Abstract

Nanostructured materials have been found to possess several enhanced and unique physicochemical properties that do not exist in their bulk counterparts. Thus synthesis of nanostructured materials in diverse shape and size is one of the forefront research areas. In the present thesis, synthesis, characterization, and a few applications of Cu_xO (x = 1, 2) nanomaterials are reported. Cu_2O crystals in the shape of octahedron, cube, and truncated cube are synthesized by a simple solution-based precipitation method by varying the reaction temperature, reaction duration, precursor [$Cu(NO_3)_2{\cdot}3H_2O$] concentration, and concentration of shape controlling agent, i.e., polyvinylpyrrolidone (PVP). The synthesized Cu_2O crystals are demonstrated for the shape-dependent catalytic reduction of toxic Cr(VI) to nontoxic Cr(III) and the detail mechanism of same is discussed. A microwave-assisted solvothermal technique is used to synthesize three-dimensional (3D) spherical CuO structures composed of either one-dimensional (1D) rod-like or two-dimensional (2D) flake-like building blocks by varying the reaction medium, i.e., water and ethylene glycol (EG). A high EG in the reaction medium promotes the growth of flake-like structure which assembled to 3D spherical flower-like structure. Such 3D spherical flower-like structure exhibits a high surface area of 168 $m^2 g^{-1}$, which is used as an electrode material for supercapacitor (energy storage) and as a photocathode for water splitting (energy generation). A two-electrode asymmetric supercapacitor device fabricated with 3D flower-shaped CuO as positive electrode and activated carbon as negative electrode delivers an energy density of 27.27 Wh kg^{-1} at a power density of 800 W kg^{-1}. Moreover, 3D flower-shaped CuO is demonstrated as oxygen evolution reaction (OER) electrocatalysts. To increase the OER activity of CuO, varying percentages of Co are doped and an optimum 5% Co-doping is found to show maximum OER activity, as confirmed from the small Tafel slope and small overpotential of 120 mV, which is ~2.66 times lower than that obtained with pristine CuO to achieveacurrent density of 10 mA cm^{-2}. This thesis primarily emphasizes on the synthesis of Cu_xO nanomaterials and their applications in environment remediation and electrochemical energy conversion/storage.

Keywords: Cuprous oxide;cupric oxide; nanocrystals; Cr (VI) detoxification; asymmetric supercapacitor; water splitting.