ATOMIC ACTIVITY OF NANO-PARTICLES FOR VEHICULAR POLLUTION CONTROL

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ABSTRACT

The catalyst increases the rate of reaction by adsorption of reactants in such a form that the activation energy for reaction is reduced far below its value in uncatalyzed reaction. Copper metal is selected for the present work as it is cheaper than platinum, palladium and rhodium also it adsorbs the reactants molecule strongly enough to hold and active the reactants but not so strongly that the product can't breakaway also the diffusion of reactants and products into and out of the pore structure of copper took place efficiently. Due to this, the pollution level for the exhaust emission of S.I. engine has found to be reduced which is better with nano-sized catalytic converter. Catalytic converters based on spray of copper nano-particle on copper sieve demonstrate superior performance. Nano-particle exhibit high temperature stability beyond that normally encounter in catalytic converter applications. Catalytic converter based on spray of copper nano-particle on copper sieve demonstrates superior performance. Nano-particle exhibit high temperature stability beyond that normally encounter in catalytic converter applications. Nano-particles less than 3–5 nm in diameter are catalytically active for several chemical reactions. We discuss the origin of this effect, focusing on the way in which the chemical activity of nano-particle may change with particle size. We find that the fraction of low-coordinated Au atoms scales approximately with the catalytic activity, suggesting that atoms on the corners and edges of nano-particles are the active sites. This effect is explained using density functional calculations. The aim of this work was to review and synthesize the existing knowledge on ultrafine particles in the air with a specific focus on those originating due to vehicles emissions. As the first step, the review considered instrumental approaches used for nano-particle monitoring and the differences in the outcomes they provide. This was followed by a discussion on the emission levels of nano-particles and their characteristics as a function of vehicle technology, fuel used and after-treatment devices applied. Specific focus was devoted to secondary particle formation in urban environments resulting from semi volatile precursors emitted by the vehicles. The review discussed temporal and spatial variation in nano-particle concentrations, as well as particle chemical composition *and relation with gaseous pollutants. Finally, the review attempted to quantify the differences between nano-particle concentrations in different environments.*

Keywords: Environment, Nano-Particles, Reaction

INTRODUCTION

Catalysts are widely used in the large-scale manufacture of chemicals and in the production of fine chemicals and pharmaceuticals. Fuel processing is a good example: the gasoline that we use in our cars requires at least ten different catalysts during its transformation from crude oil. Environmental technologies also rely heavily on catalysts; the best known example being the catalytic converter in the exhaust of every car. It is estimated that more than 20% of the gross national product (GNP) of industrial countries relies in one way or another on catalysis [Gilmour et. al., 2004]. In heterogeneous catalysis, the reacting molecules adsorb on the catalytically active solid surface. Chemical bonds are broken and formed on the surface and eventually the products are released back into the liquid or gas phase. Many of the heterogeneous catalysts used in industry today consist of small particles of a catalytically active material, typically with a diameter of 1–10 nm, anchored on a porous support. The use of nano-particles results in a large contact area between the active material of the catalyst and the surrounding gas or liquid phase. This ensures that the catalytic material is used effectively. One of the interesting scientific and technological challenges associated with the use of nano-particles as catalysts is the understanding of how the composition and atomic-scale structure of nano-particles produce the best catalytic activity. The second challenge is to synthesize these particles with maximum control over the composition and structure. Modern nanotechnology methods clearly offer great potential for future developments in both characterization and synthesis of heterogeneous catalysts based on supported nano-particles. Maximizing the surface area is not the only reason for using nano-particles as heterogeneous catalysts. Au is usually considered Natural sources and processes, as well as those resulting from anthropogenic activities have attracted an increasing level of interest in the last decade. Therefore, the aim of this work was to review and synthesize the existing knowledge and to draw conclusions as to the picture emerging with regard to these particles in atmospheric systems. Out of the two main outdoor anthropogenic sources, this paper is focused on vehicle emissions, while the companion paper targets industrial and power plants as sources of UF particles. Not included in this review is the contribution of biomass burning (controlled and uncontrolled fires), and incineration of refuse to local or global UF particle concentrations. Both are topics for independent reviews. Vehicular emissions consist of Carbon dioxide, Carbon monoxide, Nitrogen oxide, hydrocarbons including lead, particulate matter etc. Inhaling of Carbon monoxide hinders Oxygen supply from blood into the tissues, as it combines with the Iron in hemoglobin, leading to variety of ailments, viz. Cancer. Carbon dioxide causes environmental problems related to global warming. The past century has seen a dramatic increase in the atmospheric concentration of heat-trapping gasses, due to human activity. If this trend continues, scientists project that the earth's average surface temperature will increase between 2.5°F and 10.4°F by the year 2100. One of these important heat-trapping gasses is carbon dioxide (CO_2). Carbon mono-oxide (CO) is considered as toxic pollutant, whose effective reduction can be achieved by using catalytic converter [Ferin et. al., 1995]. Inhaling of Carbon monoxide hinders Oxygen supply from blood into the tissues, as it combines with the Iron in hemoglobin, leading to variety of ailments, viz. Cancer. A huge amount of research and development activity has been devoted to nano-scale related technologies in recent years. The National Science Foundation projects nanotechnology related products will become a $1 trillion industry by 2015. Nano-scale technology is defined as any technology that deals with structures or features in the nanometer range or that are less than 100 nanometers, about one-thousandth the diameter of a human hair, and larger than about 1 nm, the scale of the atom or of small molecules. Below about 1 nm, the properties of materials become familiar and predictable, as this is the established domain of chemistry and atomic physics. It should be noted that nanotechnology is not just one, but many wide ranging technologies in many technical disciplines including but not limited to chemistry, biology, physics, material science, electronics, MEMS and self-assembly. Nanotechnology is of significant interest because materials at this scale can exhibit novel properties that are different from the same substance's properties at the macro or even micro scales. Nanotechnology is already having a profound effect on a wide range of different sectors and applications, from medicine to packaging to environmental sensors and remediation [Kluwer, 2001]. Nano-structures have the ability to generate new features and perform new functions that are more efficient than or cannot be performed by larger structures and machines. Due to the small dimensions of nano-materials as shown in figure 1, their physical/chemical properties (e.g. stability, hardness, conductivity, reactivity, optical sensitivity, melting point, etc.) can be manipulated to improve the overall properties of conventional materials.

