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Analysis of copper nanomaterial as catalyst for reduction of NOx gases in diesel engine

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Abstract

In the automobile sector, the removal of pollutants (NOx) generated by diesel engines remains a fascinating scientific and technological issue. The emissions of the vehicle are in compliance with BS III standards. The Indian government came up with the Bharat Stage Emission Standards in order to place limitations on the amount of air pollution that can be released into the atmosphere by machinery that uses an internal combustion engine, such as automobiles. The central pollution control board, which is an agency under the ministry of environment and forests, is in charge of defining the requirements and the timetable for their implementation. The brake-specific fuel consumption decreased by 4.5% and 8%, while brake thermal efficiency rose by 5.5% and 14.6%. However, with CO additions of 1000 and 2000 ppm, respectively, nanoparticles increased the chemical processes and decreased the ignition delay time by 3.03% and 5.45%. The amounts of CO, HC, and NOx emissions decreased by 14.6%, 20.8%, 6.2%, and 13.4%, respectively. The catalytic oxidation of carbon monoxide is an important reaction in both commercial and academic settings. For the past years, hoplite, which is composed of copper-manganese oxides, has served as a low-cost and widely available carbon monoxide abatement catalyst.

Introduction

Today, managing emissions involves more than just engine management and design. Exhaust gas after-treatment systems are crucial as existing and upcoming auto emission rules tighten up. The catalytic converter used on most cars is the best after-treatment for lowering engine emissions. A ceramic or metal honeycombed monolith substrate that contains precious metal catalysts is the typical structure that is used in the construction of catalytic converters [1], [2], [3], [4]. Before being installed in the engine exhaust system, the coated substrate is first encased in a tumescent mat, which is a mat that expands when it is heated, and then it is packaged in a stainless steel shell. Exhaust gases encourage chemical processes that transform contaminants into safe gases and water as they pass over the catalysts. Oxygen (O_2) and hydrocarbons (HC) mix to form carbon dioxide (CO_2), while nitrogen oxides (NO, NO_2) react [5], [6], [7], [8] (See Table 1).

An essential part of emission control for creating a cleaner atmosphere is the reduction of nitrogen oxide (NO_X) species like NO, NO_2, and N_2O from stationary sources and automotive exhaust emissions. It was looked into how well they performed in the selective catalytic reduction of NOx using propene as the reducing agent from 150 to 450°C in an O_2-rich model exhaust stream. The combustion activities, such as the burning of fossil fuels in power plants and gasoline in automobiles, are the main causes of NO_X emissions. Temperature, residence duration, and oxygen concentration during combustion all affect NO_X production. The majority of nitrogen oxides (NO) are found in the exhaust and flue gases from fossil fuel-powered motors, combustion units, and reactors[9], [10], [11]. Burning fuels like coal, natural gas, fuel oil, gasoline, biodiesel mixes, or gasoline release exhaust gas, also known as flue gas. It may be expelled into the atmosphere through an exhaust pipe, a flue gas. It frequently disperses in a manner known as an exhaust plume downwind. A catalyst in chemistry is a material that starts or speeds up a chemical reaction without changing itself. However, catalysts are neither reactants or products of the reactions; they just take part in them. The temperature at which CO and HC transform into CO_2 and H_2O is lowered using a catalytic converter. Inorganic catalysts work efficiently at high temperature.Catalytic converters typically utilize the copper group of noble metals. Traditional three-way catalytic converters employ platinum, palladium, and rhodium as catalysts since they are valuable noble metals. Issues are Platinum (Pt), Palladium (Pd), or Rhodium as catalysts (Rh) and all have very high prices, extremely constrained sources of supply, and constrained future availability.

CO is a flavorless, odorless, and colourless gas that is incredibly deadly. It produces carbon dioxide with a distinctive blue flame and is only mildly soluble in water. It serves as a helpful reducing agent, eliminating oxygen from a variety of compounds, and is frequently employed in the reduction of metals, such as when separating iron from its ore in a blast furnace. Carbon is burned at high temperatures with oxygen to produce carbon monoxide, although carbon dioxide can also decompose to produce carbon monoxide [12], [13], [14]. This deactivation mechanism happens easily because CO is 210 times more attracted to haemoglobin than oxygen. As a result, it replaces oxygen in the blood, starving the body's tissues of oxygen. The symptoms of flu and early CO poisoning are so similar, including headache, shortness of breath, dizziness, disorientation, nausea, and fainting. At high concentrations, there will be vomiting, coma, and eventually brain damage and death. The deadly nature of CO has sparked a lot of interest in the field of heterogeneous catalysis, particularly studies into contact agents that function at room temperature [15], [16]. Because of the simplicity and non-dissociative nature of carbon monoxide chemisorption under typical catalytic conditions, the oxidation of CO has been used quite frequently as a test reaction to determine whether or not a catalyst is active. This process has helped both the development of the electronic theory of chemisorption on catalysts and our understanding of the phenomenon.

The work includes finding correlations between the outcomes of various experimental techniques and advancing our understanding of the reactions that take place on the surfaces of noble metal catalysts supported on copper carriers [17], [18], [19], [20], [21], [22]. The aim of the work is to learn new information about propene's role in the selective catalytic reduction of NOX. Reaction processes, as well as reaction intermediates and products, have been examined in this work since understanding their kinetics and mechanisms is essential for the development of SCR catalysts and reactors. Deriving feasible reaction pathways for NO reduction by hydrocarbons, with propene, in particular, serving as the reductant, was the main objective of the work. The production of intermediates on catalyst surfaces has been observed after research on platinum-loaded coppers [23], [24]. Precious metal-based catalytic converters are prone to a variety of issues. These elements support the potential use of materials based on non-noble metals. Because copper is poison-resistant, we opted to employ it as a catalyst because, with proper application, it might be able to display the desired activity and also give greater durability qualities [25], [26].

Section snippets

Experiment

Investigated CI engine combustion, emission, and performance traits while using our copper catalyst. We discovered that our catalyst offers nearly superior emission performance characteristics than SCR and that the emissions have decreased. An internal combustion (IC) engine is one in which the heat transmission to the working fluid takes place inside the engine, often by the burning of fuel with oxygen from the air [27]. IC engines include compression ignition (CI) engines, often known as

Engine performance

Efficiency is a measurement of engine performance. The following are associated with the engine performance parameters.

Results and discussion

Both with and without a copper catalyst, the engine's indicated power grows linearly as the load rises. However, the readings without a copper catalyst were marginally higher than those with one.

Both with and without a copper catalyst, the engine's brake power improves linearly as the load increases. However, the value of the copper catalyst-free version is somewhat greater than that of the copper catalyst-powered version.

Conclusion

In order to lessen the amount of pollution caused by the engine, this project made use of the copper catalyst reaction method. Finally, the performance, combustion, and emissions of a copper catalyst in a CI engine were looked at and compared to those of an oxidation catalyst. When tested in engines, the performance of copper catalysts is almost the same as that of oxidation catalysts. The brake-specific fuel consumption decreased by 4.5% and 8%, while brake thermal efficiency rose by 5.5% and

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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