Electroless deposition of morphologically controlled $\text{Cu}_2\text{O}$ nanoparticle films and their photocatalytic activity

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Nanostructured cuprous oxide ($\text{Cu}_2\text{O}$) is an intriguing direct bandgap semiconductor material with potential applications as a UV-Vis light absorber in solar cells, a photocatalyst for the degradation of organic pollutants, a negative electrode in Li-ion batteries, and others.

It is known that the morphology and size of $\text{Cu}_2\text{O}$ nanoparticles (NPs) may affect their photocatalytic and light-absorption properties. However, the preparation of $\text{Cu}_2\text{O}$ NPs with morphological control has been largely restricted to colloidal synthesis and electrodeposition on substrates.

Here we present an electroless (chemical) deposition (ELD) approach to direct preparation of $\text{Cu}_2\text{O}$ NP films on substrates, using $\text{CuSO}_4$-HCHO-Citrate-NaOH solutions. Our method shows a high degree of morphology control. The average NP size can be varied by controlling the deposition time, while the crystallographic structure is determined by the solution composition.

The NP films were studied by SEM, XRD, ELSRD and UV-Vis spectroscopy, and their photocatalytic activity towards the degradation of a model organic contaminant, methyl orange (MO), was evaluated and correlated with the NP morphology.

**Morphological and size control** can also be achieved by sequential immersion of the slides in solutions A and S, and controlling the deposition times.

**Photocatalytic activity** under natural light illumination

Methyl orange (MO) photodegradation was followed by UV-Vis spectroscopy, plotting the MO extinction maximum as a function of time.

Assuming pseudo-first order reaction, degradation rate constants ($k$) were normalized to the exposed $\text{Cu}_2\text{O}$ surface area (estimated from SEM images) and followed the order: cubes > suboctahedra > octahedra.

**CONCLUSIONS**

1. $\text{Cu}_2\text{O}$ NP films with controlled morphology can be prepared by ELD. The morphology is determined by competitive adsorption of citrate and OH- on (100) and (111) facets. Average NP size is controlled by the deposition time.
2. The $\text{Cu}_2\text{O}$ NP morphology can be shifted by sequential immersion in different growth solutions (solution A or S), for controlled times.
3. NPs are truncated on the substrate side and strongly adhere to it (pass the Scotch tape test).
4. NP films show efficient photocatalytic activity towards MO degradation, being similar to the original NPs, for cubes and lower for octahedra. The $\text{Cu}_2\text{O}$ catalysts can be easily recycled.