EMISSION, HEALTH EFFECTS, AND CATALYST USED FOR REMOVAL OF VOLATILE ORGANIC COMPOUNDS (VOCS) FROM VEHICLES

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ABSTRACT -Air pollution from vehicles is a fast-growing problem which has negative effects on the health of thelivingbeings and also on the environment. The problem of air pollution in the developing countries is a major concern as it causes deaths of thousands of people and loss of money in medical cost. Air pollution presently is a veryserious environmental problem in India. Volatile organic compounds (VOCs) released are one of the foremost contributions to air pollution.The main source of emission of VOCsis Vehicular exhaust. These VOCscontribute to the formation of photochemical smog and also cause many health-relatedproblems.therefore, it is necessary to control and minimize the release of VOCs into the environment.Catalytic oxidation is an attractive method to control the VOCsemission. This paper highlights the effects of VOCs on human health, natural environment and measureto control the release of VOCs.

***KEYWORDS*: Air pollution, VOCs, Health effects, catalytic oxidation**

INTRODUCTION

"Air pollution refers to the contamination of the earth's environment with constituents that have considerable effects on human health". The quality of life or the natural environment gets affected when pollutants accumulate in the air at higher concentrations [1]. Vehicles emissions have become the main source of air pollutants including carbon monoxide, lead, nitrogen dioxide, sulfur dioxide, particulate matters and volatile organic compounds (VOCs) [2].The concentration ofVOCsis considerable among these exhaust pollutants."VOCs are a compound of carbon, excluding carbon monoxide,Carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammoniumcarbonate, which participates in atmospheric photochemical reaction" [3].VOCs easily evaporate at room temperature. They contribute both indirectly or directly to theenvironmental pollution. They act as ozone precursors in an indirect way and directly as toxic substances to the environment [4].VOCs are of specific concern due to their harmful nature and their tendency to spread over avast area through theair [13].

In China, Research study shows that the vehicle emission contribution of hydrocarbons concentration about 72% of the total hydrocarbon emission (0.36 million tonnes, including natural and anthropogenic sources) and the car's contribution is 44% of the total vehicle emission in the city [8].

VOCsin addition to the transportsector is also released from other sources such as industrial sources, indoor sources,and transport sources [11]. An example of Industrial sources which release VOCsispetroleum refineries, chemicalplants, pharmaceutical plants, food,and textile manufacture, electronic component manufacture. Printers, insulating materials, solvents,and cleaning products, pressed woods, restaurant and home cooking, are the example of VOCs emission from indoor sources [5].Type and nature of the VOCs depend on the source ofemission [4].

Approximately 235 million tonnes of VOCs are released per year into the environment. In the USA, 40% of the VOCs emissions are emitted from transportation actions and the remaining 60% result from stationary sources [3].

The best method to control the VOCs pollutants is eliminated them earlier to the discharge. At the same time, various technologies, such as thermal combustion, catalytic combustion, adsorptive recovery, biofiltration,absorption have been employed to remove VOCs [7]. Among them, low-temperature catalytic oxidation has been proven to be one of the most reliable and effective post-treatment technology [9]. Catalytic oxidation offers several benefits in comparison to thermal oxidation, especially with low VOCs contents [14]. The most important is cost savings, cleanness of the process, and small size. In addition, the quality of catalysts has been significantly enhancedand newer noble metal catalysts offer a life of more than 15 years [10].

SOURCE OF EMISSION FROM VEHICLES

VOCs are emitted by vehicles in three ways normally as tailpipe emissions, as evaporative emissions, and from vehicle equipment. Tailpipe emissions, which consist of unburned fuel vapor and the VOCs generated by fuel combustion during vehicle operation. Evaporative emissions, which result from the escape of fuel vapor from vehicles while they are running or not running and as the release of VOCs from vehicle equipment, which includes plastic panels, leather seats, rubber tires etc. [6]. Evaporating gasoline is amost abundant contributor to this type of emission [15]. The amounts of VOCsreleased from vehicle equipment were considerable only for new cars and reduced with time. However, the VOCs emissions from vehicle tailpipe exhaust and evaporation could rise with the time. Hence, for a large number of in-use vehicles, the VOCs emitted into the atmosphere from vehicle tailpipe exhaust and evaporative emissions are more significant [6]. Gasoline-related emissions both gasoline exhaust and gas vapor contributed 52 % to the total amount of VOCs released in Beijing [16].

HEALTH EFFECT OF VOCS

VOCs are very harmfulto both humans and the environment. At higher concentration, indoor VOCs are considerably more harmful than their concentration in outdoor [17]. Some example of the health effects ofVOCsincludes irritation of the eyes, nose, throat, and skin. A headache, nausea, dizziness, fatigue,and shortness of breath also may occur [4]. Halogenated hydrocarbons, alcohols, aldehydes, aromatics, alkanes, ketones, olefins, ethers, esters, paraffin's and sulfur-containing compounds are an example of VOCs [4]. Health effects vary depending on the chemicals involved and the duration of the exposure [15].Carbonyls can irritate human eyes and lungs. BTEX (benzene, toluene, ethylbenzene, o-xylene, m-xylene, and p-xylene) can excite the respiratory system and causes central nerve injury. Formaldehyde, acetaldehyde,and benzene can increase the risk of cancer [16]. Benzene alone also is very harmful to humans, it disturbs the reproductive, immune, cardiovascular, and nervous system [17]. Hexane and toluene are associated with health risks to the respiratory system [18].VOCs can also damage crops and reduce agriculture yield [16]. VOCs and NO_x are the foremost chemical precursors of ground-level ozone in the presence of sunlight. But VOCs play a major role in forming ground-level ozone when the VOCs / NO_x ratio is high [18]. The concentration of ozone in theatmosphere is increased due to therelease of VOCs [15].

