# Copper-Doped Mesoporous Silica Nanoparticles with Essential Oils for Smart Antimicrobial Coatings

## A long-lasting, safe and sustainable antimicrobial additive enabling next-generation protective coatings

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Funded by the European Union

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RELIANCE

## Challenge Addressed

Conventional antimicrobial additives used in coatings, plastics and textiles often rely on high concentrations of metal ions or toxic biocides. These solutions raise growing concerns related to human health, environmental persistence, regulatory compliance and antimicrobial resistance, while also increasing formulation costs and limiting long-term effectiveness.

## The Solution

An innovative antimicrobial technology based on copper-doped mesoporous silica nanoparticles (Cu-MSN) loaded with natural essential oils. The proper functionalization of the mesoporous structure make it acting as a smart carrier that
enables the controlled, sustained release of bioactive compounds upon pH and T variation, ensuring long-lasting antimicrobial performance while minimizing the amount of active substances required.

## Key Benefits

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| Durable antimicrobial effectiveness, making it **cost-efficient** even for large-scale applications. | **Scalable synthesis** supports industrial uptake and regulatory readiness. |
| Combines copper with natural bioactives to **reduce toxicity, limit environmental impact and lower the risk of antimicrobial resistance.** | Easily integrated into existing **coating formulations**, allowing industrial users across multiple sectors to **upgrade antimicrobial performance** without changing their production processes. |

## Application Areas

- Commercialised as an ingredient or as part of a ready-to-use formulation, offering flexibility across the value chain.
- Home appliance coatings (refrigerators and washing machines)
- Healthcare (hospital surfaces, protective and functional textiles)
- Consumer electronics and high-contact public surfaces

## Validation - TRL 5

Validated in relevant industrial environments, including home appliace and textile substrates. Testing includes durability, antimicrobial efficacy & compatibility with industrial processes, supported by electrochemical validation methods.

## Sustainability & Safety

The technology follows Safe-by-Design principles and aligns with EU sustainability and chemical safety regulations. By combining low-dose copper with natural essential oils and a controlled-release mechanism, Cu-MSN minimizes environmental emissions, supports regulatory compliance and contributes to safer, longer-lasting antimicrobial solutions.