

Degradation of Organic Contaminants using Copper Nanoparticles Embedded on Natural Matrices

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Residues of organic contaminants (OC) in soil-water environments are often a major concern for humans and ecosystems. Advanced oxidation processes (AOPs) are a versatile approach to eliminate OCs. AOPs using nanoparticles (NPs) as catalysts have been shown to be very effective, enhancing electron transfer and radical interactions by utilizing their special characteristics. Because pollutant concentrations in soil-water environments are typically low, deposition of NP catalysts on permeable supports (PSs) is advantageous; moreover, if the PS acts as an adsorbent, contaminants are concentrated in the vicinity of catalytic sites. Here we present the synthesis of copper nanoparticle catalysts deposited onto sand and montmorillonite, and demonstrate degradation of atrazine as a representative OC. We further discuss the reaction kinetics and degradation mechanism. The synthesized catalyst was characterized by FT-IR, SEM, XRD, ICP-MS and TGA, and the copper NPs were found to exist as a mixture of copper (I, II) oxide species. The degradation of atrazine was initiated by mixing known amounts of catalyst and H₂O₂ over a wide range of pH and under open atmospheric conditions. A second-order kinetic model was found to describe the atrazine degradation, with constant values of $K_2 = 1.7957 \text{ g mg}^{-1} \text{ min}^{-1}$ for the Cu NPs embedded on montmorillonite and $K_2 = 0.8133 \text{ g mg}^{-1} \text{ min}^{-1}$ for the sand matrix. Changing the catalyst dosage confirmed that the copper NPs are a key factor in atrazine degradation. The reaction rate was linked to Cu₂O and CuO redox-active species within the layers and surface of the catalyst. These copper species have high oxidation activity and are easily reducible, thus functioning as reactive centres for oxidative degradation. From ESR analysis, the degradation of atrazine follows an OH• radical mechanism at circumneutral pH. To determine if the reaction is adsorption or degradation, atrazine was treated with modified and unmodified matrices in the presence and absence of H₂O₂. The modified materials (with embedded NPs) showed degradation and adsorption in the presence and absence of H₂O₂, respectively. However, in both cases, only adsorption occurred for the unmodified materials (without embedded NPs).