Low-temperature air pollutant abatement with AuNPs on manganese oxides: effect of crystalline structures and nanoparticle size

Nadia Grifasi[a], Francesca Liuzzi[b], Eleonora Cali'[a], Samir Bensaid[a], Nunzio Russo[a], Fabio Deorsola[a], Nikolaos Dimitratos[b], Stefania Albonetti[b], Fabrizio Cavani[b], Debora Fino[a], Marco Piumetti[*a]

[a]*Polytechnic of Turin, Department of Applied Science and Technology, Corso Duca Degli Abruzzi, 24, 10129, Turin, Italy*

[b] *Alma Mater Studiorum - Bologna University, Department of Industrial Chemistry "Toso Montanari", Via P. Gobetti, 85, 40129, Bologna, Italy*

* marco.piumetti@polito.it

In recent decades, air purification has gained significant attention, particularly regarding indoor pollution, which can be more hazardous than outdoor [1-3]. This study explores the catalytic oxidation of indoor air pollutants, focusing on CO and VOCs, using manganese oxides (MnO_2 and Mn_2O_3) functionalized with gold nanoparticles (AuNPs). These catalysts should enhance pollutant abatement at low temperatures, improving air quality in confined spaces. The materials were characterized to assess the physico-chemical properties and tested for stability and performance in realistic conditions. The outcomes obtained highlighted the positive impact of AuNPs on the oxidation of VOCs, especially when compared to the bare supports. Although the CO molecule exhibited a more pronounced response to the presence of AuNPs (in one case with a reduction in oxidation temperature of as much as 90 °C compared to the gold-free support), a significant decrease of about 50 °C was also observed for VOCs. This underscores the ability of gold to promote the oxidation process of gaseous pollutants. Another crucial aspect was the effect of the different crystalline structures of manganese oxides, which influenced the deposition and distribution of the nanoparticles. In particular, the MnO_2 phase proved to be the most promising, ensuring an optimal distribution of the NPs.

The results of this study are directly relevant to chemical engineering, particularly in the development of efficient catalytic systems for air purification. By investigating gold-functionalized manganese oxides, this research demonstrates how optimizing nanoparticle size and distribution can significantly enhance the catalytic oxidation of gaseous pollutants like CO and VOCs at low temperatures. The identification of a "critical radius" for gold nanoparticles highlights the importance of fine-tuning materials for improved pollutant abatement. Such advancements in catalysis and material design contribute to more effective, energy-efficient air purification technologies, offering both environmental and health benefits.

Keywords: *Low-temperature oxidation, indoor pollutants abatement, manganese oxides, gold nanoparticles*

References

1. Guo, Y., Appl. Catal. B, **2021**, 281.
2. Zhou, H., et al., Fuel, **2024**, 366.
3. Grifasi, N., et al., Appl. Catal. B, **2025**, 362.