



RESEARCH ARTICLE

Combustion and secondary atomization behavior of nanofuel droplets laden with hematite, magnetite and lanthanum orthoferrites nanoparticles

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Abstract

Current research concerns the droplet combustion behavior of gasoline-based nanofuel droplets containing hematite (Fe_2O_3), magnetite (Fe_3O_4) and lanthanum orthoferrites (LaFeO_3 , $\text{La}_{0.5}\text{Fe}_{1.5}\text{O}_3$ and $\text{La}_{0.75}\text{Fe}_{1.25}\text{O}_3$) perovskite type nanoparticles (NPs) at 2.5% wt. particle loadings. The results showed that the size distribution of hematite and magnetite NPs is on the 90–100 nm scale, while the lanthanum orthoferrites NPs have a particle size distribution of 25–40 nm. The particles with the largest surface area ($78,5098 \text{ m}^2/\text{g}$) and enhanced oxygen adsorbing ability were $\text{La}_{0.5}\text{Fe}_{1.5}\text{O}_3$ NPs. Droplet combustion experiments were recorded with a high speed camera and a $7.5\text{--}14 \mu\text{m}$ spectral area thermal camera. Fe_3O_4 and LaFeO_3 NPs high agglomerate tendency allowed only a single microexplosion event in nanofuel droplets towards the end of the experiment. Only the $\text{G}/\text{La}_{0.5}\text{Fe}_{1.5}\text{O}_3$ fuel droplets trended to obey the D^2 -law. Nanofuel droplets containing $\text{La}_{0.5}\text{Fe}_{1.5}\text{O}_3$ NPs exhibited the highest maximum flame temperature of 264°C . The catalytic activity of lanthanum orthoferrite perovskite-type NPs during combustion was improved due to the decrease in the La ratio in the A-site and the increase in the Fe ratio in the B-site.

KEYWORDS

catalytic activity, combustion catalysts, lanthanum orthoferrites, nanoparticles

1 | INTRODUCTION

Metal and metal oxide NPs have been extensively studied as potential metal fuel additives for diesel-biodiesel blends, explosives, and pyrotechnics, with their catalytic activity and high oxygen content [1–6]. Aluminum, magnesium, lithium, bismuth, titanium, iron, tin, cerium, and their oxides have been investigated to accelerate oxidation, reduce ignition delay times and improve

combustion rates [7–14]. These structures, which are often used as oxidative shells in nanothermite structures, swell the combustion efficiency by allowing oxygen diffusion to the metal particle with a high calorific value in the core. The effect of metal oxide NPs is related they allow oxygen adsorption-desorption with their large surface areas rather than the oxygen in the lattice structure, which is generally active at high temperatures [8, 15–17]. Another aspect where catalytic activity is important for

Abbreviations: BET, Brunauer–Emmett–Teller theory; ID, Ignition Delay; NP, Nanoparticle; OA, Oleic acid; SEM, Scanning electron microscope; XRD, X-Ray Diffraction spectroscopy; XPS, X-ray photoelectron spectroscopy; UV-Vis, Ultraviolet and visible (UV-Vis) absorption spectroscopy