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Reduction of Vehicular Carbon Monoxide Emission using Iron, Alumina Catalysts and Cerium Oxide

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Abstract: *The pollution caused by emissions from fairly used vehicles has been a serious concern to the wellbeing of people and environmental degradation is also a major concern that requires urgent attention to the outflows controls of polluted emissions from vehicle motors. This research was aimed to reduce the outflows of Carbon monoxide (CO) emissions from vehicle motors. The catalysts and an oxidizer were used to control vehicular emission. It was observed that, both iron and alumina catalysts with cerium oxide reduced the amount of carbon monoxide produced by the exhaust vehicle emissions. The emission of Carbon monoxide (CO) reduced significantly from 297ppm to115ppm in 120minutes as the concentration of cerium oxide increased from 15-30g with alumina catalyst and 297ppm to120ppm in 120minutes with Iron catalyst. Therefore, there are significant reduction in carbon monoxide outflow to the environment with the two tested catalysts and cerium oxide, though alumina catalyst performing better than Iron catalyst.*

Keywords: Alumina Catalyst, Cerium Oxide, Carbon Monoxide, Emissions, Environment, Iron Catalyst

INTRODUCTION

Air pollution is the release of heterogeneous mixture of gases and particulate matter into the atmosphere as pollutants that affect the quality of air in the environment causing harm to organisms, plants, properties and climate (Carlos *et al.*, 2011). Air pollutants such as carbon monoxide, carbon dioxide, oxides of nitrogen, oxides of sulphur, particulate matter, noise and volatile organic compounds such as benzene, polycyclic hydrocarbons are caused mainly by anthropogenic sources (Yang *et al.*, 2013; Mohammed *et al.*, 2016). Carbon monoxide (CO) is one of the criteria pollutants that is widely distributed in air through emissions. It is a tasteless, colourless, odourless, non-irritating but highly harmful gas when inhaled. The properties of CO make it difficult to detect when mixed with other gases, hence, causes harm to human body by displacing oxygen in the blood and deprives vital organs of oxygen (Akinyemi and Usikalu ,2013; Balan *et.al.*, 2017; Obanya *et al.*, 2018). There are approximately 15,000 intentional CO poisonings annually, accounting for over two-thirds of reported deaths (Hampson and Bodin, 2013; Hampson, 2016).

United State environmental protection agency (USEPA) stated that the annual global emissions of carbon monoxide into the atmosphere were estimated to be as high as 2600 million tonnes, of which about 60% are from human activities and about 40% from natural processes. Anthropogenic emissions of carbon monoxide emanate primarily from vehicular exhausts of internal combustion engines due to incomplete combustion of carbonaceous materials. Most developing countries are faced with the challenges brought about by technological advancement which had caused an uncontrollable change in the environment along with an alarming increase in the pollution. Pollution from motor vehicles has become an issue simply because of the steady increase both in the number of vehicles in use and the distance travelled by each vehicle each year, as a result of these increases, the use of motor vehicles now generates more air pollution than any other single human activity (Komolafe *et al.*, 2014; Oderinde *et al.*, 2016).Vehicular exhausts may contain as much as 100,000 ppm of CO (Widdop, 2002). Exposure to 70 ppm may lead to carboxyhemoglobin (CO-Hgb) levels of 10% at equilibrium (approximately 4 hours) (Raub and Benignus, 2002; Tomaszewski *et al.*, 2002).

