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Improved Photocatalytic Degradation of Phenolic Compounds With ZnAl Mixed Oxides Obtained from LDH Materials

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Abstract ZnAl layered double hydroxides (LDHs) with different M_{II}/M_{III} molar ratio (0.89–3.81) were synthesized by the co-precipitation method and calcinated at 723 K. High specific surface areas (228–155 m^2/g) and semiconductor properties (band gap values from 3.32 to 3.07 eV) were obtained. The mixed oxides were reconstructed to the crystalline LDHs (memory effect) after being put in contact with aqueous solutions containing phenol and *p*-cresol. Using UV light, a maximum in photoactivity as a function of the Zn^{2+}/Al^{3+} molar ratio was observed. The sample with a Zn^{2+}/Al^{3+}molar ratio of 1.48 photodegrades up to 95% of phenol and *p*-cresol after 4 and 6 h of irradiation, respectively. These values are lower than that obtained with ZnO and commercial P-25 TiO_2 photocatalysts. The results show the applicability of alternative photocatalysts for the degradation of organic pollutant compounds rather than others such as TiO_2.

Keywords LDHs · Photocatalysts · Phenol photodegradation · *p*-cresol photodegradation · Zinc–aluminum mixed oxides

1 Introduction

Phenol and phenol derivates used as raw materials in petrochemical and chemical industries are considered one of the most common organic water pollutants because of its high toxicity, even at low concentrations. Several methods to remove phenol and its compounds from water have been reported in literature; they include biological, thermal and chemical treatments and the named advanced oxidation processes (AOPs) [1–4]. Photocatalytic purification of wastewater by irradiated semiconductor particles has proven to be very effective for AOP [1, 5, 6]. The photocatalytic process occurs as follows: when a semiconductor particle absorb a photon of energy equal to or greater than the band gap energy width, an electron is promoted from the valence band to the conduction band leaving behind an electron vacancy or hole in the valence band. The hole may react with surface-bound H_2O or HO^- producing the $OH^·$ radicals, which are widely accepted to be the primary oxidizing species in the photocatalytic processes. The photocatalytic activity strongly depends on the energy of the electron–hole pairs produced as well as on their separation. A wider separation of the electrons and holes enhances the photocatalytic activity by reducing the electron–hole recombination [3]. The semiconductor materials most reported as photocatalysts are TiO_2, ZnO and SnO_2 [7–13]. However, some layered double hydroxides (or hydrotalcite type compounds) for example, ZnAl LDH have been recently reported as a good alternative for the photodegradation of pollutant organic compounds like methyl-orange [3], methylene blue [14] and phenol [15, 16] in aqueous media.

Layered double hydroxides (LDHs) are a family of lamellar solids which have received a considerable interest in recent years due to their potential application as basic catalysts [17], catalyst supports [18], adsorbents [19], anion exchangers [20], enzyme immobilizers [21] and medical oriented products [22], among others [23]. These applications are possible because of the possibility to obtain,

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