ABSRTACT

Copper is an engineering material and copper nanostructures (particles, rods, wires, sheets) have a variety of applications including electronics, biomedical and catalysis. However, in contrast to other metals in the same column in periodic table, work on copper nanomaterials is much less. This work aims at developing different strategies to prepare copper colloid. The main focus of this work will be the preparation of concentrated copper colloid using easy solution based techniques and preparation of nano-powder. The re-dispersibility of the powder in a variety of polar and non polar solvent will also be studied. The first chapter of this thesis discusses these goals in light of the current literature.

Second chapter deals with preparation of concentrated copper sol in aqueous (0.5-100 mM Cu) and organic solvents (1-300 mM Cu). In aqueous phase, charge stabilized and sodium citrate stabilized concentrated sol is prepared. The optimum concentration of sodium citrate (8 mM) plays a vital role in the stability of sol against oxidation and aggregation. These sols are successfully transferred to low polarity organic solvents by using HCl mediated and ethanol mediated phase transfer protocols. To increase the concentration of particles in the organic phase, a new strategy based on repeated phase transfer has been successfully introduced. Stability and oxidation resistance of all the sols have been thoroughly studied. Stable organosol containing 2–4 nm particles has been formed by repeated phase transfer. The resulting sols have very high particle loading.

Third chapter focuses on preparation of sub 10 nm copper nanopowder. First, a PVP-PEG stabilized copper sol was formed which was subsequently washed to form re-dispersible powder. The optimum polymers concentration (PVP: 0.0015 M and PEG: 0.013 M) (PVP+PEG) has been successfully found to prepare stable polymer stabilized copper nanoparticles. These polymer stabilized particles were also phase transferred successfully to toluene using a suitable protocol. Stable organic dispersible nanopowders have been produced from the organosol by drying the organosol with inert gas purging. The particle size (sub 10 nm) is preserved after phase transfer and redispersion in organic solvent.

Fourth chapter aims at preparation of highly monodisperse copper and silver nanoparticles (5 nm with <10% COV) and separation of these particles by forming crystal like superlattices of size 30 μm. Superlattices have been formed using slow destabilization of the colloid. A confined environment of emulsion droplet has been used to promote formation of 3D superlattices. It has been shown that very compact crystal like superlattices can be formed if the destabilized sol is aged for 10 days at − 4 °C.

Fifth chapter discusses a facile method for preparation of copper nanosheets (0.4-0.5 μm width, 1-1.5 μm length and thickness 6-30 nm) as powder redispersible in a variety of solvents. A simple fast reduction technique has been developed to prepare copper nanosheets in aqueous phase. The size of the nanosheet found to be very sensitive to reactant concentrations and an optimum concentration range has been determined experimentally. The large nanosheets could be centrifuged and dried as a powder and re-dispersed without any apparent size or shape change. Strong centrifugal field has been shown to initiate oriented attachment of small nanosheets leading to very large nanosheets.

Keywords: Copper nanoparticles, Phase transfer, Citrate stabilized copper nanoparticles, Thiol coated copper nanoparticles, Nanopowder, Redispersion, Polymer stabilized copper nanoparticles, Centrifugation, Monodisperse copper nanoparticles, Superlattices, Copper nanosheets.