Nigeria is a developing country threatened by traffic emissions aside the oil pollution and general industrial pollution (Magbagbeola, 2001). This is as a result of high vehicle population which most of them are fairly used or old. The Nigerian Bureau Statistics (NBS) reported vehicle population of 11,653,871 as at Q1 2018 which leads to environmental impact with major contribution to output of CO emissions in most part of Nigeria. Hence, the reduction of CO becomes a major concern. Several measures have been put to place to combat the release of CO in automobile to the atmosphere such as improvising engine design and fuel pre-treatment (Mukherjee *et al.*, 2016); adoption of producing body cars light in weights to minimize the fuel consumption (Abdelati and EL-Bourawi, 2010); the use of methanol as additives in various percentages in gasoline (Mallikarjun and Mamilla, 2009); use of molecular sieve (Balan *et al.*, 2017); catalysis of carbon monoxide oxidation (Snytnikova *et al.*, 2007; Cam Loc *et al.*, 2015). Among these ranges of options available catalytic converter is found to be a better way for establishing an efficient combustion in the controller engine of the vehicle , though, the techniques are still under development owing to some of its limitations which are needed to be dealt with but the application of this technique has better achievement points (Mukherjee *et al.*, 2016). A catalytic converter is a simple device that uses basic oxidation and reduction reactions to convert around 98% of the harmful pollutants produced in an internal combustion engine into less harmful gases. It requires a catalyst and an oxidizer to convert CO and unburnt hydrocarbons to carbon dioxide and water. Cerium oxide is a versatile reducible oxide with a wide range of publications in catalysis (Cam Loc *et al.*, 2015). Under low oxygen conditions releases its stored oxygen to increase the oxidation efficiency of CO and Hydrocarbon (HC). It allows the catalyst to operate efficiently under suitable conditions. The aim of the present study is to compare the use of alumina and iron catalysts and cerium oxide as an oxidizer with varying concentrations to reduce the emission rate of CO from automobile exhaust.

MATERIAL AND METHOD

The catalysts (iron and alumina) used in this study was purchased from Afrik Gold Ltd, Cerium oxide **(**C_eO_2) was purchased from Crystal Glass Ltd, Nigeria. All reagents used are of analytical grade.10g of the cerium oxide an oxidizer was dissolved in 5ml of distilled water. 2g of Alumina catalyst was dissolved in 2ml of distilled water and mixed with the resultant pastry mixture of cerium oxide. 10ml of the liquid binder was added into the mixture to obtain a homogenous blend for effective bonding to the wire gauze at a temperature of 30 – 50^0C for about 30 – 40 minutes.

The resultant mixture was plastered on the wire gauze, and dried at a temperature of 70^0C. The wire gauze was shaped into a pipe and placed inside the exhaust pipe of an automobile. The automobile was run for a period of 120 minutes to determine the performance of the oxidizer and catalyst by measuring the outlet emissions. Varying concentrations of the cerium oxide ranging from 15g, 20g, 25g, 30g, was used to investigate its performance using alumina catalyst. The above method was also repeated with same concentrations for Iron catalyst. The monitoring of the carbon monoxide was carried out using CO alarm model No. 900-0146, model name Kidde, EN 50291-2001 KM98848. The test was carried with fairly used four plug vehicle of 2002 model.

RESULTS AND DISCUSSION

Fig. 1 shows the evaluation of the effect of various concentrations of cerium oxide with aluminum catalyst in reduction of carbon monoxide emission.

