

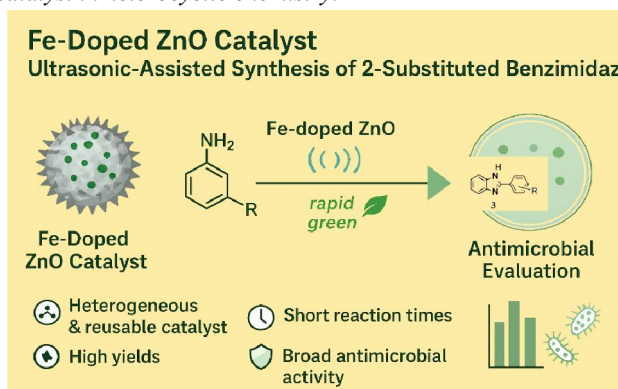
Fe-Doped ZnO as a Green Heterogeneous Catalyst for Rapid Synthesis of Biologically Active 2-Substituted Benzimidazoles under Ultrasonic Irradiation and Their Antimicrobial Evaluation

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Abstract: Benzimidazoles are esteemed heterocyclic frameworks with extensive uses in medicinal chemistry, attributed to their varied pharmacological properties, encompassing anticancer, antifungal, antiviral, antihypertensive, and antiparasitic actions. Conventional techniques for synthesizing benzimidazole derivatives frequently need severe conditions, costly catalysts, and exhibit low atom economy, hence constraining their sustainability and scalability. This study produced and evaluated a series of iron-doped zinc oxide (ZnO) catalysts using X-ray diffraction (XRD), confirming the effective integration of iron ions into the ZnO lattice. The catalytic effectiveness of Fe-doped ZnO was assessed in the one-pot synthesis of 2-substituted benzimidazoles through the condensation of o-phenylenediamine with diverse aromatic aldehydes under ultrasonic irradiation. The improved catalyst demonstrated superior activity, achieving high product yields (86–97%) in 10–15 minutes and allowing efficient recyclability for up to six cycles without substantial performance degradation. The structural validation of the synthesized compounds was accomplished by FTIR, ¹H NMR, and GC/LC-MS studies. Additionally, the antibacterial efficacy of the compounds was evaluated against Gram-positive and Gram-negative bacteria, yeast, and fungus. Numerous substances, including P3, P5, P9, P11, and P13, had substantial inhibitory effects, underscoring their medicinal potential. This environmentally sustainable, efficient, and economical methodology offers a viable framework for the synthesis of pharmacologically significant benzimidazole derivatives and identifies Fe-doped ZnO as a promising green heterogeneous catalyst in heterocyclic chemistry.



Graphical Abstract

Keywords: Benzimidazoles; Green synthesis; Fe-doped ZnO catalyst; Ultrasonic Irradiation; 2-Substituted benzimidazoles; One-pot synthesis; Antimicrobial activity; Heterogeneous catalysis; Multicomponent reaction; Pharmacophore

