Studies on Dielectric, Electrical, Magnetic and Hetero-photocatalytic Properties of Bismuth Layered Aurivillius Oxides

Thesis submitted in partial fulfilment

For the Award of Degree

DOCTOR OF PHILOSOPHY

By

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2022

Conclusions

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Synthesis of Bismuth Layered Aurivillius oxides and some experimental procedures carried out on ceramic materials. In general ceramic materials are hard and brittle, shows immense stability due to their inherent quality of being heat and corrosion resistive. Their interesting properties are further enhanced by employing different compositions and synthetic routes. The purity of the synthesized materials is of utmost importance; hence single-phase formation of the materials was controlled by reaction conditions and sintering temperature. Characterization of synthesized materials to obtain information regarding microstructure and particle size were obtained using various physicochemical techniques. Few physical properties such as dielectric, impedance, magnetic and hetero-photocatalytic were investigated too at a few selected temperatures and frequencies. In the present work, following Bismuth Layered Aurivillius oxides were synthesized.

i. $Bi_4Ti_3O_{12}$-$BaTiO_3$ (BTO-BT) by modified solid-state route
ii. $Bi_4BaTi_4O_{15}$ (BBTO) by chemical route
iii. $Bi_4SrTi_4O_{15}$ (BSTO) by chemical route

The above-mentioned ceramic materials were characterized using Powder X-ray diffraction (XRD), Fourier transmission electron spectroscopy (FTIR), Transmission electron microscopy (TEM), Atomic force microscopy (AFM), Scanning electron microscopy (SEM), Energy-dispersive X-ray spectroscopy (EDX), X-ray photoelectron spectroscopy (XPS), Zetasizer Nano-ZS, UV–*vis* diffuse reflectance spectroscopy (*DRS*) UV-DRS, Brunauer-Emmett-Teller (BET). Dielectric and ferroelectric properties were detected using LCR meter at a few selected temperatures and frequencies. Magnetic properties were observed by MPMS (SQUID magnetometer quantum design).

Aurivillius oxides synthesized studied as a photocatalyst and dielectric material. Formation of BTO-BT composite (orthorhombic and cubic), confirmed by Le-Bail fitting analysis with the help of XRD data. The average crystallite size (D) obtained by XRD for BTO-BT was 32.31 nm, whereas the crystalline nature was confirmed by TEM analysis. The mean particle size of the material was determined by dynamic light scattering being 52.8 nm. Dielectric constant of BTO-BT nanocomposite was found to be 4.75 x 10^3 at 368 K. Stability in the suspension was confirmed by the negative zeta potential. The electrical measurement of the materials shows the presence of Maxwell relaxation curve due to the existence of semiconducting grains and insulating grain boundaries in the materials. The frequency dependent AC conductivity and frequency exponent parameter(s) were interpreted in terms of Correlated Barrier Hopping (CBH) model while the temperature dependent AC conductivity shows lattice scattering. The Magnetic behavior for the materials revealed anti-ferromagnetic with a weak ferromagnetic moment and shows magnetically frustrated materials. BET analysis confirmed the presence of mesoporous slit-like pores formed by pellets-like grains. The optical band gap obtained was 3.4 eV. Furthermore, the photocatalytic activity of fabricated BTO-BT nanocomposite was evaluated by photodegradation of Rhodamine B dye. The photocatalyst degrades almost 43% of RhB dye in 60 minutes of the time period. The kinetic plot proved that the experiment followed the first-order kinetics. The outcomes demonstrate that $OH^{\cdot}$ radicals and $O_2^{\cdot -}$ are the major reactive species generated during the photocatalytic reaction and BTO-BT nanocomposite shows the considerable potential for the photodegradation of Rhodamine B dye.

Aurivillius oxides BBTO and BSTO synthesized by the chemical method, sintered at 950˚C for 8 h and studied as a photocatalysts and dielectric materials. The crystalline nature of the ceramics was established by TEM analysis and Le-Bail fitting analysis with the help of XRD data confirmed the single-phase formation of BBTO and BSTO ceramics having orthorhombic structure having average crystallite size (D) of 39.24 nm and 38.53 nm, respectively. The negative value of the zeta potential of the materials obtained through the dynamic light scattering technique indicates the stability of ceramics in suspension form. A high dielectric constant value of 3.08×10^3 and 2.78×10^3 were obtained for the BBTO and BSTO ceramics at 368 K. Through electrical measurement of the materials, the existence of semiconducting grains and insulating grain boundaries in the materials were ascertained by the presence of the Maxwell relaxation curve. The Correlated Barrier Hopping (CBH) model explains the frequency dependent AC conductivity and frequency exponent parameter(s). According to it, the movement of charge carriers are assumed to be in discontinuous jumps "hopping" from one well defined localized site to another within the solids. Apart from showing these desirable properties, the ceramics were also found to be a very efficient photocatalysts, examined by the photodegradation of Rhodamine B dye in the presence of solar radiations. BBTO degraded 80% of RhB dye within 1 hour time period, while BSTO in similar conditions degraded 84% of RhB dye and almost same value for the optical band gap obtained for the BBTO and BSTO ceramics using UV-DRS i.e., 3.13 eV and 3.14 eV, respectively. BET analysis corroborated the existence of mesoporous slit-like pores constituted by pellets-like grains in both the ceramics, which enhanced their catalytic activity. The $OH^{\cdot}$ radicals and $O_2^{\cdot-}$ are the major reactive species generated during their photocatalytic reactions as identified by adding various scavengers. Thus, it is concluded that BBTO and BSTO ceramics proved to be a highly efficient photocatalysts for the photodegradation of Rhodamine B dye.