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Polyaniline-Barium Titanate Nanocomposites: Synthesis and Characterization

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Abstract: Barium titanate ($BaTiO_3$) *nanoparticles have been synthesized by co-precipitation method.* Polyaniline synthesized by the oxidation of aniline in presence of ammonium persulphate *Polyaniline-barium titanate nanocomposites synthesized by embedding different weight percentage of barium titanate. XRD analysis was used to study the structure and estimate the size of the particles. Scanning electron microscopy was used to study the morphology of composite materials.*

Keywords: *Polyaniline, barium titanate, co-precipitation , PANI-BT nanocomposites.*

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I. Introduction

Materials have been very important in the history of human endeavors. One of the more important groups of materials in our lives today is *composite material.* Composite materials have many advantages over monolithic materials, because their mechanical, chemical and electrical properties can be tailored as per the requirements for particular applications. Sometimes the properties of a composite can be strikingly different from the properties of the constituent materials. For example, two materials with positive thermal expansion coefficients can be combined to create a porous structure to give a composite with a negative thermal expansion coefficient [1].

Barium titanate (BT) is the inorganic compound having oxides of barium and titanate with the chemical formula $BaTiO_3$ exist in the form of white powder and transparent as larger crystals. It is an dielectric materials due to its high dielectric constant, positive temperature coefficient, and nonlinear optical properties [2-3]. It has five phases as a solid, listing from high temperature to low temperature: hexagonal, cubic, tetragonal, orthorhombic, and rhombohedral crystal structure. All of the structures exhibit the ferroelectric effect except cubic. It is insoluble in water and soluble in concentrated sulfuric acid [4-6].

The polymers having poly-conjugated structures and possess poor electrical conductivity but the oxidized polymers exhibit appreciable electrical conductivity [7-9]. Among the conducting polymers, polyaniline (PANI) have attracted a great deal of attention as is unique among the most researched organic conducting polymer which is easy to synthesize, having good electrical conductivity, fair chemical stability and widely studied for electronic and optical applications[10-11].

II. Materials and Methods

The analytical grade materials were used to synthesize the required samples.

Synthesis of $BaTiO_3$: The co-precipitation method was adopted to prepare BT nanoparticles.0.1M Titanium tetrachloride ($TiCl_4$) solution and 0.1M $Bacl_2.2H_2O$ solutions were prepared in distilled water and both of these solutions were mixed and stirred for 5 minutes.0.1M solution of oxalic acid taken in 1000ml beaker and stirred for 2minutes and a mixture solution of $TiCl_4$ and $Bacl_2$ was added slowly drop wise from the burette with continuous vigorous stirring for 2 hours. The precipitation was allowed to settle down and dried at room temperature and grinded with mortar and pestle for 10minutes and calcinated for 2hours at 450^oC.

Synthesis of Polyaniline (PANI): PANI was synthesized by the oxidation of aniline in presence of ammonium persulphate. A solution of 0.5 M aniline was prepared in 0.5M Hcl . A solution of 0.5M ammonium persulphate was also prepared in distilled water. A known volume of aniline hydrochloride solution was taken in a 1000 ml beaker and is stirred for about five minutes. Now an equivalent quantity of 0.5M ammonium per sulphate is added drop by drop by using a burette and continuously stirred using a magnetic stirrer. The colourless solution of aniline hydrochloride slowly turns to green. After addition of entire quantity of ammonium persulphate stirring was continued for 15minutes. Precipitate was allowed to settle down and then was filtered. The dark green coloured precipitate of polyaniline was obtained. The precipitate was washed with distilled water several times to remove the impurities. Finally the precipitate was washed with acetone to remove the foreign bodies.

Now the precipitate was allowed to dry completely on its own at room temperature. The dried material was grinded to fine powder using mortar and pestle for about 20 minutes [12] and stored for further process.

Synthesis of PANI- BT **Nanocomposites:** PANI-BT composites were synthesized by adding known wt% of BaTiO3 powder to the polymerization reaction .0.5M of aniline ($C_6H_5NH_2$) solution dissolved in 0.5M Hcl and stirred for 5 minutes and 0.5 g (5wt %) of $BaTiO_3$ nanoparticles was added and stirred with magnetic stirrer for about 15 minutes then ammonium persulphate {$(NH_4)_2S_2O_8$) } was added drop by drop. Even after complete addition of ammonium persulphate, stirring was continued for another 30 minutes and allowed the precipitate for about 30-40 minutes to settle down. Now precipitate was filtered and washed with distilled water several times to remove the impurities. Finally washed with acetone and precipitate was dried on its own at room temperature and was grinded for 15 minutes with mortar and pestle. Now the resultant sample is the PANI- BT nanocomposite with 5wt% BT.

