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Effect of shock wave flows on Ce-$BaTiO_3$ nanoparticles for photocatalytic applications

*P. Sivaprakash[1], Surendhar Sakthivel[1,2], S. Arumugam[2], Ikhyun Kim[3]**

Abstract

In this study, we investigated the synthesis, characterization, and photocatalytic activity of cerium-doped barium titanate (Ce-$BaTiO_3$) nanoparticles (NPs) in the degradation of methyl blue dye under shock impulsion experimentation. Ce-$BaTiO_3$ nanoparticles have been synthesized by using the sol-gel method. Shock wave impulsion experiments were performed on samples 50, 100, and 150 to evaluate the stability of the chemical and physical properties of Ce-$BaTiO_3$ NPs. X-ray diffraction (XRD) was used to analyses the sample's structural properties. The crystallographic characteristics of the Ce-$BaTiO_3$ NPs were ascertained by performing a Rietveld refinement analysis and confirmed tetragonal structure with good crystalline nature. According to the FESEM investigation, the average grain size of the ambient gradually decreases from 430.02 to 174.75 nm (50 shocks) nm and then drops to 148.19 nm (150 shocks). Our photocatalytic experiment reveals that variables including stress, strain, and bond length have a significant influence on photocatalytic application.

Keywords: *Photocatalytic, Ce-$BaTiO_3$ nanoparticles, Shock wave*

1. Introduction

The removal of colors (dyes) from wastewater is one of the main problems encountered in the textile and color industries. Dyes come in a variety of forms, including azo, inorganic, and organic. the hue and additional chemical structure dictate a dye's characteristics. In the last several years, a lot of studies have been sparked by the use of metal oxides to dissolve chemical bonds in the MB dye. Several metal oxides are employed as catalysts. $BaTiO_3$ is thought to be the most effective catalyst for using photon energy to remove harmful dye from wastewater among the other catalysts. In the present study, the Ce-$BaTiO_3$ NPs were synthesized by the sol-gel method. The entire reaction took place in a compressed environment (i.e. shock wave flow).

Shock wave-induced engineering in analyzing the properties of materials has started to gain significant momentum. The advantage of this method is that it is that we can get an idea of how it behaves in extreme conditions of high pressure and high temperature. This field of study intends to investigate the effectiveness and stability of photocatalytic systems throughout extreme flow environments. We analyzed the structural, molecular, optical, and photocatalytic properties of the synthesized Ce-$BaTiO_3$ NPs subjected to 50, 100, and 150 shock pulses.

[1] *Department of Mechanical Engineering, Keimyung University, Daegu 42601, Republic of Korea*
[2] *Centre for High Pressure Research, Bharathidasan University, Tiruchirappalli 620024, India*
[3] *Department of Mechanical Engineering, Keimyung University, Daegu 42601, Republic of Korea, kimih@kmu.ac.kr*

2. Experimental details

The Sol-gel technique was adopted to synthesize Ce-doped $BaTiO_3$ nanoparticles. The impulsion of shock waves in the current work is accomplished via Reddy shock Tube. The parameters employed in this experiment include a Mach number of 2.2, a transitory pressure of 2.0 MPa, and a temperature of 864 K. For a thorough investigation, the title content has been split into four sections, such as ambient, 50, 100, and 150. For Rietveld refining, GSAS-2 software is employed.