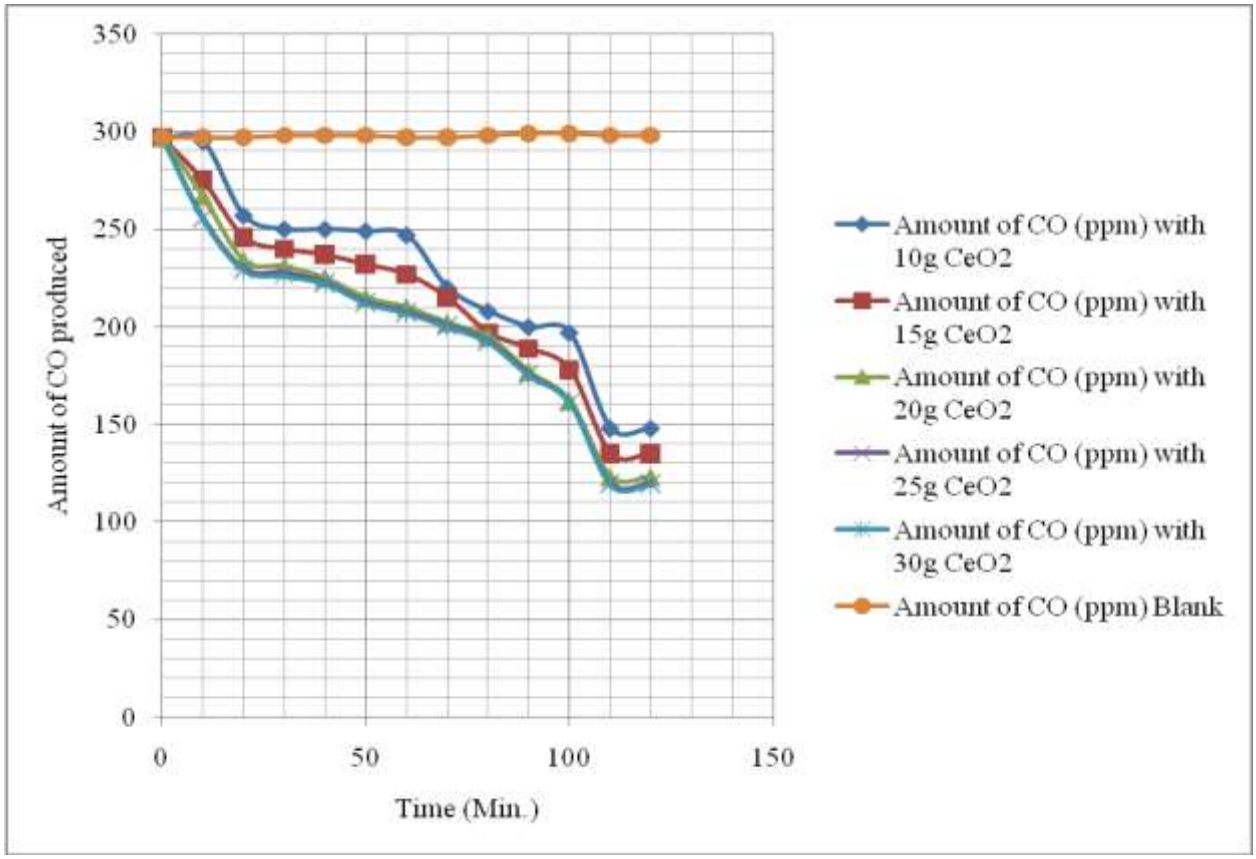

Fig.1 Effect of various concentrations of cerium oxide with aluminum catalyst in reduction of carbon monoxide emission.

The carbon monoxide emitted by the exhaust pipe of the fairly used vehicle using fuel was gradually reduced by the presence of cerium oxide with aluminium catalyst. There are no significant differences between the amounts of CO emitted by 20g CeO_2 to 30g CeO_2 concentration. However, the 20g, 25g and 30g concentrations of CeO_2 gave the highest reduction in CO emitted from 297ppm to115ppm in 120minutes as shown in Fig. 1.

The control/blank which does not contain cerium oxide increased slightly recorded 300ppm at the time of 90minute and remained stable which is the highest amount of carbon monoxide emitted during the experiment Fig. 1.