In the same manner, PANI- BT nanocomposites with 10wt%, 15 wt%, and 20wt% of BT were synthesized. The prepared PANI- BT_3 nanocomposites were characterized by XRD and SEM.

III. Results and Discussion

The XRD patterns of pure PANI and BT nanoparticles are shown in Figure-1 and 2 respectively. The XRD pattern of pure PANI shows three broad peaks at 2θ values 10.5°, 20.5° and 25.5° and indicates its semi-crystalline structure nature. The XRD pattern of BT reveals crystalline structure of the sample formation of tetragonal phase of BaTiO3, which is approved by the appearance of X-ray reflections at 2θ values 22.152°, 31.528°, 38.889°, 45.273°, 50.855°, 56.235°, 65.797°,70.586°,74.96° and 79.153° (JCPDS 05-0626). The average crystallite size of the BT nano crystals is estimated to about *20.766 nm* by Scherrer's formula.

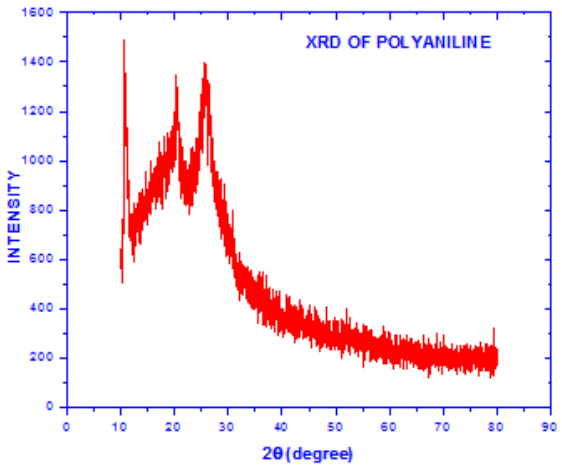


Figure 1: XRD pattern of pure PANI

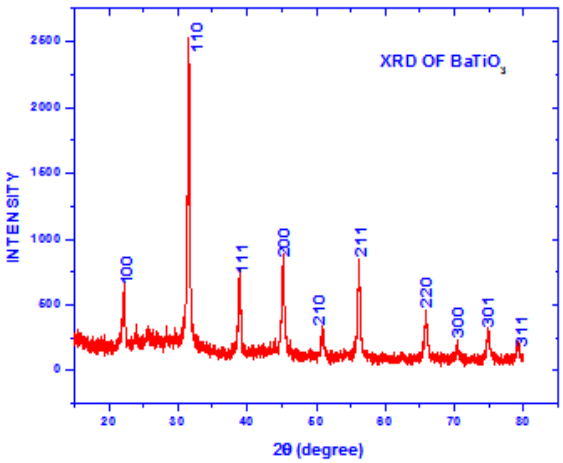
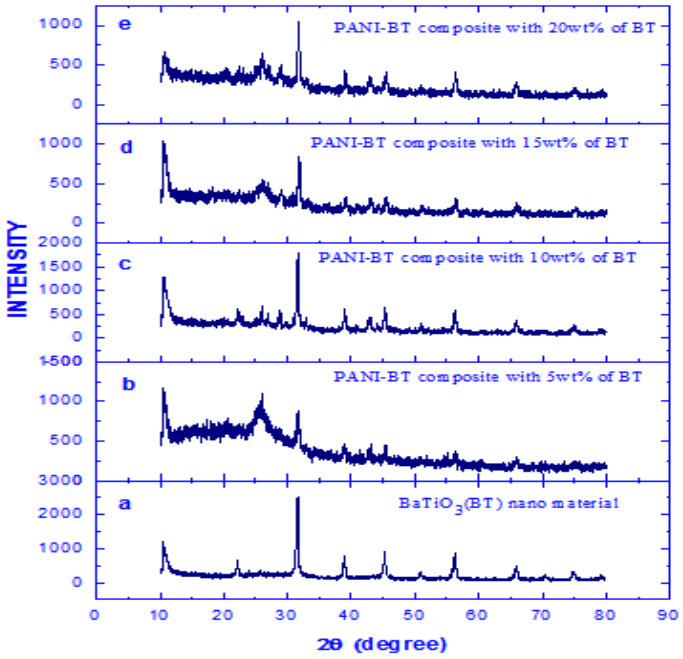


