Thesis title:

Hierarchical Cu-oxide based nanostructures for application in supercapacitors

ABSTRACT

Till a decade or two back, fossil fuel based sources were expected to continue catering the increasing energy demand linked to rapid urbanization. Then came the 'evidences', proving the limited reserves of fossil fuels and their long-term devastating impact on the climate. Consequently, worldwide research saw a paradigm shift towards finding alternative renewable energy sources for both -grid and off-grid applications. In addition, use of energy storage systems such as supercapacitors and Li^+/Na^+ batteries became essential owing to the intermittent nature of the renewable energy sources. With the growing understanding pertaining to the materials used in these technologies, the recent trends indicate the need for an energy storage device, which simultaneously has the characteristics of both batteries and supercapacitors. Such hybrid storage devices may actually be termed as "superbats". Hierarchical and hollow nanostructures of various metal oxides, with enhanced surface area and volume, are gaining attention in supercapacitors and batteries. These materials possess additional properties viz., enhanced reaction/redox sites, low diffusion coefficient, low mass and density. Cu_2O has been proposed as efficient electrode material for supercapacitors due to its high theoretical specific capacitance, easy synthesis in large scale, tunable particle morphology, etc. The work presented in the thesis establishes a novel, facile and cost-effective solution based synthesis route for obtaining hierarchical hollow structures of Cu_2O. To show superiority of hollow structures, performance is compared with synthesized solid and porous structures of Cu_2O. Based on the extensive characterization using XRD, FTIR, Raman, SEM, TEM, zeta potential, particle size distribution and BET surface area, the major findings of the work can be summarized as:

a) Precursors type and concentrations plays an important role in determining the growth mechanism of the hollow nanostructures.
b) The hollow nanostructures has >70% higher specific capacitance than its solid counterparts.
c) The electrochemical performance of the porous structures lies in-between the two morphologies.
d) The performance of the devices can be further enhanced by modifying the electrolyte using redox additives i.e. the external agents with redox couples. These contribute synergistically in ion exchange at the electrode-electrolyte interface. On adding redox additives such as KI and $K_4Fe(CN)_6$ in 2 M KOH, an additional enhancement of >50% can be easily obtained.
e) The performance of fabricated devices, tested at elevated temperatures of 65 ^oC, further proves the stability and usefulness of Cu_2O as electrode material in supercapacitors.

Keywords: Hollow nanostructures, metal oxides, supercapacitors, redox additive, temperature.