Name of the Scholar: Mohd Shahazad

Name of the Supervisor: Dr. Tokeer Ahmad

Department: Chemistry, Faculty of Natural Sciences

Title of Ph. D. Thesis: Synthesis, Characterization and Dielectric Properties of Ceria and Titania Based Ceramic Nano-composites

Abstract

Keywords: Polymeric Citrate Precursor Method, Zirconia Nanoparticles, Nanocomposite, Ceria-Titania, Zirconia-Ceria.

This thesis deals with the brief introduction of the nanotechnology, nanoscience, nanoparticles, nanocomposites, properties of nanoparticles, methods of the synthesis and various characterization techniques used for as-synthesized nanoparticles and nanocomposites. The synthesis, characterization and dielectric properties of metal oxide nanoparticles (CeO_2, TiO_2, ZrO_2 and Y_2O_3). Ceria (CeO_2), titania (TiO_2), and yttria (Y_2O_3) nanoparticles have been studied. PXRD studies showed that the as-prepared CeO_2, TiO_2, ZrO_2 and Y_2O_3 nanoparticles were monophasic and indexed in cubic, tetragonal, monoclinic and cubic geometry respectively. The average particle size was found to be 42, 45, 25 and 25 nm for CeO_2, TiO_2, ZrO_2 and Y_2O_3 nanoparticles respectively using TEM studies. The surface area of as-prepared CeO_2, TiO_2, ZrO_2 and Y_2O_3 nanoparticles was found to be 258, 315, 186 and 238 m^2/g with DA pore radius of 12.9, 14.7, 11.9 and 14.5 Å respectively by using BET surface area studies. The dielectric constant and dielectric loss of the nanoparticles were found to be 15, 0.0494 (for CeO_2), 68, 0.0032 (for TiO_2), 7.5, 0.0094 (for ZrO_2) and 3.25, 0.4251 (for Y_2O_3) for as-synthesized nanoparticles at 500 kHz frequency at room temperature. In this thesis, synthesis, characterization and dielectric properties of TiO_2-CeO_2 ceramic nanocomposites at low TiO_2 concentration and CeO_2-TiO_2 ceramic nanocomposites in low ceria region. $_{(x)}CeO_2$ - $_{(1-x)}TiO_2$ ceramic

nanocomposites have been prepared by means of CeO_2 and TiO_2 nanoparticles. $_{(x)}TiO_2$-$_{(1-x)}CeO_2$ nanocomposites have been prepared at low TiO_2 composition of 5%, 10%, 15% and 20%, by using TiO_2 and CeO_2 nanoparticles obtained by polymeric citrate precursor method. BET surface area studies showed the specific surface area of as prepared nanocomposites in the range of 239-288 m^2/g. 20% TiO_2 based titania-ceria nanocomposite was found to have smallest particle size of 30 nm and highest surface area of 288 m^2/g among all the as-prepared nanocomposites. The dielectric constant of $_{(x)}TiO_2$-$_{(1-x)}CeO_2$ at room temperature was found to be maximum (35.6) at 500 kHz for x = 0.20.

$_{(x)}ZrO_2$-$_{(1-x)}CeO_2$ nanocomposites have been prepared at low ZrO_2 composition of 5%, 10%, 15% and 20%, by using ZrO_2 and CeO_2 nanoparticles. BET studies showed the specific surface area of as-prepared nanocomposites in the range of 210-240 m^2/g. 20% ZrO_2 based zirconia-ceria nanocomposite was found to have smallest average particle size of 35 nm and highest surface area of 240 m^2/g among all the as-prepared nanocomposites. The dielectric characteristics were measured as a function of frequency. The dielectric constant of $_{(x)}ZrO_2$-$_{(1-x)}CeO_2$ at room temperature was found to be maximum (ε =16) at 500 kHz for x = 0.20. $_{(x)}Y_2O_3$-$_{(1-x)}CeO_2$ nanocomposites have been prepared at low Y_2O_3 composition of 5%, 10%, 15% and 20%, by using Y_2O_3 and CeO_2 nanoparticles obtained by polymeric citrate precursor method. X-ray diffraction studies indicate the formation of nano composites. BET surface area studies showed the specific surface area of as-prepared nanocomposites in the range of 242-264 m^2/g. 5% Y_2O_3 based yttria-ceria nanocomposite was found to have smallest average particle size of 18 nm with highest surface area of 264 m^2/g among all the as-prepared nanocomposites. The dielectric constant of $_{(x)}Y_2O_3$-$_{(1-x)}CeO_2$ at room temperature was found to be maximum (26) at 500 kHz for x = 0.05.