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# Solution Synthesis of Bimetallic Copper–Based Nitrides $Cu_3M_xN$ (M = Pd, Ag, Zn, Ni)

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## Extended Abstract

Copper(I) nitride ($Cu_3N$) is a semiconductor with an *anti*-$ReO_3$ cubic crystal structure, that has attracted considerable interest due to its optical and electrical properties and potential applications in optical data storage, and integrated circuits [1]. The defect tolerance of the $Cu_3N$ structure also makes it suitable for energy conversion and storage, e.g. for solar cells and batteries [2]. A significant area of study is focused on the electrocatalytic activity of $Cu_3N$ in various redox reactions, e.g. electrochemical reduction reaction of carbon dioxide ($CO_2RR$) [3] and oxygen reduction reaction (ORR) [4].

The cubic crystal structure of $Cu_3N$ allows for the intercalation of other metal atoms into the unit cell, which can significantly change the material properties. There are numerous reports on the synthesis of $Cu_3M_xN$ structures, where M is a transition metal atom, e.g. Sc, Cr, Zn, Pd; however, they are limited to physical deposition methods, such as magnetron sputtering [5].

This study attempted to synthesize $Cu_3M_xN$ structures with palladium, silver, zinc, and nickel. The chemical solution method was applied using long-chain primary amine as a reducing agent. Different reaction conditions were studied, e.g. heating technique, time, and temperature of the reaction, and type of metal precursors. As a result, homogenous Ag- and Pd-doped $Cu_3N$ nanocrystals with diameters < 20 nm were successfully obtained [5]. Doping with zinc resulted in a mixture of $Cu_3N$/ZnO due to the low reduction potential of zinc(II). Syntheses with nickel led to mixtures of copper nitride, metallic copper, and copper and nickel oxides. The crystal structure, chemical composition, and morphology were studied using high-resolution transmission electron microscopy (HR-TEM), X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), IR, and Raman spectroscopy. The obtained materials were also tested for their electrochemical properties using voltammetric techniques. Ag-doped $Cu_3N$ nanostructures revealed electrocatalytic activity in ORR higher than binary $Cu_3N$, comparable to a commercial Pt/C electrode [5]. Pd-doped $Cu_3N$ NCs also showed activity in $CO_2RR$, higher than binary $Cu_3N$.

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