CATALYST USED FOR OXIDATION OF VOCS

"A catalyst is a substance which accelerates reactions by lowering the activation energy needed at the start of the reaction" [19]. The catalytic converter is used to convert harmful pollutants into less harmful emissions before they leave the vehicle's exhaust system with the help of a suitable catalyst [21].

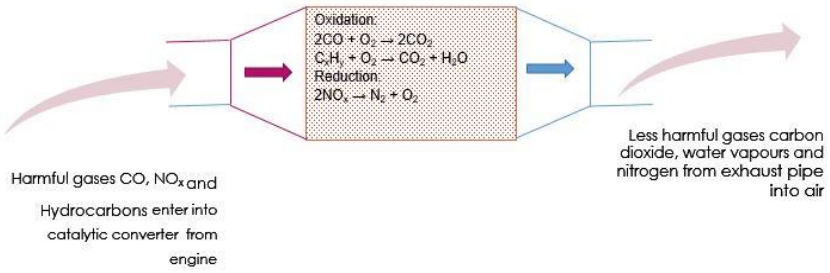

Fig 1: oxidation and reduction reaction in the catalytic converter [21]

Various combination of metal oxides and supported metals are used to get complete oxidation [12]. Selection of catalyst depends upon thevarious factors like nature of pollutants, cost, availability.Noble metals are a most used as a catalyst for environmental protection against the VOCs due to higher activity [14],but they also have limitations like high cost and poor stability, particularly inthe presence of Cl_2 and HCl. Supported transition metal oxides of chromium, manganese, nickel, copper, and cobalt and other acidic oxide materials such as zeolites and TiO_2/SiO_2 are also used [19]. In view of economic prospects and more resistant to poisons, they have advantages over the noble metal catalyst [13]. But in general, they have low activity as compared to the noble metal [19]. Among metal oxides,Perovskites have also occupied a good role as a total oxidation catalyst but major limitations of these are lower surface area and a higher tendency to sinter [13].

Several factors influence the catalyst activity like active phase, surface area, loading, dispersion of active compound and promoters. VOCsstructure is also animportantfeatureinperspective of catalytic oxidation. reactivity of VOCs with different functional groups for total oxidation varies as:

alcohols > aromatics > ketones >carboxylic acids > alkanes [14].

Different type of support on which catalyst is dispersed also play a significant role in catalyst activity. Most supports are applied on the surfaces of a honeycomb-like monolithic block [19].

Type of catalyst is also important for total oxidation of VOCs. For example, palladium is more active for short chain hydrocarbon and platinum is more active for long-chain hydrocarbon and aromatic compounds [14].The activity of catalyst also affected by the catalyst loading on the support, theaddition of other metal and metal oxides, and thecombination of different catalysts. The combination of platinum and rhodium provides ahigh reaction rate at a lower temperature with less formation of NO_x. The addition of CeO_2 in thecatalystis also promoted oxidation of some VOCs like benzene. Figure 2 shows the effect of varying amount of platinum catalyst with a fixed amount of rhodium on theconversion rate of benzene oxidation on Al_2O_3 support. It is observed that with anincrease in platinum loading at fixed temperature conversion rate increased [21].

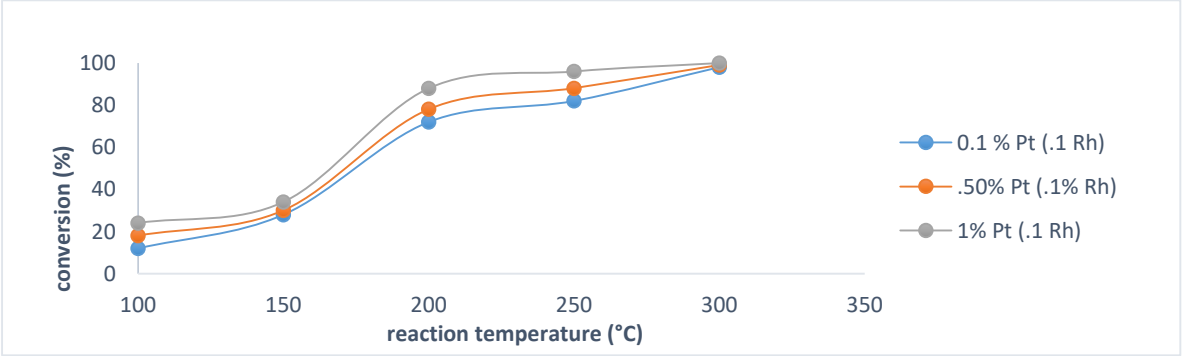

Fig 2: Effect of varying amount of platinum catalyst with a fixed amount of rhodium on conversion rate [21]

CONCLUSION

Volatile organic compounds (VOCs) from the vehicles are agreat contributorto anincreasein airpollution and related to photochemical smog, ground-level ozone and also cause health problems like eye irritations, nausea, headache, and respiratory infections and nerves system failure. Some of them may even becarcinogenic. Many techniques are used to remove the VOCs such as thermal combustion, catalytic combustion, adsorptive recovery, absorption, and biofiltration but catalytic combustion is the best way to remove the VOCs at low temperature. The different catalyst is used in catalytic combustion but platinum group metals (Pt,Pd,Rh) have been proved best for removal of VOCs.

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