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Green synthesis of benzimidazole scaffolds using copper-substituted zinc aluminate in a sol-gel process

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ABSTRACT

Benzimidazole is a favored scaffold in the field of heterocyclic chemistry because of its diverse range of biological and pharmacological characteristics. As a result, synthetic organic chemistry has seen a sharp increase in interest in developing environmentally friendly synthesis methods for benzimidazole derivatives. Here, we present a novel technique that uses magnetic nanoparticles of copper-substituted zinc aluminate to efficiently catalyze the production of benzimidazole derivatives in water at room temperature and pressure. The catalyst was synthesized via a sol-gel auto-combustion method. The produced copper-substituted zinc aluminate magnetic nanoparticles were thoroughly characterized utilizing a range of spectroscopic methods. The TEM analysis revealed that the catalyst's average grain size was around 50 nm. We are aware that the chemical composition closely resembles the predicted stoichiometry determined from the reactant solutions because of electron density-functional theory elemental analysis. With ferrimagnetic and nanocrystalline properties, the catalyst was highly recyclable and could sustain up to five consecutive reaction cycles before exhibiting a little decrease in activity. The ability of the synthesized material to promote reactions between a range of aldehydes and ortho-phenylenediamine, producing benzimidazole derivatives in moderate to good yields, demonstrated its catalytic effectiveness. Also, this work demonstrates how magnetic nanoparticles may be used in eco-friendly synthetic procedures to produce benzimidazoles by acting as a reusable and effective catalyst.

1. Introduction

Heterocyclic compounds constitute one of the most significant and diverse classes of organic molecules, playing pivotal roles in various scientific and industrial domains, particularly in synthetic organic chemistry, agrochemical chemistry, and medicinal chemistry. These compounds are characterized by the presence of heteroatoms such as nitrogen, oxygen, or sulfur within their ring structures, which confer unique chemical and biological properties. Consequently, heterocyclic chemistry has consistently been at the forefront of organic synthesis, driven by the continuous demand for novel medicinal agents and functional materials [1].

Among the myriad heterocyclic compounds, benzimidazoles have established a prominent position due to their extensive biological and pharmacological profiles. Benzimidazole derivatives are renowned for their ability to interact with biological systems, making them valuable scaffolds in the development of therapeutic agents. They exhibit a broad spectrum of biological activities, including anticancer, antibacterial, antimalarial, antiviral, antifungal, antiparasitic, and anti-inflammatory effects [2–9]. This versatility underscores their importance in drug discovery and development, prompting substantial research efforts aimed at synthesizing benzimidazole derivatives with enhanced pharmacological properties and improved biological efficacy [10].

However, traditional synthetic routes for benzimidazole derivatives

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