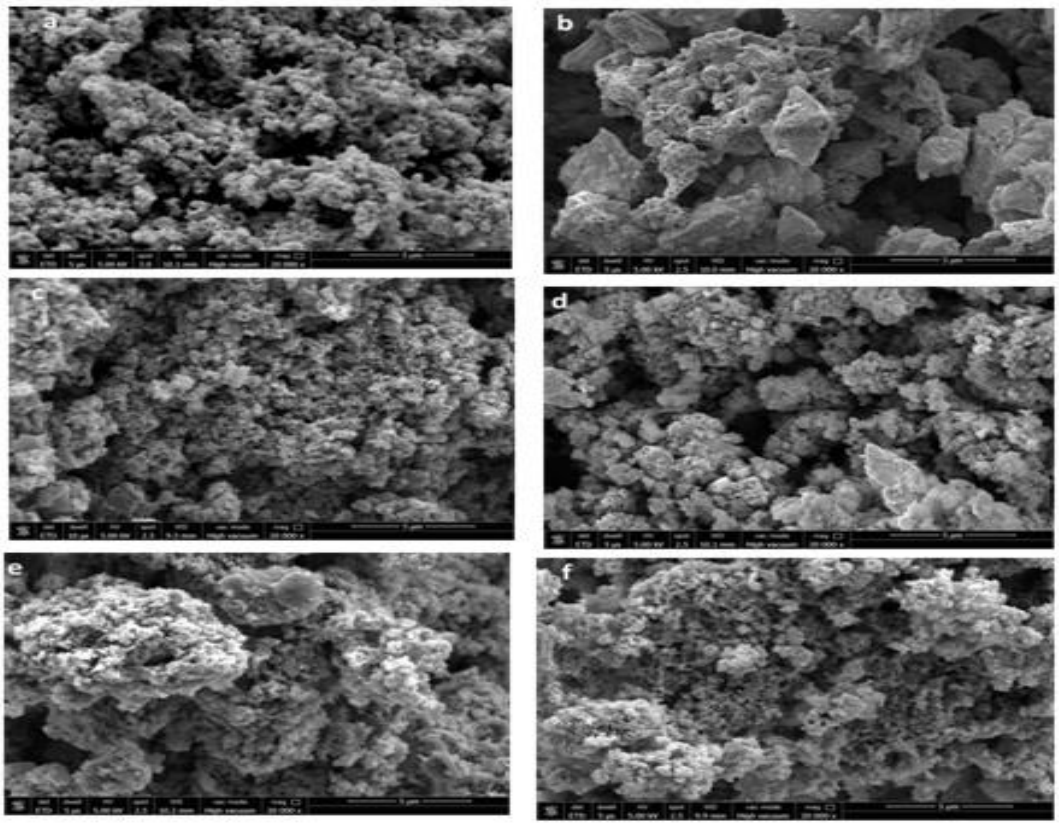
Figure 2: XRD pattern of pure BT

The X-ray diffraction patterns of BT and PANI-BT nanocomposites are shown in Figure-3.The long peak of BT XRD pattern at 31.47° can be seen in all prepared PANI-BT composites which reveals that BT retained its structure even though dispersed in PANI during polymerization reaction. The interaction between PANI and BT results in gradual disappearance of broad peaks of PANI with increase in wt% of BT. This result reveals the formation of PANI-BT nanocomposites and the estimated particle sizes are as in the following table.

PANI-BT COMPOSITES With	Particle size
5wt% of BT	39.35nm
10wt% of BT	22.99nm
15wt% of BT	17.74nm
20wt% of BT	17.36nm



The SEM images of PANI, BT and PANI-BT nanocomposites were obtained to analyze their surface morphology. The SEM photographs of (a) PANI (b) BT and (c-d) PANI-BT composites of magnification 20kx are presented in figure-4. Figure- 4(a) shows SEM image of PANI indicates micro-porous structure.Figure-4(b) is the SEM image of BT indicates the existence of its crystalline structure The Figures-4(c),(d), (e) and (f) are the are the respective SEM images of 5 wt % , 10 wt % , 15 wt % and 20 wt % PANI-BT nanocomposites. The increase in wt% of BT results in increase of the crystallinity of composite materials. The wide dispersion of filler particles (BT) in the matrix (PANI), confirms the formation of nanocomposite.



IV. Conclusion

Polyaniline and $BaTiO_3$ nanoparticles have been synthesized successfully. Polyaniline - $BaTiO_3$ nanocomposites have been successfully synthesized by in situ chemical polymerization of aniline using ammonium persulphate as oxidizing agent by co-precipitation method. The particle sizes were estimated ffrom XRD plots and surface morphology analyzed from SEM images.

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