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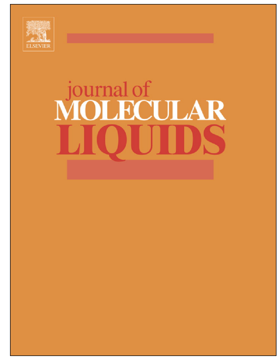

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Sonochemical synthesis of Sm-doped ZnS nanoparticles for photocatalytic degradation of Direct Blue 14: Experimental design by response surface methodology and development of a kinetics model

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ABSTRACT

In this research, a facile and swift method was presented to synthesize pure and samarium (Sm)-doped zinc sulfide (ZnS) nanoparticles by ultrasonic probe. The synthesized samples were characterized by XRF, DRS, XRD, and FE-SEM. The prepared samples have a cubic zinc blende ZnS phase with nanoscale particles and uniform morphology. The photocatalytic activity of the synthesized samples was evaluated through the degradation of Direct Blue 14 (DB14) under UV light irradiation. The 5% Sm-doped ZnS nanoparticles revealed a higher photocatalytic performance than the pure ZnS and other Sm-doped ZnS nanoparticles. The impact of operational factors on the removal efficiency of dye was investigated by response surface methodology (RSM). The optimum conditions for photocatalytic degradation of DB14 (86.36%) were found to be 10 mg L^{-1} of DB14, 0.8 g L^{-1} of 5% Sm-doped ZnS, at pH=3.5, and an irradiation time of 48 min. A kinetics modeling of the process was also proposed, based on the Langmuir–Hinshelwood mechanism, and an empirical equation was obtained for the estimation of apparent pseudo first-order rate constant (k_{ap}) as a function of operational factors. Finally, byproducts resulting from the photocatalytic degradation of DB14 were identified using the GC-MS technique.

Keywords: Sonochemical; Photocatalyst; Sm-doped ZnS; Direct Blue 14; RSM; Kinetics modeling.

1. Introduction

Textile and dyeing industries are considered the most significant water consumers; so, a considerable amount of wastewater is produced by these industries in different production stages. Such wastewater contains high amounts of organic and toxic compounds, which must be removed before entering in the environment [1-3]. Currently, the application of advanced oxidation processes (AOPs) for the removal of contaminants has a special place, especially from aqueous media [4-8]. The importance of such processes is doubled when they are used to remove a wide range of organic and inorganic compounds, because other purification methods do not have this feature; common physicochemical methods are only able to transfer contaminants from one phase to another, but they cannot degrade contaminant compounds [9-11]. Among different methods of AOPs, the importance of the photocatalytic processes in the degradation of contaminants and their conversion into non-detrimental compounds is clear. For such processes, the presence of a proper semiconductor as the catalyst and irradiation with appropriate energy (equal or greater than the semiconductor band gap) are necessary [12-15]. TiO_2 and ZnO are common semiconductors in photocatalytic processes, and the application of such semiconductors