From Curcumin to Catalysts: Green Nanomaterials and Spectroscopic Strategies for a Sustainable Future

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Thematic Area: Structural, Analytical & Physical Chemistry

Abstract

Curcumin, a natural compound derived from turmeric, is widely used in food, cosmetics, industry, and biomedical applications due to its non-toxic and safe profile. In recent years, it has gained attention as a green reagent for nanoparticle synthesis, as it significantly reduces toxic waste. Curcumin can act both as a reducing agent and a stabilizer, making it an effective component in the green synthesis of various nanoparticles. Using curcumin, different nanoparticles such as gold (Au NPs), silver (Ag NPs), and copper oxide (CuO NPs) have been synthesized. For example, curcumin-conjugated gold nanowires (Au NWs) demonstrate excellent catalytic performance, with the reduction rate of 4-nitrophenol being ~10 times higher than that of conventional Au NPs. This highlights that catalytic efficiency can be tuned by controlling the size and shape of gold nanostructures. Similarly, in curcumin-conjugated silver nanoparticles, smaller particle sizes exhibit superior catalytic activity in reduction reactions. In the case of curcumin-conjugated CuO nanograins, the particles show high efficiency in reducing methylene blue, with nanograins outperforming spherical nanoparticles, underscoring the importance of shape in catalytic performance. Beyond catalysis, curcumin-based nanoparticles also hold promise in optical biosensing, where their unique structural and photophysical properties can be exploited for sensitive detection using different strategies.

Keywords: Green synthesis, curcumin, reducing agent, stabilizing agent, metallic nanoparticles, Au NPs, Ag NPs, CuO NPs, optical sensing