References

1. *Panda P.K., Sahoo B., Thejas T.S., and Krishna M. High d33 Lead-Free Piezoceramics: A Review // Journal of Electronic Materials. – 2022. – Vol. 51. – № 3. – P. 938–952.*

TAILORED TETRAGONAL BARIUM TITANATE NANOPARTICLES FROM BARIUM CARBONATE PRECURSOR VIA HYDROTHERMAL METHOD

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Barium titanate ($BaTiO_3$) stands as a fascinating ferroelectric material due to its remarkable dielectric, piezoelectric, and pyroelectric properties, reflecting its high compatibility for diverse applications such as capacitors, sensors, and actuators. However, the synthesis of $BaTiO_3$ nanoparticles with the requisite attributes, including high purity, uniform size, and controlled crystal structure, persists as a ubiquitous challenge [1]. Among the various methodologies for producing $BaTiO_3$ n anoparticles, the hydrothermal method has gained prominence owing to its simplicity, scalability, and environmental friendliness [2]. Therefore, our research aims to synthesize tetragonal $BaTiO_3$ from $BaCO_3$ under elevated temperature and pressure via a hydrothermal reactor with the merit of a more uniform particle size distribution and less energy consumed than the solid-state approach [3].

$BaTiO_3$ nanoparticles were synthesized through a reaction of 3.25 g barium carbonate and 0.685 g titanium dioxide in a water-ethanol solution with sodium hydroxide. Following a 24 h hydrothermal

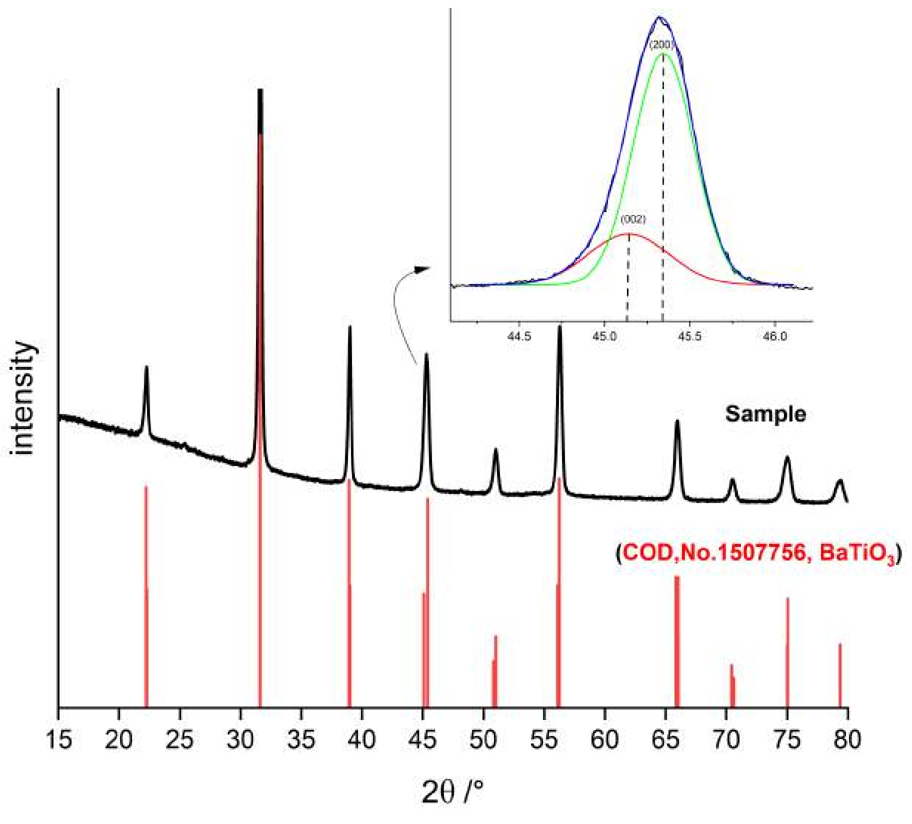

Fig. 1. *XRD patterns of hydrothermally synthesized barium titanate nanoparticles*

