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ORIGINAL PAPER

Nanomodified Geopolymers with Copper Ferrites for Methylene Blue Degradation

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Abstract
The photocatalytic properties of copper ferrites can be exploited in the degradation of organic contaminants in aqueous media, such as methylene blue. The interaction of ferrites with electromagnetic radiation results in the formation of chemical species capable of acting in the degradation of methylene blue molecules. The incorporation of these nanomaterials into geopolymeric matrices makes it possible to produce polymeric nanocomposites with improved properties. Geopolymers loaded with different percentages of copper ferrites were placed in contact with a solution of methylene blue, exposed to UV light and it was possible to observe photocatalytic activity in the degradation of this dye. Analysis in a UV–Vis spectrophotometer, at the maximum absorbance wavelength of the dye equivalent to 670 nm, showed that the geopolymer loaded with 2% copper ferrites was more effective in degrading methylene blue. These results display the potential of copper ferrite-loaded geopolymers as viable photocatalysts for organic pollutant remediation.

Keywords Geopolymer · Ferrites · Photocatalysis · Organic · Pollutants

1 Introduction

Ferrites, nanoparticles comprising iron oxides, are recognized for their ferrimagnetic properties and remarkable thermal stability. They boast a metal cation coordination with oxygen atoms, forming a densely packed face-centered cubic structure with eminent crystallinity. Spinel ferrites, with the formula AB_2O_4, are particularly noteworthy. The A site may host divalent metal cations like Mn^{2+}, Fe^{2+}, Co^{2+}, Ni^{2+}, Cu^{2+}, or Zn^{2+}, while the B site is typically occupied by ferric ions (Fe^{3+}). The positioning of these ions in either the tetrahedral (site A) or octahedral (site B) sites is primarily determined by cation radii and interstitial size [1–6].

When exposed to light, ferrites display vital photocatalytic behaviors [6–8]. Electrons in the ferrite's valence band are propelled to the conduction band in electromagnetic radiation, forming a photogenerated gap. In aqueous solutions, these gaps interact with hydroxide ions, forming hydroxyl radicals, while excited electrons engage oxygen to produce superoxide radicals. These radicals, known for their aggressive reactivity, can break down organic molecules [1, 3, 4, 8–10].

Copper ferrites fall into the category of spinel ferrites ($CuFe_2O_4$). These ferrites are ceramic nanoparticles which exhibit a face-centered cubic structure where Fe^{3+} ions are situated at tetrahedral sites and Cu^{2+} ions at octahedral ones. These ferrites have garnered significant attention due to their versatile applications, ranging from catalysts and inorganic pigments to magnetic resonance imaging (MRI) and biosensors [3, 5, 11, 12].

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