ORIGINAL RESEARCH PAPER
Volume - 14 | Issue - 06 | June - 2025 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

"FTIR SPECTROSCOPIC ANALYSIS OF SODIUM ALUMINATE ($NAAL_5O_8$) AND CE-DOPED $NAAL_5O_8$ SYNTHESIZED BY THE COMBUSTION METHOD"

Physics

Sanyogita Gaikwad	N.B. Mehta Science College, Department Of Physics Bordi, Dahanu, Palghar- 401701., India
Dr. Mohan A. Gaikwad*	N.B. Mehta Science College, Department Of Physics Bordi, Dahanu, Palghar- 401701., India *Corresponding Author
Tripti J. More	N.B. Mehta Science College, Department Of Physics Bordi, Dahanu, Palghar- 401701., India
Dr. Dinesh S. Bobade	RNC Arts, JDC Commerce And NSC Science College, Nashik Road, Nashik.

ABSTRACT

This study presents a comparative Fourier Transform Infrared (FTIR) spectroscopic analysis of undoped and cerium (Ce)-doped sodium aluminate ($NaAl_5O_8$) synthesized using the combustion method. The incorporation of Ce into the $NaAl_5O_8$ host matrix is investigated by analyzing changes in vibrational modes and bonding characteristics. The analysis confirms successful doping without the formation of secondary phases.

KEYWORDS

Sodium aluminate, Combustion synthesis, FTIR spectroscopic analysis, Phase analysis.

1.INTRODUCTION

Sodium aluminate ($NaAl_5O_8$) has emerged as a promising material for various applications due to its stable oxide framework and favourable physicochemical properties. Doping with rare-earth elements such as cerium (Ce) can modify its structural and electronic properties, potentially enhancing its performance in optoelectronic and catalytic applications. FTIR spectroscopy is employed to probe the local bonding environment and to confirm the phase integrity upon doping.

2. Experimental Method

$NaAl_5O_8$ and Ce-doped $NaAl_5O_8$ samples were synthesized via the combustion method. FTIR spectra were recorded in the range of 400–4000 cm^{-1} using KBr pellet technique. The recorded spectra were analyzed to identify characteristic functional groups and structural changes resulting from Ce doping.

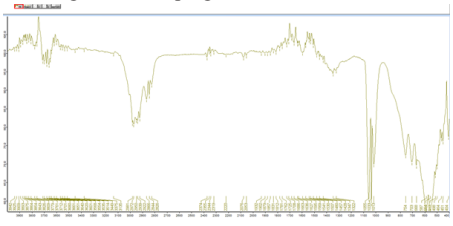

Figure 1. FTIR spectrum of undoped $NaAl_5O_8$ showing typical bands for O–H, Al–O, and Al–O–Al vibrations.

3. RESULTS AND DISCUSSION

3.1 FTIR Analysis of $NaAl_5O_8$ (Host)

FTIR spectroscopy was employed to investigate the vibrational modes and bonding environment in pure and Ce-doped $NaAl_5O_8$ samples. The spectra were recorded in the range of 4000–400 cm^{-1}. In the undoped sample (Fig.1), a broad band around 3450 cm^{-1} and a corresponding peak at 1640 cm^{-1} are observed, which can be attributed to O–H stretching and H–O–H bending vibrations of adsorbed water or hydroxyl groups. The strong band in the region of 1100–1000 cm^{-1} corresponds to Al–O stretching vibrations within the AlO_6 octahedral framework, while the bands around 800–400 cm^{-1} arise from Al–O–Al bending modes and lattice vibrations typical of the $NaAl_5O_8$ structure.

The FTIR spectrum of undoped $NaAl_5O_8$ exhibited the following features:

- A broad absorption band around 3450 cm^{-1} corresponding to O–H stretching vibrations due to surface-adsorbed water.
- A band near 1630 cm^{-1} attributed to H–O–H bending vibrations of molecular water.
- Sharp and intense peaks between 1000–1100 cm^{-1}, indicating asymmetric Al–O–Al stretching modes, typical of AlO_6 octahedra.
- Bands within 800–600 cm^{-1} due to Al–O bending vibrations.
- Low-frequency bands around 470–420 cm^{-1} associated with lattice vibrations of the Al–O framework.

