INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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Thesis Title: SYNTHESIS AND CHARACTERIZATION OF HIGH OXYGEN STORAGE CAPACITY NANOPARTICLES DISPERSED DIESEL FOR THE EMISSION REDUCTION AND PERFORMANCE ENHANCEMENT OF A DIRECT INJECTION ENGINE

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SHORT ABSTRACT

In order to meet the increase in stringent regulation for exhaust gas emission from diesel vehicles, an exhaust-gas-after-treatment has become an essential process in most of the countries leading to use diesel particulate filters and catalytic converters as a treatment device. The effective utilization of the fuel is one of most essential requirements by considering the depletion of fossil fuel. Hence, there is a need to increase the effective utilization of different types of fuel in an engine without making any changes in the system. The objective of present work is to improve the performance and reduce the harmful emission of a diesel engine by homogenously dispersing the nanosized high oxygen storage capacity (OSC) materials of CZY (C=Ce; Z=Zr; Y= Al, Mn, Bi, La, Nd) oxides in diesel, named as a nanofuel. An attempt was made to synthesize nanoparticles having the improved OSC, which were homogenously dispersed in diesel with the help of oleic acid as a surfactant in order to meet the objectives. Cerium based solid solutions were prepared by sol-gel process and characterized. It is observed that the synthesized solid solutions had stable cubic fluorite structure, higher OSC, lattice defects and <10 nm crystallite size. The quantitative and qualitative studies on OSC of different solid solutions were done using suitable characterization techniques. It was observed that the cerium based solid solutions of $Ce_{0.6}Zr_{0.2}Al_{0.26}O_2$, $Ce_{0.6}Zr_{0.2}Al_{0.39}O_2$ and $Ce_{0.6}Zr_{0.2}Mn_{0.2}O_2$ were found to have the higher OSC in a decreasing order, where the CeO_2 and $Ce_{0.6}Zr_{0.4}O_2$ were considered as base materials. The OSC of base materials was increased if the doping element has lower ionic radius than the cerium. A tip sonicator, magnetic stirrer and a combination of both were used systematically to verify their versatility for the preparation of stable nanofuel. Though different types of surfactant based on anionic, cationic and nonionic were attempted, the ceria based nanofuel synthesized using Tween 80 as a surfactant and the combined preparation technique yielded a more stable nanofuel with the dispersion stability of 100 % for the period of 24 hrs. An accelerated sedimentation technique

using centrifuge was also proposed to study the influence of ageing on the dispersion stability of nanofuel and it was found that the nanoparticles were settled completely after 620 hrs. The optimum concentration of nanoparticles to be dispersed in diesel was selected as 0.06 wt. % based on the performance enhancement study using CeO_2 based nanofuel, where the brake thermal efficiency and mechanical efficiency of an engine were increased by 12.8 and 9.2 %, respectively. In addition, the brake specific fuel consumption and frictional power were decreased by 11.3 and 20.8 %, respectively. The relative stability of CeO_2, $Ce_{0.6}Zr_{0.4}O_2$, $Ce_{0.6}Zr_{0.2}Al_{0.26}O_2$, $Ce_{0.6}Zr_{0.1}Al_{0.39}O_2$ and $Ce_{0.6}Zr_{0.2}Mn_{0.2}O_2$ dispersed diesel was found to be 87, 88, 88, 91 and 89.5 %, respectively, at 0.06 wt. % after 168 hrs of synthesize. It was found that the properties of diesel were not varied significantly by dispersing different types of nanoparticle at 0.06 wt. %. When highest OSC material $Ce_{0.6}Zr_{0.2}Al_{0.26}O_2$ was dispersed in diesel and tested, it was observed that the brake thermal efficiency and mechanical efficiency of an engine were found to be increased by 20.7 and 8.2 %, respectively with respect to diesel at 100 % loading conditions and the brake specific fuel consumption and frictional power were decreased by 17.1 and 15.3 %, respectively. If only mechanical efficiency is considered, $Ce_{0.6}Zr_{0.4}O_2$ dispersed diesel was observed to show 11 % enhancement in comparison to that of diesel at 100 % loading condition. The highest reduction of NO_x, CO and hydrocarbon was found to be 68, 60 and 44 %, respectively, when 0.06 wt. % of $Ce_{0.6}Zr_{0.2}Al_{0.26}O_2$ based nanofuel was used in an IC engine at 100 % loading. A field study was also carried out with high OSC nanoaprticles dispersed diesel, where the utilization period of $Ce_{0.6}Zr_{0.2}Al_{0.26}O_2$ based nanofuel was increased by 25±1 % compared to that of pure diesel. In addition, the maximum utility time of CeO_2, $Ce_{0.6}Zr_{0.4}O_2$, $Ce_{0.6}Zr_{0.2}Mn_{0.2}O_2$ and $Ce_{0.6}Zr_{0.1}Al_{0.39}O_2$ dispersed diesel was noted to be 5±1, 17±1, 20±2 and 22 %, respectively. Thus, the $Ce_{0.6}Zr_{0.2}Al_{0.26}O_2$ based nanofuel is recommended to be effectively used in an IC engine in order to enhance the performance of an engine and to reduce its emission, which can be commercially explored.