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Cu-Al OXIDE NANOCOMPOSITE-BASED EXTERNAL FILTERS FOR GAS PURIFICATION FROM PETROL AUTOMOBILE EXHAUST

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Currently existing exhaust gas catalytic converters in automobiles are expensive because they use precious metals, such as Pt, Pd, and Rh, as active components in conversion catalysts. However, they are unable to convert all toxic gases (e.g., CO, NO_x, and hydrocarbons) into less harmful pollutants before emission to the atmosphere. This is more so in case of automobiles with old petrol engines and fuel types (standard unleaded petrol) causing air pollution. In this work, equimolar copper–aluminium oxide-based nanocomposites devoid of precious metals were prepared using cost-effective wet chemical methods rendering a nano crystalline-amorphous catalyst matrix and tested for NO_x reduction. An external filter with the proposed catalyst was developed and used at the tailpipe of a 350 cc petrol engine to assess the impact on exhaust gas emissions. We also studied the growth and composition of chemically stable composite and analyzed their functional properties using X-ray diffraction, adsorption, and gas chromatography. Nanocomposite was dip coated on ceramic honeycomb substrates and mounted inside welded casings to fabricate an external filter. Emission tests were carried out with and without the exhaust filter. A reduction in NO_x along with that of CO and hydrocarbons from the flue gas by about 45, 12, and 32%, respectively, was obtained when the tailpipe emissions were treated at ambient conditions. To the best of our knowledge, this is one of the primary studies on a simple and well-designed Cu-Al oxide nanocomposite matrix for three-way catalysis during exhaust flue gas treatment.

KEY WORDS: *Cu-Al oxide nanocomposite, three-way catalyst, ceramic honeycomb structure, gas filter*

1. INTRODUCTION

Air pollution levels remain dangerously high in many parts of the world. Data from the World Health Organization (WHO) showed that nine out of ten people breathe air containing high levels of pollutants. As per their estimation, a staggering seven million people die every year from exposure to polluted air and the impact is next to tobacco smoking among the non-communicable diseases (Hanna et al., 2019; Alberto et al., 2019). The transportation sector has been responsible for ~ 25% of air pollution around the world and is the second major contributor (Alberto et al., 2020; Gregor et al., 2014; Maione et al., 2021; Sarath et al., 2014). In India and the U.K., almost 50% and 25% of the pollution, respectively, is reported due to petroleum-based products (Gove et al., 2020). They are also one of the major cause of pollutions in Europe (Balaram, 2020). During combustion of fuel in the automobile engine, exhaust gases are produced containing carbon monoxide (CO), nitrogen oxide (NO_x), and unburnt hydrocarbons (HCs) that are harmful to humans, animal health, and the environment. These are released to the atmosphere and in significant quantities during incomplete combustion.

Presently, vehicles are equipped with catalytic converters that have gas conversion catalysts, which are a mix of precious heavy metals and metal oxides. Though the catalytic converters are reducing the level of pollution in flue gas emissions, the active ingredient of the catalysts, namely heavy metals, pose a further challenge during disposal. These metals are expensive and extremely harmful to the environment (Soham et al., 2018). Over the years, researchers have come up with methods to replace them with cheaper and more environmentally friendly components (Liu et al., 2005; Mohiuddin, 2015; Zhang et al., 2011). George et al. (2019) studied zeolite/CuO–based nanocomposites for CO and smoke reduction by > 50% in exhaust emission. Kruczynski et al. (2021) fabricated an Ag/Al_2O_3-SiO_2–based composite for NO_x reduction in emission from compression engine exhaust. Despite the fact that these efforts yielded significant success in understanding controlled growth, morphology, and composition of CuO- or Al_2O_3-based catalysts and their properties, the structure–property relationships with regard to tailoring peak gas conversion temperatures have not been adequately explored for three-way catalysis. The temperature of the exhaust gas from a vehicle varies greatly based on the utility, and it has been a challenge to find appropriate materials that could yield good conversion in a range of temperatures and oxidation conditions (Fritz and Pitchon, 1997).

In this study, a Cu-Al oxide-based nanocatalyst with the potential to work for three-way catalysis toward automobile exhaust gas conversion was developed. The nanocomposite was prepared by wet chemical synthesis, and the pH of the medium was varied in the procedure for surface functionality changes for optimum performance. Literature is available on copper oxide for NO_x reduction reactions (Bahrin et al., 2016; Bereketidou et al., 2012; Chiang and Lin, 2017). However, use of earth abundant metal oxide nanocomposite catalysts devoid of precious metals for exhaust filter design and fabrication, and their emission control testing have not been reported. Again, in catalytic converters, the core or substrate is often a ceramic or stainless steel honeycomb structure that increases