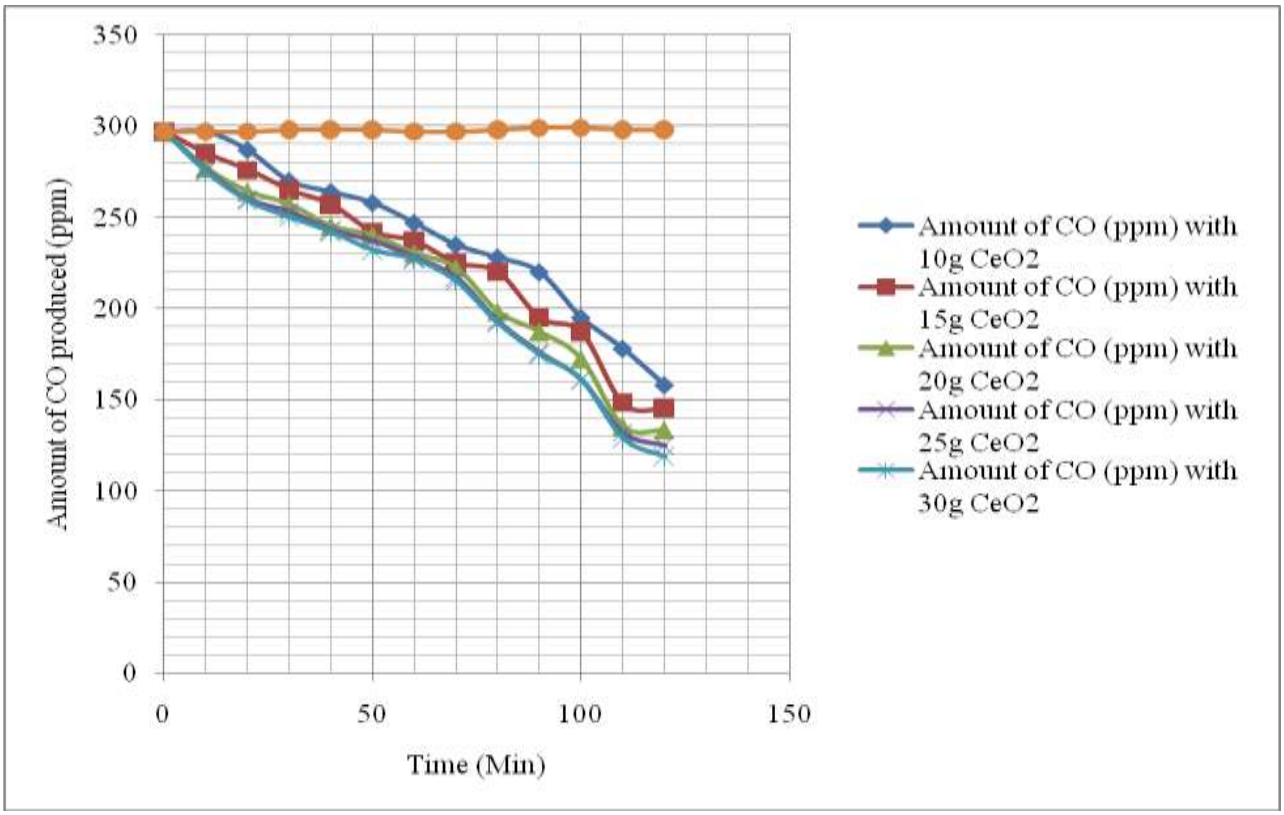

Fig. 2 Performance of various concentrations of cerium oxide with iron catalyst in comparison with blank.

In Fig. 2, the carbon monoxide emitted by the exhaust pipe of the fairly used vehicle using fuel was also gradually reduced by the presence of cerium oxide with iron catalyst. Increase in concentration of CeO_2 (10g-20g) with the iron catalyst decreased the amount of CO emitted. The 20g CeO_2 with the iron catalyst decreased the amount of CO from 297ppm at 0minute to 130ppm at 110minutes. There are no much differences between the amounts of CO emitted by 25g CeO_2 and 30g CeO_2 concentration. However, both concentrations gave the highest reduction in CO emitted from 297ppm to120ppm in 120minutes as shown in Figure 3.2. The optimum performance was observed by 25g CeO_2 concentration. The control/blank which does not contain cerium oxide increased slightly from 297ppm at the time of 0min and recorded 300ppm at the time of 90min and remained stable which is also the highest amount of carbon monoxide emitted during the experiment. This implies that the Cerium oxide (CeO_2) catalysed with aluminum catalyst or iron catalyst have the potential of reducing carbon monoxide emission into the environment by oxidizing the carbon monoxide (CO) to Carbondioxide CO_2.

$$2CO + C_eO_2 \rightarrow 2CO_2 + C_e \quad (1)$$

In comparing the two-catalyst performance from the analysis in Fig. 1 and Fig. 2, the aluminum catalyst performed a little better than the iron catalyst between the time of 110minutes to 120 minutes.

CONCLUSION

The wellbeing and environmental degradation is a major concern that requires urgent attention to the outflows controls of polluted emissions from vehicle motors. Experiments have been conducted to reduce the outflows of CO emissions from vehicle motors. The catalysts and an oxidizer have been proven to control vehicular emission, it is concluded that, both iron and alumina catalysts with cerium oxide reduced the amount of carbon monoxide produced by the exhaust emissions. Though, it was observed that, the emission of CO reduces significantly from 297ppm to 115ppm in 120minutes as the concentration of cerium oxide increases from 15-30g with alumina catalyst and 297ppm to120ppm in 120minutes with Iron catalyst. The optimum performance was recorded by 25g of the alumina catalyst giving 115ppm in 120minutes and also 25g of Iron catalyst giving 120ppm in 120minutes. This indicates that alumina catalyst is a better catalyst in this study.

CONFLICT OF INTEREST

We hereby state that no conflict of interest will arise in any form from the publishing of this research work.

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