Bimetallic nanoparticles-poly(glycidyl methacrylate)-clay ternary nanocomposites as highly active and stable catalysts for the reduction of toxic nitroaromatic compound

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Nanostructured chelatant nanocomposites are emerged as promising platforms for homogeneous immobilization and stabilization of (bi)metallic nanoparticles. In this contribution, we report the preparation, characterization and catalytic applications of a new type of hybrid nanocatalysts based on gold and gold@silver mono- and bimetallic nanoparticles on polymer grafted-clay. Montmorillonite (MMT) clay was successively surfacegrafted with 3-(trimethoxysilyl)propyl methacrylate (ϒ-MAPS) and poly(glycidyl methacrylate) (PGMA) chains. The polymerization was conducted under UV-irradiation to ensure the fast growth of PGMA. The epoxy groups of MMT@PGMA have been readily converted into carboxylic acid and amino groups using H2SO4/KMnO4 and ethylene diamine, respectively. Finally, Au and Au-Ag nanoparticles have been synthesized through the in situ and hydride-assisted reduction of gold or silver followed by gold ions immobilized on amino or acid carboxylic-functionalized PGMA@MMT, respectively.

The hybrid nanocomposites have been characterized after each synthesis step using a combination of complementary methods (TGA, TEM, XRD, FT-IR, XPS) providing information about chemical composition, structure, and morphology. Of particular interest, the TEM results indicated that Au and AgAu NPs with a spherical shape and narrow size distribution were homogeneously and densely dispersed at the surface of chelatant nanocomposites. The so-designed Ag-Au nanoparticles decorated MMT@PGMA ternary nanocomposites have shown noticeably enhanced catalytic activity than the monometallic AuNPs in the chemical reduction of nitrophenol (p-NP) and pesticide (pemdimethalin, PDM) pollutants in the presence of sodium borohydride with high recyclability for consecutive 5 runs. The UV-monitoring of the reduction reactions indicated that pseudo-first-order kinetics associated with a rate constant of 2.10^{-2} s^{-1} and $2.8\ 10^{-2}$ s^{-1} towards p-NP $1.2\ 10^{-3}$ s^{-1} and $4.3\ 10^{-3}$ s^{-1} towards PDM using MMT@PGMA-NH_2@Au and MMT@PGMACOOH@Ag-Au, respectively.

Further progress aims at enhancing the catalytic performances of (bi)metallic nanoparticles decorated MMT-PGMA nanocomposite catalysts for the treatment of contaminated waste water via a hybrid process combining heterogeneous catalysis and membrane separation.