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Preparation of $LaFeO_3$ Perovskite Nanoparticles using the Nitrate Method (from Nitrate Precursors)

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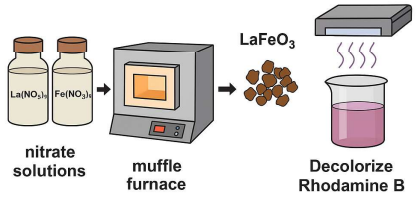
INTRODUCTION & AIM

Lanthanum ferrite ($LaFeO_3$) is highly valued in energy and catalytic systems. Traditional solid-phase synthesis at ≥1400 °C typically results in large particles (>300 nm, often micrometer-sized [1]), which negatively impacts surface area and activity.



Soft chemistry methods such as the polyol or Pechini methods require organic gelling agents (citric acid, glycine), which may contaminate the sample and increase the carbon footprint [2]. In contrast, the nitrate evaporation method using only $La(NO_3)_3$ and $Fe(NO_3)_3$ without organics produces phase-pure $LaFeO_3$ nanoparticles of ~76 nm in size after a single treatment step at 1200 °C for 7 h. The aim was to investigate the photocatalytic benefits of $LaFeO_3$ prepared by the nitrate method.

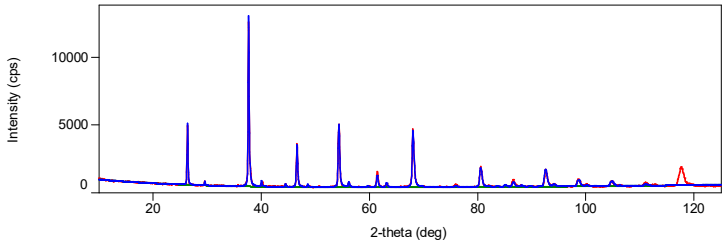
METHOD

- $LaFeO_3$ perovskite nanoparticles were obtained by the nitrate method by evaporation of an aqueous solution of a stoichiometric mixture of $La(NO_3)_3$ and $Fe(NO_3)_3$ followed by annealing *for 7 hours at 1200 °C*.
- The study of *the morphology and elemental composition of the surface* of $LaFeO_3$ nanoparticles was carried out by SEM on a JSM-7600F instrument (JEOL, Japan) equipped with an EDX detector (Oxford Instruments, UK).
- *The quality and composition* of the synthesized perovskite materials were characterized by Fourier transform infrared spectroscopy on a Vertex 80v spectrophotometer (Bruker, Germany) in the range from 400 to 4000 cm^{-1}.
- *The crystalline phase and crystallinity* of the samples were characterized by X-ray diffraction (XRD, Rigaku MiniFlex 600 benchtop diffractometer) using Cu Kα radiation (λ = 0.154 nm) in the 2θ angle range from 20° to 120°.
- *For photocatalytic tests*, 40 mg of $LaFeO_3$ nanoparticles were ultrasonically dispersed in 50 ml RhB solution (10 $mg \cdot L^{-1}$). The suspensions were kept in the dark for 30 min to reach adsorption–desorption equilibrium, then irradiated for 180 min with a 145 W UV lamp (ANTs 170/70-P3-3, Russia) in quartz beakers. RhB degradation was monitored by UV–Vis spectroscopy (400–800 nm, UV mini-1240, Shimadzu) with aliquots taken every 10 min. MB content was determined using a calibration curve (0.01–110 $mg \cdot L^{-1}$). Radical trapping was performed with isopropyl alcohol (·OH scavenger) and benzoquinone ($\cdot O_2^-$ scavenger).
- *Optical absorption spectra* were recorded using a UV mini-1240 spectrophotometer (Shimadzu).

RESULTS & DISCUSSION

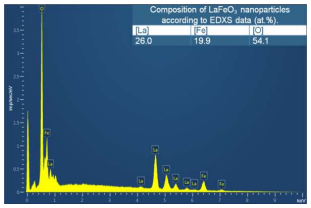
WPPF Analysis

Phase name	Formula	Space group	Phase reg. detail	DB card number	Content(%)	Crystallite size(A)	Strain(%)
Lanthanum iron(III) oxide	$LaFeO_3$	62 : Pbnm	ICDD (PDF2.DAT)	01-074-2203	100(7)	760(5)	0.210(3)
	a(A)	b(A)	c(A)	alpha(deg)	beta(deg)	gamma(deg)	V(A³)
	5.5357(8)	5.5352(9)	7.8324(10)	90.000000	90.000000	90.000000	239.99(6)

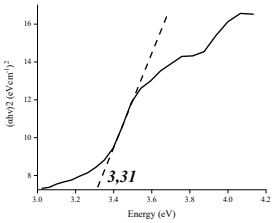


X-ray diffraction pattern of $LaFeO_3$ nanoparticles

- Nanoparticles of orthorhombic perovskite $LaFeO_3$ with an average crystallite size of about 63 nm were obtained

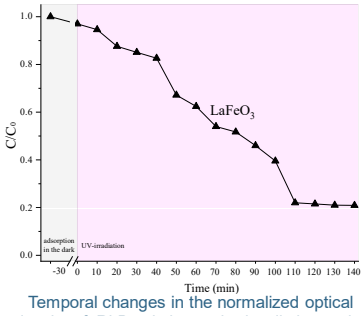


EDS spectra of $LaFeO_3$ nanoparticles

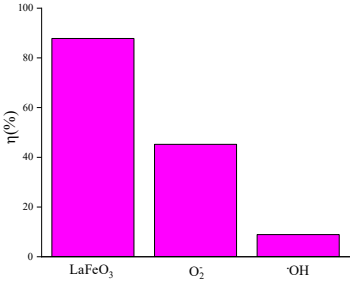


Tauc plot for $LaFeO_3$ nanoparticles

- $LaFeO_3$ contain only the elements O, La and Fe.
- The band gap of LaFeO3 nanoparticles is 3.21 eV



Temporal changes in the normalized optical density of RhB solution under irradiation under the action of $LaFeO_3$ nanoparticles



Photocatalytic efficiency (η,%) of RhB solution under irradiation under the action of $LaFeO_3$ nanoparticles

- $LaFeO_3$ nanoparticles exhibit high photocatalytic activity in the UV range: the solution is decolorized within 90 minutes; the active particles are OH radicals.

CONCLUSION

It has been demonstrated that photocatalytically active $LaFeO_3$ nanoparticles with a size of t approximately 76 nm can be obtained using the nitrate method in one stage within 7 hours at a synthesis temperature of 1200°C. The LaFeO3 nanoparticles obtained using this method have high photocatalytic activity due to the generation of OH radicals upon irradiation with light of a wavelength of 350 nm.

FUTURE WORK / REFERENCES

[1] Kumar, D., Yadav, R. S., Singh, A. K., & Rai, S. B. (2020). Synthesis techniques and applications of perovskite materials. In Perovskite Materials, Devices and Integration. IntechOpen.
[2] Navas, D., Fuentes, S., Castro-Alvarez, A., & Chavez-Angel, E. (2021). Review on sol-gel synthesis of perovskite and oxide nanomaterials. Gels, 7(4), 275.