Ph.D. PROPOSAL

INVESTIGATION ON TRANSITION METAL OXIDE BASED NANOPARTICLES

Nanomaterials (size range: 1-100 nm) have emerged as an exciting class of materials that are in high demand for a range of practical applications. The length of a nanometer can be understood through the example of five silicon atoms or 10 hydrogen atoms are lined up, which is one nanometer. Nanomaterials can be produced with outstanding magnetic, electrical, optical, mechanical, and catalytic properties that are substantially different from their bulk counterparts. Nanoparticles are used in variety of applications like Supercapacitor, Biosensor, Photocatalytic, Li-ion Batteries, Fuel Cell Sensors, H_2 storage, Coatings, Fluorescent, CO_2 capture & conversion, Photothermal theraples, Drug delivery, etc.

Owing to the rapid development of the global economy, accelerating the consumption of fossil fuels like coal, fuel, and natural gas, the problems of global climate change and environmental pollution are increasing to significant levels. Developing solar, wind, tidal, and other renewable clean energy is a way to mitigate current energy and environmental pollution problems. However, those renewable clean forms of energy are severely restricted by environmental factors and energy supply is intermittent. Therefore, it is urgent to develop effective and reliable devices for energy storage. As a new type of storage device, supercapacitors have gained great attention in recent years thanks to their advantages of fast charge/discharge rate, high power density, and very long cycle life. Supercapacitors have great potential in the area of portable electronic equipment, renewable energy systems, and hybrid power cars. Transition metal oxides (TMOs) have higher specific capacitance (100–2000 F g^{-1}), higher energy density than carbon materials, and better chemical stability than conductive polymers. TMOs with mesopores (size between 2 and 50 nm) are complimentary for building supercapacitors with high performance due to their large specific surface area and suitable pore size distribution. These include RuO_2, MnO_2, CO_3O_4, TiO_2, SnO_2, IrO_2, NiO, Fe_3O_4, V_2O_5, MoO_3, Bi_2MoO_6, $NiMoO_4$, $CoMoO_4$, $MnMoO_4$, $NiCo_2O_4$, $CuCo_2O_4$, $CoMn_2O_4$ etc. Metal oxides have high specific capacitance and conductivity, making them suitable for electrode fabrication focused on high energy and high power supercapacitors. The most studied ones are ruthenium and manganese oxides. Thanks to its high theoretical capacitance and rapid Faraday redox reaction, RuO_2 is thought to be an optimal pseudocapacitive electrode material. However, its high price and toxicity to the environment seriously hinder its application in supercapacitors. A number of less expensive metal oxides (mentioned above) can be used to replace ruthenium oxides, which is efficient to reduce the cost.

Nanoparticles are being prepared by varies chemical and physical methods like Hydrothermal, Co-Precipitation, Microwave Combustion, Electrochemical deposition, Sonochemical, Thermal decomposition, Gas-phase deposition, Electron beam lithography, Pulsed laser ablation, Laser-induced pyrolysis, Powder ball milling, etc.

In this work, the transition metal oxide nanoparticles will be prepared by any suitable technique. The growth conditions will be varied to get good quality nanoparticles. The resultant nanoparticles will be subjected to different characterization studies such as X-ray Diffraction (XRD), Energy - dispersive X-ray Spectroscopy (EDX), Field Emission Scanning Electron Microscopy (FESEM), Fourier Transform Infrared Spectroscopy (FTIR) or Raman Spectroscopy, Ultraviolet-visible spectroscopy (UV) and Photoluminescence (PL) to identify their various physical properties. Finally an attempt will be made to examine the device quality of optimum conditioned nanoparticles.

References:

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