Copper Ferrite (CuFe$_2$O$_4$) Nanoparticles

Compiled by Reuben Hudson

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Introduction

Ferrite (Fe$_3$O$_4$) nanoparticles (NPs) have been used as a catalyst for many organic transformations because their nano-scale size equates to a large surface area to volume ratio (meaning many accessible active sites). Moreover, iron-based magnetic properties enable easy catalyst recovery by the application of an external magnet. The catalytic scope of iron, however, pales in comparison with that of copper. Therefore, by substituting copper within the crystal lattice, the catalytic scope is greatly expanded, while the means of easy magnetic recovery are retained. The resulting copper ferrite nanoparticles (CuFe$_2$O$_4$ NPs) contain copper(II) and iron(III) species. Such nanoparticles can be obtained by co-precipitation of copper(II) and iron(III) salts (Scheme 1). They are also commercially available. Herein, the catalytic scope of CuFe$_2$O$_4$ NPs is highlighted and reviewed.

Abstracts

(A) Azide–Alkyne ‘Click’ Reaction
Under homogeneous copper(I) conditions, this reaction can occur at room temperature in water. Under heterogeneous conditions, the reaction requires either 70 °C temperature or the addition of a ligand such as 2,2'-bipyridine.

(B) C–C Cross-Coupling
Panda and co-workers demonstrated a synergistic effect between copper and iron within the CuFe$_2$O$_4$ lattice to catalyze the coupling of terminal alkynes with aryl halides. Neither CuO NPs, nor Fe$_3$O$_4$ NPs alone, could catalyze the transformation as effectively.

(C) C–N Cross-Coupling
Panda and co-workers again demonstrated a synergistic effect between copper and iron, this time in the CuFe$_2$O$_4$ NP-catalyzed coupling of N-heterocycles with aryl halides.

(D) C–O Cross-Coupling
The Sun group effectively coupled aryl halides with phenols to generate the corresponding biaryl ethers by catalysis with CuFe$_2$O$_4$ nanoparticles.
(E) **C–S Cross-Coupling**
The coupling under basic conditions and elevated temperatures of aryl halides with either aromatic thiols or diaryl sulphides afforded the corresponding diaryl sulphide in excellent yields. The catalytic efficiency of various [M]Fe₂O₄ nanoparticles were compared and M = copper was found to be the most reactive for this transformation.¹⁰

(10) Asymmetric Hydrostililation

With the aid of a chiral BINAP ligand, CuFe₂O₄ NPs have catalyzed the asymmetric hydrostililation of prochiral ketones, which afforded the corresponding alcohols upon TBAF workup.¹⁵
