Chemical Sciences Journal

Sirajudheen and Ismayil, Chem Sci J 2015, 6:4
http://dx.doi.org/10.4172/2150-3494.1000111

Research Article Open Access

Synthesis Characterization and Photocatalytic Activity of $SnTiO_3$ Prepared by Co-Precipitation Peroxide Method

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Abstract

Tin titanate powder was prepared by an organic free co-precipitation peroxide method. Tin chloride and titanium (IV) isopropoxide were used as the primary material with the ratio of (Sn:Ti) was 1:1 and the later compound was prepared by mixing titanium chloride with isopropanol. The prepared powder was calcined at 850°C. The stoichiometric ratio of the synthesized titanate was measured by using AAS. The synthesized titanate had analyzed by X- ray diffraction (XRD). FTIR was taken for confirming the bonding characteristics of Sn-O and O-Ti-O. Thermo gravimetric analysis (TGA) was used to analyze the decomposition temperature. The photocatalytic activity of the synthesized powder was evaluated by Lead carbonate test by using Hunter lab color difference meter.The prepared SnTiO powder had exhibited better photocatalytic activity.

Keywords: Tin titanate; FTIR; TGA; Lead carbonate test; Photocatalytic activity

Introduction

Most materials with great electric polarization are based on the perovskite structure ABO_3, such as $PbTiO_3$. $SnTiO_3$ with perovskite structure has been expected as potential environmentally benign ferroelectric material calculated by first principles within density functional theory (DFT) in recent years [1]. The ferroelectricity with a polarization in $SnTiO_3$ is at least as high as in $PbTiO_3$. Full geometry optimization provides a stable tetragonal structure relative to cubic one reported by Matar. A larger tetragonality leading to a higher polarization and a larger dielectric constant were identified. With respect to PZT, it has superior physical properties of the dielectric [2-4], ferroelectric [5-9]. pyroelectric. Up to date, $SnTiO_3$ has been focused on the piezoelectric materials as a new environmentally piezoelectric ceramic [1].

It is difficult to prepare $SnTiO_3$ using solid state reactions from SnO and TiO_2. This is due to the disproportionate reaction of stannous oxide to stannic oxide and tin metal [10]. Complex oxides containing Sn^{2+} have been reported only for several compounds, for example $SnWO_4$, $SnNb_2O_6$ and Sn_2TiO_4. So, $SnTiO_3$ may be expected as a metastable phase with positive cohesive energies [1]. It is well known that the different raw materials can affect the reaction method and chemical reaction barrier and even the ability to react. In this work, the synthesis explore of the $SnTiO_3$ was carried by a simple co-precipitation peroxide method and characterized by XRD powder diffraction. FTIR was taken for confirming the bonding characteristics of Sn-O and O-Ti-O. Thermo gravimetric analysis (TGA) was used to analyze the decomposition temperature. The optical and photocatalytic activity of the synthesized powder was evaluated by Lead carbonate test by using Hunter lab color difference meter. Color difference was determined using a white medium and strength had been determined using black medium. The prepared $SnTiO_3$ powder had exhibited better photocatalytic activity.

Materials and Methods

Materials

Anhydrous stannous chloride and titanium chloride in isopropanol were used as the starting materials for tin titanate synthesis. Hydrogen peroxide and ammonia solutions from Merck are also used. The chemicals are not purified further. The crystalline structure of the samples was determined by powder XRD using BRUKER D8 Advance X-ray diffractometer using CuKα radiation. FT-IR spectra were recorded using Shimadzu IR affinity spectrophotometer in the range from 4000 cm^{-1} to 400 cm^{-1}. TGA experiments were carried out using SDT Q600 V20.9 instrument. The photocatalytic activity of the synthesized powder was evaluated by Lead carbonate test, using Hunter lab color difference meter of model DP-9000. Strength was determined using black medium and the color difference was determined using a white medium and

Preparation of the sample

0.2 mol (0.372 g in 100 ml) stannous chloride $SnCl_2$ was dissolved in 100 ml of water and about 0.2 mol of titanium tetra chloride ($TiCl_4$) in isopropanol was also made up to 100 ml. The two solutions were mixed together to form a homogenous solution. Then about 15 ml of hydrogen peroxide and 20 ml of ammonia solutions are mixed and about 165 ml of water was added to it. The solution containing stannous chloride and titanium tetra chloride are added to the second solution drop by drop by using a burette. A precipitate was developed in the beaker it was allowed to resolve for some time and filtered. The residue obtained was washed with water desiccated by using Owen and calcined in Muffle furnace at 800° c about an hour in a silica crucible. The tin titanate formed (Scheme 1) is powdered and used for further experiments. The reaction involved in the preparation of tin titanate was given in the Scheme 1.

