# Low-Cost Nanostructured Catalysts Promise Cleaner Indoor Air

Poor air quality has serious public health consequences, as highlighted recently by the COVID-19 pandemic and Western U.S. wildfires. According to World Health Organization (WHO) and World Bank reports, the annual societal cost associated with air pollution is close to eight million premature deaths and $5.7 trillion.

Heterogeneous catalysts have been widely in use for air pollution abatement for decades, most commonly as catalytic converters in internal combustion engine vehicles. Nevertheless, applications of catalysis in air treatment, beyond regulated pollution abatement, have become increasingly limited due to the significant use of scarce platinum group metals (PGMs) and the high energy cost associated with maintaining elevated temperatures required for catalysis. Yet, catalysts hold great promise for broader air purification applications, including indoor air purification, if they could overcome issues related to their price, stability, and operating costs.

Boston-based start-up, Metalmark Innovations, Inc., is developing and commercializing a new approach for producing heterogeneous catalysts from the nanoscale up, with funding from the National Science Foundation (NSF). The catalyst material forms the basis of Metalmark's new air purification system to remove and destroy a broad spectrum of organic pollutants, such as pathogens and wildfire smoke particulates, to deliver cleaner air.

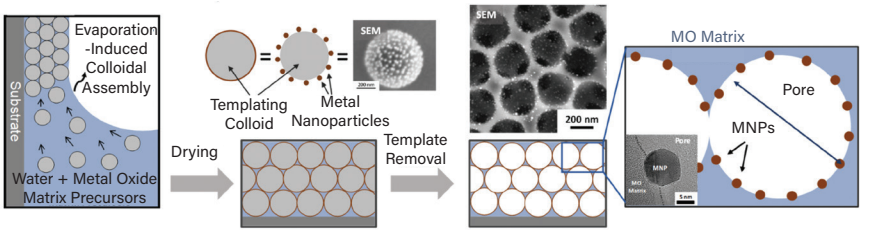
The novel, bioinspired catalyst material preparation is driven by a colloidal self-assembly process, in which templating colloidal particles (of a few nanometers to several micrometers in size) are decorated with catalytic nanoparticles to form 3D nanostructured frameworks. The subsequent removal of the colloidal particles results in a porous network of metal oxides that features high surface area as well as excellent distribution and retention of catalytic nanoparticles. The catalytic nanoparticles may be made of platinum, palladium, gold, silver, or virtually any other stable metallic or nonmetallic particles.

Owing to the material's high surface area and easily accessible nanoparticles, the novel catalyst has been shown to achieve the following when compared with relevant commercially available catalysts: lower reaction initiation temperatures (by 20–100°C); reduction in the overall amount of the PGMs (up to 95%) required to support a similar performance; and complete oxidation of volatile organic compounds (VOCs). Furthermore, by anchoring nanoparticles within the metal oxide framework, the material substantially improves stability and durability against agglomeration even under harsh operating conditions (>850°C). The highly modular approach also enables mixing and matching of a variety of material combinations, leading to a large design space for targeting various airborne organic pollutants simultaneously.

Together, these features make the material relevant for improving general air quality. Submicron particles make up the vast majority of indoor air particles, including viral aerosols emitted by infected individuals. Similarly, over 90% of wildfire smoke particulates are submicron.

Leveraging Metalmark's materials platform, the catalyst's nanostructure can be designed to effectively target the removal of submicron pollutants and pathogens. The material has been demonstrated to achieve over 99.99% reduction of airborne viral and bacterial pathogens when applied as a coating on complementary filter substrates. Elevating the temperature within the air purification system activates the embedded catalysts to inactivate pathogens and completely destroy arrested particulates without the generation of byproducts such as VOCs, ozone, or ions. In addition, the air purification system offers a lifetime of up to 10 times longer than comparable commercial filters and sorbents, with an expected total cost of ownership much lower than the current state of the art.

The start-up is scaling their system from an air purification pilot testbed to a full-scale commercial design capable of treating a space up to a 1,000 ft$^2$ per purification unit. Integration into HVAC systems is also possible with some system modifications. Metalmark targets product launch in 2022. CEP




▲ The Metalmark process uses low-cost, colloidal assembly-based techniques to create highly porous ordered catalytic arrays, with active metal nanoparticles (MNPs, *e.g.,* Pt, Pd) positioned precisely at the pore-matrix interface. Such novel catalytic structures can be created on a variety of substrates.

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