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Photocatalytic activity of mont-La (6%)-$Cu_{0.6}Cd_{0.4}S$ catalyst for phenol degradation under near UV visible light irradiation

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ABSTRACT

A mont-La (6%)-$Cu_{0.6}Cd_{0.4}S$ nanocomposite was prepared by a simple cation exchange and impregnation method and its application for the phenol removal from wastewater was studied. The photocatalyst was characterized by X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (XEDS) and UV–vis diffuse reflectance spectroscopy (UV–vis DRS). Phenol in aqueous solution was used as a model compound for evaluation of near UV–vis (filter cut-off for $\lambda \geq 366$ nm) photocatalytic activity. We have studied the following parameters: load of photocatalyst, load of phenol, pH, [O_2], and irradiation wavelength. Within 240 min, heterogeneous suspensions of 1 g·L^{-1} of mont-La (6%)-$Cu_{0.6}Cd_{0.4}S$ nanocomposite allowed removal of ca. 86% of 20 mg·L^{-1} solution of phenol at pH = 5.44, with dissolved oxygen from air, with 77.8% TOC removal. The kinetics of photocatalytic transformation followed the Langmuir–Hinshelwood kinetic model. Pseudo-first-order kinetics adequately fitted the experimental data and the obtained rate constants are reported. With the mont-La (6%)-$Cu_{0.6}Cd_{0.4}S$ catalyst 84% removal of phenol degradation efficiency was achieved after five consecutive photocatalytic cycles. Twelve main photoproducts were observed from phenol photodegradation, using HPLC–MS. The used photocatalyst is promising for green chemistry use in abatement of persistent organic pollutants.

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1. Introduction

The release of toxic and persistent organic pollutants (POPs) into the aquatic environment is a matter of growing concern, and addressing this issue for remediation is considered to be an urgent environmental need [1]. Many persistent organic pollutants, which are highly toxic and hazardous to human health and ecosystems, are present in industrial wastewaters from chemical factories [2], and are responsible for contamination of ground and surface water [1]. The biodegradability of these compounds is usually very low, leading to their accumulation in the environment [2].

Among POPs, phenol and its derivatives are generally considered as some of the most relevant organic pollutants discharged into the environment, considered by the US EPA as some of the most pollutant compounds, causing considerable damage to human health and to the ecosystems [3] and recognized as carcinogenic compound [4]. Phenols are harmful to living organisms even at low concentrations [5]. They are easily absorbed through the skin and mucous membranes, and toxic to different organs and tissues: lungs, liver, kidneys, and genitourinary system [6]. They are released from herbicides, pesticides, textiles, dyes, paints, oil refining, coal conversion, plastics, pharmaceutical, chemical, agrochemical, and petrochemical industries, etc. [3,7–10]. Phenol, with rather high solubility [11], causes unpleasant taste and odor of drinking water [5,12].

For all the above mentioned reasons, phenols have been listed as priority pollutants for degradation by many governmental environmental agencies [4]. It has become a challenge to achieve an effective removal of this POP from wastewater, to minimize risks. Consequently, considerable efforts have been devoted to develop suitable treatment methods that can easily get rid of these highly recalcitrant POPs [12].

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