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Fabrication of AgNi Nano-alloy-Decorated ZnO Nanocomposites as an Efficient and Novel Hybrid Catalyst to Degrade Noxious Organic Pollutants

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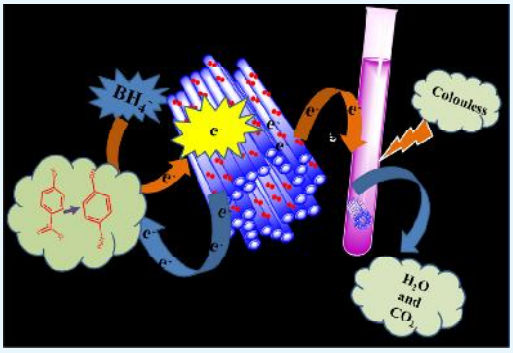
ABSTRACT: Contamination through industrial effluents is a major threat to the environment. Degradation of organic pollutants remains a major challenge, and semiconductor-based catalysis is reported to be a viable solution. Recently, AgNi bimetallic alloy nanoparticles attracted great attention with superior properties. We report the synthesis of AgNi nano-alloy particles immobilized over the surface of ZnO hexagonal rods through an in situ chemical co-reduction process to develop a novel AgNi@ZnO nanocomposite for catalytic applications. The crystal structure, phase purity, morphology, particle size, and other properties of the as-synthesized AgNi@ZnO nanocomposite were scrutinized using powder X-ray diffraction, scanning electron microscopy, Raman spectroscopy, energy-dispersive X-ray analysis, multipoint Brunauer−Emmett−Teller, and transmission electron microscopy. The composite exhibits excellent catalytic activity toward the reduction of nitroarenes and environment polluting organic dyes. The synthesized nanocomposite shows enhanced catalytic activity with an incredible reaction rate constant, noticeable low degradation time, and greater stability. The catalyst is easily recyclable and exhibits consecutive catalytic cycle usage.



1. INTRODUCTION

The rapid growth of industrialization results in increased discharge of harmful effluents that leads to serious intimidation to the ecosystem and also to the human health.[1−4] As a consequence, the polluted water discharged in larger quantities is considered as one of the foremost challenges for pollution control. The massive amount of effluents from the industrial discharge contains various hazardous compounds including nitroarenes and organic dyes. However, nitroarenes are considered to be important compounds due to their use in production of anilines, pharmaceuticals, agrochemicals, dyes, explosives, and so forth.[5] These aromatic nitro compounds are used as important precursors in the fabrication of several analgesics and antipyretic drugs like paracetamol, acetaminophenol, phenacetin, and acetanilide.[6−8] Although, concurrently, these aromatic nitro compounds are a major source of water contaminants and are found to be environmentally hazardous materials that cause severe health threats to human, animal, and aquatic lives.[9] 4-Nitrophenol has been reported as a prospective carcinogen, mutagen, and teratogen; therefore, several aromatic nitro compounds have been counted in environmental legislation.[7,10,11] On the other hand, in the industrial synthesis of several important products, the reduction of nitroarenes to the corresponding amine derivatives is a very crucial process. The aminophenols are utilized as the paint for wood and the dyeing medium for fur and feathers in dye industries.[12] Aminophenol compounds are also used as a photographic developer, an anticorrosion lubricating medium in fuels for two-cycle engines, and a corrosion inhibitor in paints.[6] Therefore, in order to make the environment safe by reducing the water pollutants and to meet the demand of 4-aminophenol (4-AP), the scientific community is continuously working for the catalytic reduction of 4-nitrophenol.[11,13,14]

Recently, the semiconducting material ZnO having a wide band gap (3.37 eV) has earned a lot of attention as it exhibits various application domains such as fascinating optical, luminescence, chemical, electrical, and biological properties.[15,16] ZnO nanoparticles exhibit an extensive series of promising applications in photodetectors, antibacterial treatment, catalysis, transparent transistors, UV-light emitters, fabrication of gas sensors, solar cells, piezoelectric transducers, short-wavelength optoelectronic devices (LED and lasers), and so forth.[17,18] Various methods and techniques including thermal evaporation,[19−22] hydrothermal synthesis,[23,24] electro-

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