Chapter 9

Summary and Future Scope

Summary

Pure crystallographic phases Anatase, Rutile and Brookite of TiO_2 nanocrystallites have been prepared by precipitation as well as hydrothermal method. The crystallite size was found to be in nano meters for Anatase (14.71 nm), Rutile (12.88 nm) as well as Brookite (5.27 nm). The calculated optical bandgap was found to be 3.32 eV, 2.45 eV and 2.60 for Anatase, Rutile and Brookite phases of TiO_2 respectively.

The surfactants play a major role in modification of particle size, surface area and surface morphology of the material prepared by hydrothermal method. TiO_2 samples were prepared using different surfactants (SLS, CTAB, Glycine and Triton X-100) by hydrothermal method. The XRD results confirmed the formation of TiO_2 with dual phase (Rutile and Anatase). The average crystallite size of all the samples was found to be between 4.06 nm to 6.13 nm. All the samples contain more than 60% of Anatase phase of TiO_2. The optical bandgap was found to be between 2.84 eV and 3.07 eV.

A series of TiO_2-ZrO_2 composites with various ratio of TiO_2 and ZrO_2 (9:1, 7:3, 6:4, 6:4, 7:3 and 1:9 mol %) were prepared by hydrothermal method. The XRD results confirmed the formation of TiO_2 in Anatase as well as Rutile phases and ZrO_2 in Monoclinic as well as Tetragonal phases. The average crystallite size of all the samples was between 6.97 nm to 19.88 nm. The band gap of TiO_2-ZrO_2 composites calculated from UV-Vis spectra vary from 1.62 eV to 3.07 eV. Based on the structural properties and objective of the study sample with 70% TiO_2 and 30%

ZrO_2 has been found suitable as the electrode material for dye sensitized solar cell application.

A set of metal (Al, Cu, Mg, Zn, Ce, La, Eu, Fe, Ni, Mn, Er, Cd, Yb and Pb) doped TiO_2-ZrO_2 composites were prepared. The metal doping stabilized the Anatase phase of TiO_2 which is the most preferred phase for DSSC application. For La, Cd, Yb and Pb doped TiO_2-ZrO_2 samples, TiO_2 exists in pure Anatase phase. For most of the samples, the Anatase phase is more than 80% and average crystallite size of all the samples is below 23 nm. The band gap of metal doped TiO_2-ZrO_2 composites calculated from UV-Vis spectra varies from 2.00 eV to 3.34 eV.

Different combinations of four transitions/alkaline earth metal ions (Al, Cu, Zn, & Mn) and two rare earth elements (Ce & Eu) were co-doped in TiO_2-ZrO_2 composites. The formation of both TiO_2 and ZrO_2 is confirmed by XRD analysis and average crystallite sizes of all the samples vary between 9.12 nm and 31.80 nm. All the samples have more than 80% Anatase phase. Al, Ce doped TiO_2-ZrO_2 shows 100% Anatase phase. The optical bandgap of all the samples lie between 3.00 eV to 3.45 eV.

Simple and inexpensive solar cells have been fabricated successfully. The DSSC prepared using different TiO_2-ZrO_2 nanocomposites shows highest efficiency of 2.87%. Further increment in efficiency has been observed for DSSC prepared using metal doped TiO_2-ZrO_2 nanocomposites. The doping of metals have improved the structural properties and inhibited the recombination process. The highest efficiency of 9.94% has been recorded for the DSSC prepared using Pb doped TiO_2-ZrO_2. The efficiency of DSSC prepared using co-doped TiO_2-ZrO_2 is much lower than the efficiency of metal doped TiO_2-ZrO_2 nanocomposites. The highest efficiency of 2.55% has been observed for Mn, Ce doped TiO_2-ZrO_2. This lowered efficiency is attributed to the generation of new trap states below the conduction band of TiO_2-ZrO_2 nanocomposite, which results into increased recombination.

Future Scope

Simple and inexpensive solar cells have been prepared in the present work. Lot of modification can be done in the set up for photovoltaic performance measurement.

Better meters for current and voltage measurements can be used in the set up for better measurements. Low resistance wires can be used in the circuit to minimize the series resistance of solar cell.

Light source of different wavelength can be used to study the performance of DSSC at different wavelength.

Optimization of film thickness can be done to increase the efficiency of DSSC. The value of porosity and amount of dye adsorbed can be calculated and modified to get optimum result. Porosity of the film can be varied by using different surfactants for preparation of photoelectrode material paste.

Bonding of dye with the photoelectrode material dependence on the material itself. Different natural dyes can be used to prepare dye sensitized solar cell with the prepared material to study the effect of dye on efficiency.

Degradation of the dye sensitized solar cells with longer time interval can be studied. Thickness, porosity, electrolyte and dye dependent study can be done to get the best combination for efficient dye sensitized solar cell.

Recombination inhibiting layer of different metal oxides can be studied along with effect of the thickness of these layers on efficiency.

The amount of dopant which give better efficiency can be optimized.