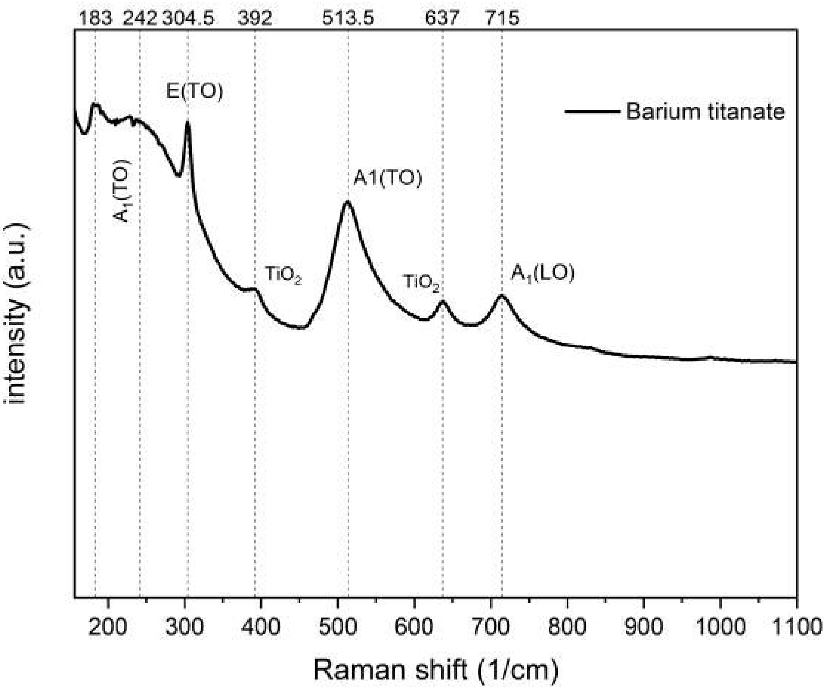

Fig. 2. *Raman spectra analysis of $BaTiO_3$ nanoparticles*

process at 230 °C, the resulting precipitate was filtered, washed, and dried at 80 °C for 12 h. Subsequent grinding and analysis via X-ray diffraction (XRD) and Raman spectroscopy to identify phase composition and crystal structure.

In Fig. 1, the XRD pattern of synthesized $BaTiO_3$ nanoparticles matches the reference card (COD, No. 1507756, $BaTiO_3$), indicating a single-phase sample free from impurities. However, the observed peak splitting around 2θ = 45°, which consistent with existing literature [2], and confirms the tetragonal crystal structure of $BaTiO_3$ nanoparticles wasn't clear, therefore, Raman spectra analysis was done to identify the crystal structure.

In Fig. 2, Raman spectra revealed the crystal structure and phase composition of $BaTiO_3$ nanoparticles. Herein, characteristic peaks for $BaTiO_3$ at 183, 242, 304.5, 513.5, and 715 cm^{-1}, specifically associated with the tetragonal phase, were identified. Notably, the robust presence of sharp peak at 304.5 cm^{-1} assigned to the local asymmetry within the octahedral [TiO_6], and signifies the prevalence of the tetragonal phase of barium titanate, providing an agreement with XRD results. However, we noticed traces of anatase-TiO_2 with characteristic peaks at 392, and 637, respectively.

In conclusion, we prepared hydrothermally tetragonal $BaTiO_3$ nanoparticles from $BaCO_3$ precursor via hydrothermal reactor, as confirmed by the results of XRD and Raman spectra. the merit of hydrothermal synthesis is to obtain more uniform and controllable particle size than the solid-state approach and less energy consumed. However, the limitation in our synthesis was the presence of a trace amount of anatase-TiO_2, which requires further study about the reason through the crystallization process to obtain high purity $BaTiO_3$.

References

1. *Jiang B., Iocozzia J., Zhao L., Zhang H., Harn Y., Chen Y., Lin Z. // Chemical Society Reviews. – 2019. – Vol. 48. – № 4. – P. 1194–1228.*
2. *Wu M., Long J., Wang G., Huang A., Luo Y., Feng S., Xu R. // Journal of the American Ceramic Society. – 1999. – Vol. 82. – № 11. – P. 3254–3256.*
3. *Buscaglia M.T., Bassoli M., Buscaglia V., Alessio R. // Journal of the American Ceramic Society. – 2005. – Vol. 88. – № 9. – P. 2374–2379.*