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Received September 31, 2015; **Accepted** Novmber 02, 2015; **Published** November 09, 2015

Citation: Sirajudheen P, Muhammed Ismayil KM (2015) Synthesis Characterization and Photocatalytic Activity of $SnTiO_3$ Prepared by Co-Precipitation Peroxide Method. Chem Sci J 6: 111. doi:10.4172/2150-3494.1000111

Photocatalytic Activity

The photocatalytic activity of the synthesized powder was evaluated by Lead carbonate test. The instrument used for the test is Hunter lab color difference meter of model DP- 9000. The principle used in this experiment is the reflection of light. Lead carbonate test is one of the monitoring tests used to find out the photo durability of the synthesized titanate. The photocatalytic activity is expressed in terms of catalytic activity coefficient (CAC) [12]. In this test, a mixture of lead carbonate, titanium dioxide, and glycerin is illuminated with UV- light. Different moisture contents and the presence of traces of oxygen influence the measurements [13,14].

Results and Discussion

Results of structural and thermal analyses

The X-ray diffraction patterns of prepared $SnTiO_3$ calcinated 800°C were shown in figure 1. All the peak values are well matched with tin titanate particles [1]. The peak position of a new phase were found at 21.62°, 29.01°, 33.4°, 34.8°, 37.8°, 49.09°, 50.96°, 59.8°. The peaks are corresponds to the characteristic peroveskite structural values [14]. The new phase containing Sn^{2+} is weak acid and strong water absorption. The formation of tin titanate is evidenced by the characteristic peak of tin titanate in the XRD spectrum.

The FTIR spectra of the prepared tin titanate ($SnTiO_3$) sample calcined at 800°C for 3 h was displayed in figure 2. The calcination decreases the peaks intensity of the $SnTiO_3$. In IR spectra, band near 455 cm^{-1} assigned to the Sn-O stretching vibrations and the peak near 619 cm^{-1} stands for O-Ti-O bands and the value below 800 cm^{-1} were assigned to the Ti-O stretching and bending mode of bond vibration corresponding to the formation of tin titanate.

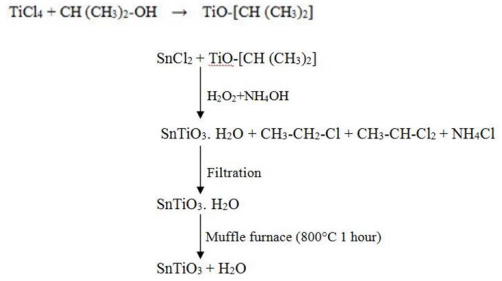
The Differential Thermal Analysis (DTA) curve of tin titanate was shown in Figure 3. The TGA graph shows a gradual weight loss in the temperature range of 220°C-400°C. The lines might related to the combustion of the organic residues and crystallization of the amorphous sample with development of $SnTiO_3$ and a small weight loss at 500 and 680°C,which is due to the evaporation of water. It was confirmed that the decomposition as well as endothermic reaction appeared in the temperature range of 242.69°C and 384.13°C, and an endothermic peak was observed at 354.43°C in the DTA analysis.

Photocatalytic activity

The photo catalytic efficiency is expressed in terms of catalytic activity coefficient (CAC). The CAC values of TiO_2 were found to be low when compared to the prepared tin titanate. It shows that the pigment tin titanate has high photocatalytic efficiency and low photo protection activity in UV when compared to that of TiO2. From the graph (Figure 4), it is clear that there was a deviation in the brightness of TiO_2 i.e., before (93.82) and (59.58) after UV exposure, but in the case of tin titanate, there was a drastic change in the brightness of sample, before (92.73) and after UV exposure (59.58), although in the case of tin titanate, there was a drastic change in the brightness of sample, before (92.73) and after (59.48) UV exposure. Hence, the catalytic coefficient values of tin titanate was (50.9) higher than to natural titanium dioxide (36.49). From the values it was clear that, the prepared tin titanate had more photocatalytic activity in UV- light when compared to that of natural titanium dioxide.

