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Graphene oxide modified with Ag and CeO_2 nanoparticles as a catalyst for catalytic and light-induced nitroarenes reduction

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Nowadays, the global chemical society is taking a course to develop current chemical industry to addresses the challenges in material and technology design for both energy-efficient manufacturing and environment protection. The Ag-based catalysts are in the focus of green chemistry as advantageous systems due to relatively low cost, low-temperature activity, nontoxicity, and facile preparation and modification procedures [1]. Moreover, being a plasmonic metal, nanosized silver is attractive for the surface plasmon resonance-induced photocatalytic processes under visible light irradiation [2]. The CeO_2 incorporation into Ag-containing catalysts provides the enhancement of the catalytic activity due to the metal-support interaction resulting in the interfacial charge transfer and synergistic action of the metal and oxide active sites [3, 4]. Graphene, a two-dimensional carbon nanomaterial, and its derivatives (e.g., graphene oxide (GO), reduced graphene oxide (RGO)) are considered promising environmentally benign adsorbents and catalyst supports. In addition, unique electroconductivity and synergy to metals and semiconductors allows utilizing this material as an active support in photocatalysis [5]. This work aims to synthesize the Ag-CeO_2/GO system and study its catalytic and photocatalytic activity in the 4-nitrophenol (4-NP) reduction into 4-aminophenol (4-AP) at room temperature and ambient pressure.

The graphene oxide was synthesized according to the modified Hummers' method [6]. Silver- and/or ceria-containing catalysts (Ag/GO, CeO_2/GO, Ag-CeO_2/GO) were synthesized by the deposition-precipitation technique. The synthesized samples were characterized by a set of physical-chemical methods: XRD, TGA, UV-visible spectroscopy, etc. Catalytic activity of the samples was tested in 4-NP reduction into 4-AP by sodium borohydride ($NaBH_4$) as a reducing agent at room temperature and atmospheric pressure in water medium. Photocatalytic activity was estimated in 4-NP reduction into 4-AP in presence of hole scavengers (alcohols, Na_2SO_3) under UV-visible light source at room temperature.

According to the TGA results, the synthesized support decomposes through two characteristic steps at 200 °C (decarboxylation) and 600 °C (combustion) in the oxidizing medium, which indicates the graphene oxide structure. The XRD data also indicate the GO formation by the diffraction peak at $2\theta \approx 13^{\circ}$ that is attributed to (002) plane of the hexagonal GO lattice. The average size of Ag and CeO_2 nanoparticles is about 20 nm in the Ag- and/or CeO_2-containing catalysts. The UV-visible spectra for suspension of catalysts indicate reduction of catalysts in the reducing medium and the evolution of SPR band of metallic Ag nanoparticles. The Ag-CeO_2/GO catalyst shows the highest both catalytic and photocatalytic activity and stability in the synthesized catalysts series.

To sum up, the considered synthesis technique allows preparing the Ag-CeO_2/GO catalysts that are advantageous and environmentally benign systems for both catalytic and photocatalytic processes such as nitroarenes reduction under mild conditions.

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