These bands confirm the formation of a well-defined $NaAl_5O_8$ phase with strong Al–O bonds.

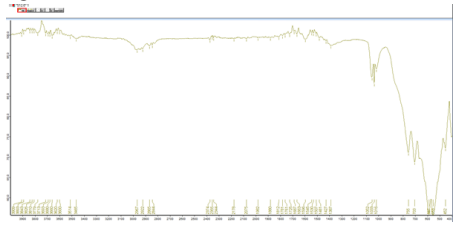

Figure 2. FTIR spectrum of Ce-doped $NaAl_5O_8$ indicating spectral shifts in Al–O and metal–O regions due to Ce^{3+} incorporation. In FTIR spectrum of Ce-doped $NaAl_5O_8$ showing characteristic vibrational bands associated with O–H, Al–O, and Ce–O bonds

3.2 FTIR Analysis of Ce-Doped $NaAl_5O_8$.

The FTIR spectrum of the Ce-doped sample retained all the significant absorption bands observed in the undoped sample, with minor changes:

- The O–H and H–O–H bands (~3450 cm^{-1} and ~1625 cm^{-1}) remained, though with reduced intensity, suggesting a possible reduction in surface-adsorbed moisture due to Ce doping.
- Al–O stretching modes (~1000–1100 cm^{-1}) were preserved, indicating that the basic framework of $NaAl_5O_8$ was maintained.
- Slight broadening and minor shifts in the 800–400 cm^{-1} region suggested lattice distortion caused by the substitution of Ce ions, owing to their differing ionic radii compared to Al.

Importantly, no new absorption bands appeared, indicating that Ce was incorporated into the $NaAl_5O_8$ lattice without forming secondary or impurity phases.

In the Ce-doped sample (Fig. 2), the spectral features remain largely consistent with those of the undoped counterpart, indicating that the primary crystal structure is retained. However, certain differences are notable. The Al–O stretching region shows a clearer doublet near 1052 and 1022 cm^{-1}, suggesting a modification in the local coordination due to Ce^{3+} incorporation. Peaks in the low-frequency region—specifically at 562, 492, and 452 cm^{-1}—are more pronounced and slightly shifted, implying interactions between Ce ions and the surrounding oxygen atoms. These spectral shifts support the successful substitution or

interstitial incorporation of Ce in the $NaAl_5O_8$ matrix

4. CONCLUSION

FTIR analysis confirms the successful synthesis of both undoped and Ce-doped $NaAl_5O_8$ using the combustion method. The fundamental Al–O bonding characteristics of the host lattice are preserved upon Ce doping, with minor vibrational shifts indicating local lattice distortions. The absence of new peaks in the doped sample spectrum confirms that Ce integrates into the host matrix without forming unwanted phases.

Acknowledgements

The authors gratefully acknowledge the Department of Physics, N.B. Mehta Science College, Bordi, for providing the necessary facilities to carry out this research.

REFERENCES

[1] R.K. Sharma, S.P. Ojha, Structural and vibrational studies of sodium aluminate, Mater. Sci. Eng. B 150 (2008) 144–149. https://doi.org/10.1016/j.mseb.2008.02.018
[2] M.A. Ali, M.M. Nasef, FTIR and structural properties of alumina based nanoceramics, Ceram. Int. 41 (2015) 2301–2306. https://doi.org/10.1016/j.ceramint.2014.10.061
[3] A. Pandey, P. Sharma, Effect of cerium doping on structural and optical properties of alumina nanoparticles, J. Rare Earths 36 (2018) 954–960. https://doi.org/10.1016/j.jre.2018.01.017
[4] B.R. Srinivasan, A review on structural and vibrational properties of Ce-doped oxide materials, J. Mol. Struct. 1204 (2020) 127511. https://doi.org/10.1016/j.molstruc.2019.127511
[5] K. Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination Compounds, sixth ed., Wiley-Inter science, Hoboken, NJ, 2009.