PREFACE

Diesel engines have been widely employed in light duty vehicles such as passenger cars, mini school vans, auto rickshaw, light-duty trucks and heavy-duty vehicles such as locomotive, ships, tractor, trucks because of their high fuel efficiency, low maintenance cost, durability, and reliability. The major drawback associated with them is emissions of the significant amount of particulate matter (PM) and NOx along with minor other pollutants. Apart from health problems, PM (soot) causes pollution of air, water, and soil, soiling of buildings, reductions in visibility, adverse impact on agriculture productivity, global warming and climate change. NOx form more deleterious secondary pollutants such as acid rain, smog, tropospheric ozone, PAH, PAN and causes greenhouse effect. As the regulations on diesel engine emissions are made more stringent, permissible limits decrease for soot and NOx. Diesel soot and NOx elimination are known to be a very hard task, since this mixture burns above $600^{o}C$, while temperature of the diesel exhaust generally lies between $150\text{-}450^{o}C$. Therefore, in order to reduce the combustion temperature of the soot, oxidation catalyst coated diesel particulate filter (DPF) has been suggested.

The DPFs are becoming widespread as an effective measure to reduce soot emissions from diesel vehicles because these devices have filtration efficiencies greater than 98%. As the filters accumulate PM, it builds-up back pressure that has many adverse effects for instance decreased fuel economy and possible engine and/or filter failure. To prevent such effects, DPFs are regenerated by oxidizing (i.e. burning) the trapped PM. An attractive option to remove PM is a passive regeneration of DPF, which involves catalytic combustion of trapped PM during normal operation of the engine. The soot is burned out by oxidation catalysts deposited onto the filter. One of the major challenges in diesel exhaust treatment is removal of NOx under lean (oxygen-rich) conditions. Currently, SCR is used to remove NOx using a reducing agent such as ammonia, urea, HC such as propane, propene, hexane, octane etc. and hydrogen. There is trade-off between soot and NOx as at high temperature soot get oxidized but simultaneously NOx is produced but when temperature is controlled soot combustion is not efficient. Therefore, it is difficult to control soot and NOx simultaneously. The various technologies are available for the control of soot and NOx but they have their own limitations. Thus, combined system for control of both soot and NOx is needed. Simultaneous removal of PM and NOx from diesel engine exhausts may be controlled by the combination of DPF and SCR technology. The simultaneous removal of PM and NOx by a single catalytic system would be very effective as compared to individual control technologies. Use of a low-cost and effective catalyst is desirable. The main challenge is to find a catalyst system that is active within the window of the exhaust temperature.

Perovskite oxides with general formula ABO_3 have been tested as catalysts for a variety of reactions, due to double advantages of tailoring flexibility and thermal stability at high temperature. Such catalysts also have been extensively investigated as potential substitutes for costly PGM-based catalysts in automotive exhaust emission control. Thus, the main objective of the present work is to develop an efficient perovskite catalyst for simultaneous removal of diesel soot and NOx. The catalyst should be active within the temperature range of diesel exhaust. To design and develop PGM-free improved perovskite catalysts, sol-gel method of preparation followed by a novel route of reactive calcination of the precursors were used, which were based on rational correlations of various physicochemical parameters to achieve the eventual goal of ultra-low emission norms.

The thesis entitled “**Simultaneous Catalytic Removal of Soot and NOx Emissions from Diesel Engine Exhaust**" comprises of six chapters.

Chapter 1 is introductory in nature, which contains a brief account of current scenario of the diesel engine and their applications. Main pollutants emitted by diesel engines include Particulate matter (PM)/Soot and NOx. It presents the impacts on human health, vegetation, materials, and environment including global warming and climate change and also discusses the emissions and control of NOx and soot from diesel vehicles.

Chapter 2 describes simultaneous control of diesel soot and NOx. Present “state of the art” is to control soot and NOx separately in two different converters. The first converter is diesel particulate filter (DPF), which removes more than 98% soot. The soot is trapped in DPF, which causes increase in back pressure and so it is regenerated by burning the deposited soot on a catalyst coated onto the filter. Control of NOx is done in the second converter by urea selective catalytic reduction (SCR). Simultaneous removal of soot and NOx in a single catalyzed trap may be more desirable than the presently used two converters technologies. The simultaneous technology may result in a compact converter and so, it has been explored recently in view of the advantages that it may offer in terms of both investment cost and pressure drop reduction.

Chapter 3 describes of various conventional catalysts in brief for simultaneous control of diesel soot and NOx with relevant literature survey presented at a glance in a tabular form. Outcome from the literature reviews helps to identify the effective catalysts for simultaneous control of NOx and soot. Objectives of the present work are mentioned in this chapter.

Chapter 4 describes preparation method for diesel soot and its characterization by different techniques, i.e., proximate analysis, particle size analysis, calorific value calculation and XRD analysis. This chapter also explains the preparation methods of different effective catalysts and their characterization techniques, i.e., SEM, EDX, XRD, XPS, FTIR, and BET surface area.

Chapter 5 experimental results and discussion are presented in this chapter. The preparation methodology (sol-gel, solution combustion synthesis, reactive grinding etc.) and calcination strategies of catalyst precursor (temperature - 600, 650, 700, 750^oC and environment - stagnant air, flowing air, reactive calcination) on efficiency of $LaFeO_3$ catalyst for simultaneous removal of NOx and soot are discussed. Reactive calcination of the catalyst precursor is carried out in a flowing reactive environment containing 4.5% CO in air. The results exhibited that the catalyst prepared by sol-gel method and reactively calcined at 700^oC exhibits total soot oxidation at 319^oC within the temperature window of diesel exhaust (150-450^oC) and the maximum NOx reduction of 75.62% at 378°C.

Chapter 6 reports the conclusions based on the experimental results and discussion and future scope of in this area.

At the end, the list of references and publications are provided.