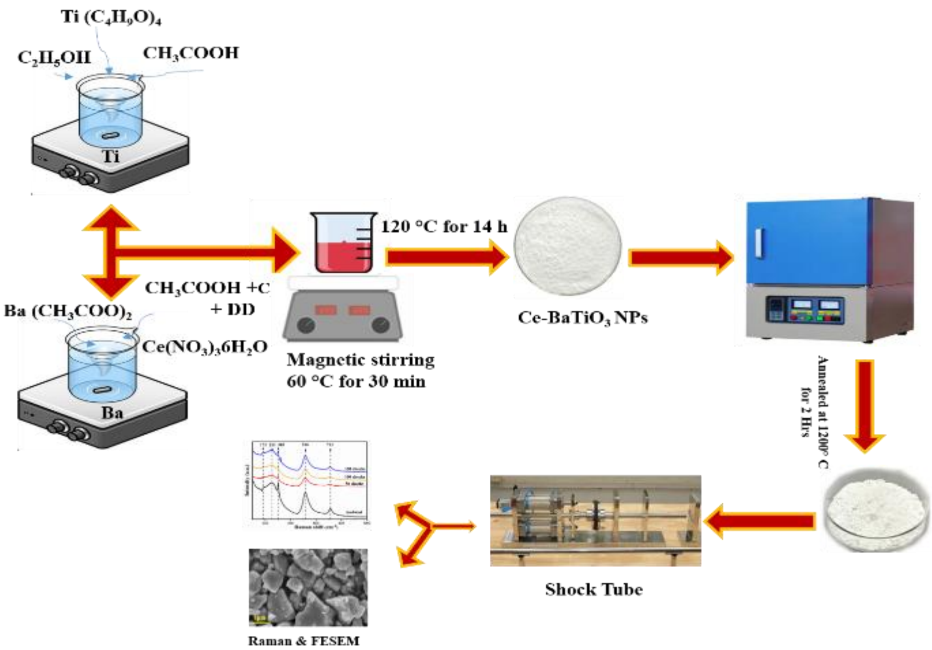

Fig 1. Schematic diagram of synthesis of Ce-$BaTiO_3$ NPs

3. Results and discussion

The X-ray diffraction test verifies the Ce-$BaTiO_3$ that was produced. Additionally, when the shock waves rise, the sample grain size decreases. Rietveld refinement analysis reveals that there has been no crystallographic phase transformation in the synthesized sample. The morphology of the synthesized sample is in good agreement with the sample that was previously reported, and FESEM analysis reveals that the sample is stable up to 50 shocks.

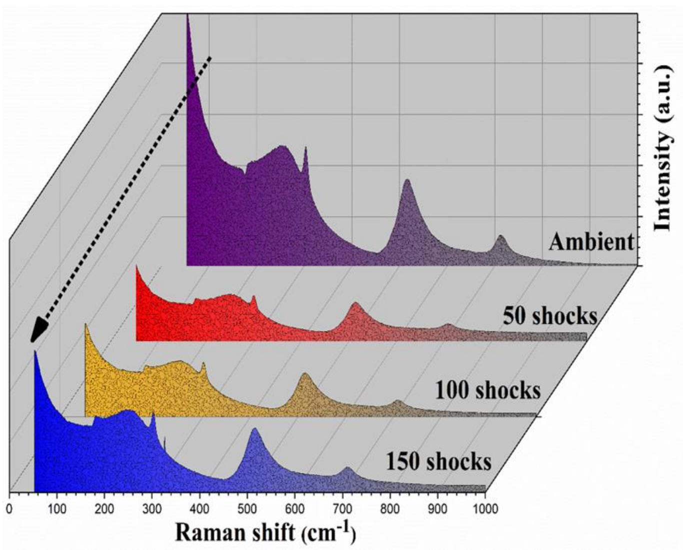

Fig 2. Raman shift results for ambient and shocked Ce-$BaTiO_3$ NPs

4. Conclusion

Ce-$BaTiO_3$ NPs were created using the sol-gel method, and to enhance their photocatalytic activities, shock pulses (50, 100, and 150) were applied to the nanoparticles. The FESEM investigation found that when the number of shock waves increases, the particle size of the materials under assessment decreases. According to the UV DRS data, an increase in Bandgap is seen. The application of shock has been shown to have significant and advantageous impacts on the test sample's photocatalytic property, according to the results of a thorough investigation into the impact of shock waves on Ce-$BaTiO_3$ NPs' photocatalytic abilities. After shock wave treatment (150 shocks), it is shown that the peaks of Sr, Ti, and O gradually move toward greater binding energy.

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