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Photo- and radiation-induced preparation of nanocrystalline copper and cuprous oxide catalysts

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Radiation method of copper and cuprous oxide preparation produces material of high chemical purity and catalytic activity. Reduction of metal ions in aqueous solutions via UV, γ irradiation or accelerated electrons results in formation of nanosized particles of both Cu/Cu₂O with uniform spherical shapes at normal temperature. This method of preparation is very simple and relatively efficient; it requires mostly only one additive –·OH scavenger –in order to promote process of reduction. Oxygen present in water readily oxidises formed nanoparticles of non-noble metals and causes their dissolution; therefore the solutions must be deaerated prior to irradiation.
In this work, aqueous solutions containing copper sulphate or formate (0.001 to 0.01 mol.dm⁻³) in the presence of ·OH scavenger propan-2-ol (1.3 mol.dm⁻³) and surfactant polyvinyl alcohol PVA were irradiated. Following radiation sources were used: Medium pressure mercury lamp with power input 400W for UV irradiation, LINAC 4-1200 for electron irradiation and ⁶⁰Co radionuclide source Gammacell 220 for γ irradiation. Effects of radiation were evaluated using UV-Vis absorption spectrophotometry, SEM and XRPD. Catalytic activity of prepared Cu₂O powder was studied by measuring the rate of catalytic decomposition of hydrogen peroxide H₂O₂ to oxygen at several temperatures.
In separated black or brown solid phases, the presence of crystalline copper, cuprous oxide Cu₂O or their mixture was confirmed. Irradiation of 0.01 mol.dm⁻³ solutions with low doses yields pure Cu₂O, whereas at lower pH and lower copper concentration, copper particles are formed predominantly. SEM images showed that prepared particles are spherical in shape and have wide size range (50 - 500 nm in diameter, average size being cca 200 nm).
The stability of colloidal copper was investigated with respect to changes of absorption spectra and pH in the presence of air. Whereas the value of pH steadily increased with time, the absorbance changed non-monotonously –in the first stage, a rapid increase of absorbance in the range from 600 to 900 nm occurred, followed by long lag-phase (absorbance remained constant) and finally in the third stage, copper absorption spectrum reappeared, but slowly decreased.

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