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Enhanced Structural, Optical, and Photocatalytic Performance of Sm3+-Doped LaFeO3 Nanoparticles Synthesized via Solution Combustion

Sm3+-doped LaFeO3 nanoparticles were synthesized via a solution combustion method using isoleucine as fuel. The influence of Sm^{3+} incorporation (0–9 mol%) on the structural, morphological, optical, and photocatalytic properties was systematically investigated. X-ray diffraction (XRD) confirmed the formation of single-phase orthorhombic perovskite structures with reduced crystallite size upon Sm3+ doping. Rietveld refinement revealed variations in lattice parameters, strain, and dislocation density with increasing dopant concentration. Scanning electron microscopy (SEM) showed porous, agglomerated morphologies, while energy-dispersive X-ray spectroscopy (EDS) confirmed the elemental composition. Diffuse reflectance spectroscopy (DRS) indicated a reduction in optical band gap with Sm3+ substitution, enhancing visible-light absorption. X-ray photoelectron spectroscopy (XPS) revealed the presence of mixed-valence Fe2+/Fe3+ states and abundant surface oxygen, contributing to improved redox activity. BET analysis confirmed mesoporous structures with enhanced surface area at optimal doping. Photoluminescence (PL) spectra showed defect-related broad emissions, with quenching behavior at higher doping levels, suggesting improved charge separation efficiency. Photocatalytic experiments demonstrated significant degradation of Indigo Carmine dye under visible light, with maximum activity observed at 9 mol% Sm3+ doping. Furthermore, elevating the Sm3+ levels in the La1-xSmxFeO3 resulted in enhanced photocatalytic decomposition of the indigo carmine dye, exhibiting a maximum efficacy of 94 % at neutral pH and a stabilization period of 70 min under visible light. The enhanced photocatalytic performance is attributed to reduced particle size, increased surface area, optimized band gap, and defect-mediated charge carrier dynamics. These results highlight Sm3+ -doped LaFeO3 as a promising photocatalyst for wastewater treatment and related environmental applications.

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