functionality, the safety and sustainability.

### Design Space

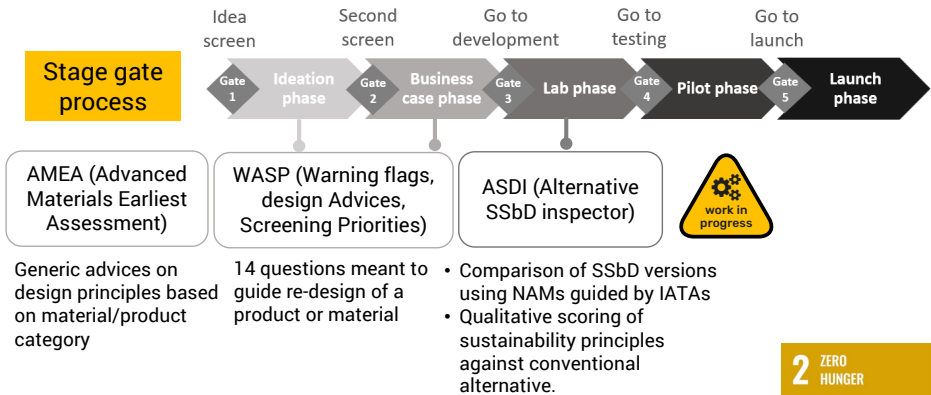
The modification of inner chemical groups of imogolites influences

their properties at individual nanoparticles scale but also at larger scale through collective properties. The functionalization by copper/copper oxide nanoparticles adds a new functionality. The modified imogolites are designed through controlled synthesis to test their performance.



## Innovation in Industry

In HARMLESS, this case study was analysed through a SSbD approach in the framework of HARMLESS Decision support system from ideation to lab phase, mainly for imo\_OH and imo\_CH<sub>3</sub>.



## Benefits of the Case Study

Positive impact to SDG 2 (Target 2.4: By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production), SDG 6 (target 6.3: release of hazardous chemical and materials), and SDG 12 (Target 12.2: proportion of critical raw material and ability for reuse and for recycling).



## Outcome of Case Study:

The HARMLESS DSS allows identifying the optimized modified imogolites in terms of safety and sustainability with recommendation for handling. However, stability issues for copper functionalized imogolites do not permit to go further in HARMLESS development case studies and will not proceed to the pilot phase. Follow the novelty with modified imogolites in the future!

## User testimonials / Call to action:



Synthesis of imo\_OH and imo\_CH<sub>3</sub> mastered at CEA (high purity level and production PRO-DIGE Facility)



Collaboration for academic research group/ industry on modified imogolite (high expertise in synthesis and characterization)



WASP questionnaire takes less than 20 minutes and AMEA only a couple of minutes

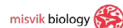
**Give it a try!**

## References

To see the full references, scan the QR code:



## Partners involved: **CEA** (as main contributor)



**Get in touch:**

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