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A novel Cu(II) complex immobilized on $ZrFe_2O_4$ Magnetic Nanoparticles catalyzed synthesis of pyranopyrazols

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Heterogeneous catalysis plays a crucial role in many chemical processes, including advanced organic preparations and the design and synthesis of new organic moieties [1]. Efficient and sustainable catalysts are vital to ecological and fiscal viability [2]. This is why green multicomponent reaction (MCR) approaches have gained prominence. Owing to a broad range of pharmacological applications, pyranopyrazole syntheses (through the one-pot strategy, employing sustainable heterogeneous catalysts) have received immense attention [3]. Here, the synthesis of efficient heterogenous catalysts for the environmentally friendly and economic synthesis of pyranopyrazoles was reported via multicomponent reactions between hydrazine hydrate, ethyl acetoacetate, malononitrile, and aromatic aldehydes. A nanomagnetic Cu(II) complex was synthesized through the immobilization of tryptophan on the $ZrFe_2O_4$ surface and its complexation with Cu salt. It was characterized by FTIR, XRD, EDX, Map, SEM, TEM, VSM, and BET/BJH methods. The structures of pyranopyrazol compounds were fully confirmed via IR, ^{1}H NMR, and ^{13}C NMR spectroscopic studies. High yields of products, the use of a green solvent, the easy work-up procedure, the short reaction times, and the easily separable catalyst are the main advantages of this protocol.

***Keywords*:** $ZrFe_2O_4$, tryptophan-Cu(II) complex, pyranopyrazoles, Lewis acid catalyst.

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