Conclusion

The crystals of a new tin titanate powders were synthesized by a simple organic free co-precipitation method and its crystal structure was determined by X-ray diffraction data. FTIR and TGA are also



Scheme 1: Steps involved in the synthesis of $SnTiO_3$.

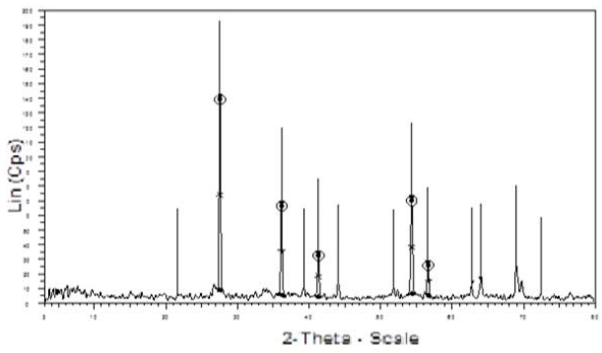


Figure 1: XRD of $ZnTiO_3$.

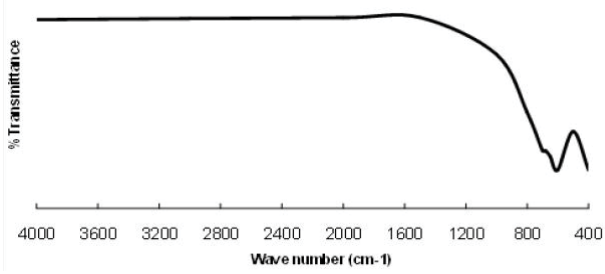


Figure 2: IR spectra of $SnTiO_3$.

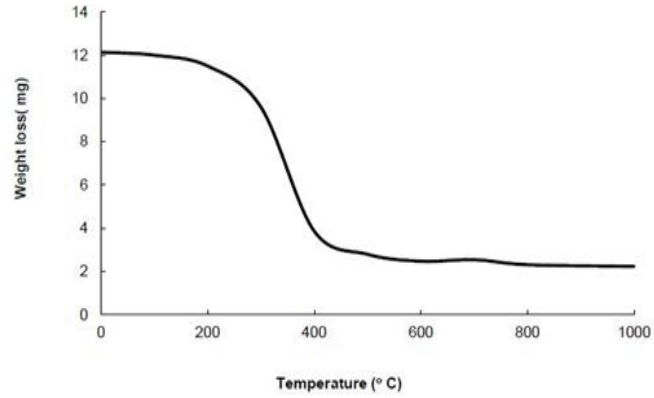


Figure 3: DTA curve of $SnTiO_3$.

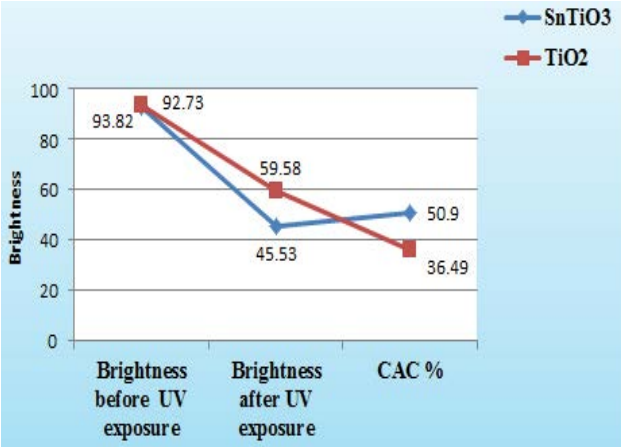


Figure 4: Photo protection activity of $ZnTiO_3$ in UV-Light.

determined. Chemical analysis shows that the prepared tin titanate comprises approximately 43 percentage of tin and 23.68 percentage of titanium and the compound displays peroveskite structure. Photocatalytic activity of $SnTiO_3$ prepared by co-precipitation method was improved in comparison to that of TiO_2.

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