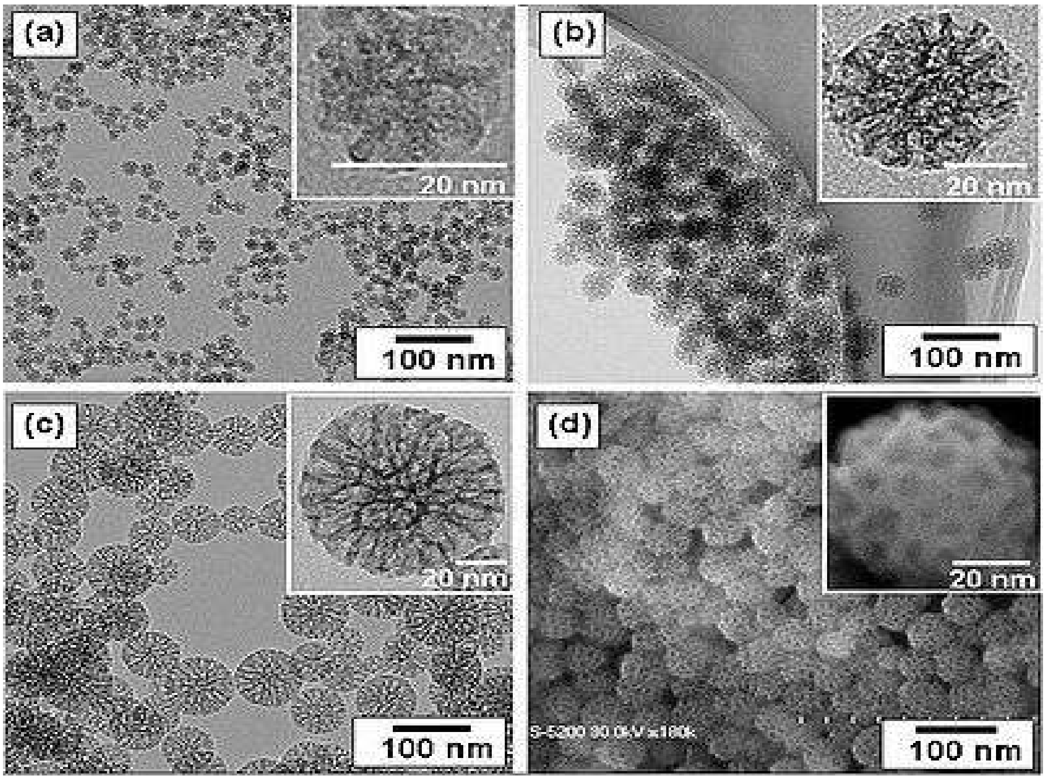

Figure 1. Nano-particles

At nanometer scales, the surface properties start becoming more dominant than the bulk material properties, generating unique material attributes and chemical reactions. Metal nano-particles are being considered for potential use in catalytic converters since the catalytic reactivity is significantly enhanced due to the increased surface area and altered electronic structure of the metal nano-particle coolants utilize nano-particles and nano-powders to increase the efficiency of heat transfer and potentially reduce the size of the automotive cooling equipment. Behavior of materials at nano-scale is not necessarily predictable from what we know at macro-scale. At the nano-scale, often highly desirable, properties are created due to size confinement, dominance of interfacial phenomena, and quantum effects. These new and unique properties of nano-structured materials, nano-particles, and other related nanotechnologies lead to improved catalysts, tunable photo activity, increased strength, and many other interesting characteristics.

METHODOLOGY

In the past few years, considerable interest has been focused on metal nano-particles due to their special properties and potential applications in diverse fields. Among various metal particles, copper nano-particles have attracted considerable attention because of their catalytic, optical, and electrical conducting properties. Several methods were developed for the preparation of copper nano-particles, including thermal reduction, metal vapor synthesis, radiation methods, micro-emulsion techniques, laser ablation, mechanical attrition, and chemical reduction [Samim et. al., 2007]. Nano-material-based catalysts are usually heterogeneous catalysts broken up into metal nano-particles in order to speed up the catalytic process. Metal nano-particles have a higher surface area so there is increased catalytic activity because more catalytic reactions can occur at the same time. Nano-particle catalysts can also be easily separated and recycled with more retention of catalytic activity than their bulk counterparts. These catalysts can play two different roles in catalytic processes: they can be the site of catalysis or they can act as a support for catalytic processes.

They are typically used under mild conditions to prevent decomposition of the nano-particles at extreme conditions. A catalytic converter is a vehicle emissions control device which converts toxic byproducts of combustion in the exhaust of an internal combustion engine to less toxic substances by way of catalyzed chemical reactions. The specific reactions vary with the type of catalyst installed. These were "two-way" converters which combined carbon monoxide (CO) and unburned hydrocarbons (HC) to produce carbon dioxide (CO_2) and water (H_2O). Two-way catalytic converters of this type are now considered obsolete, having been supplanted except on lean burn engines by "three-way" converters which also reduce oxides of nitrogen [Krishna et. al., 2008]

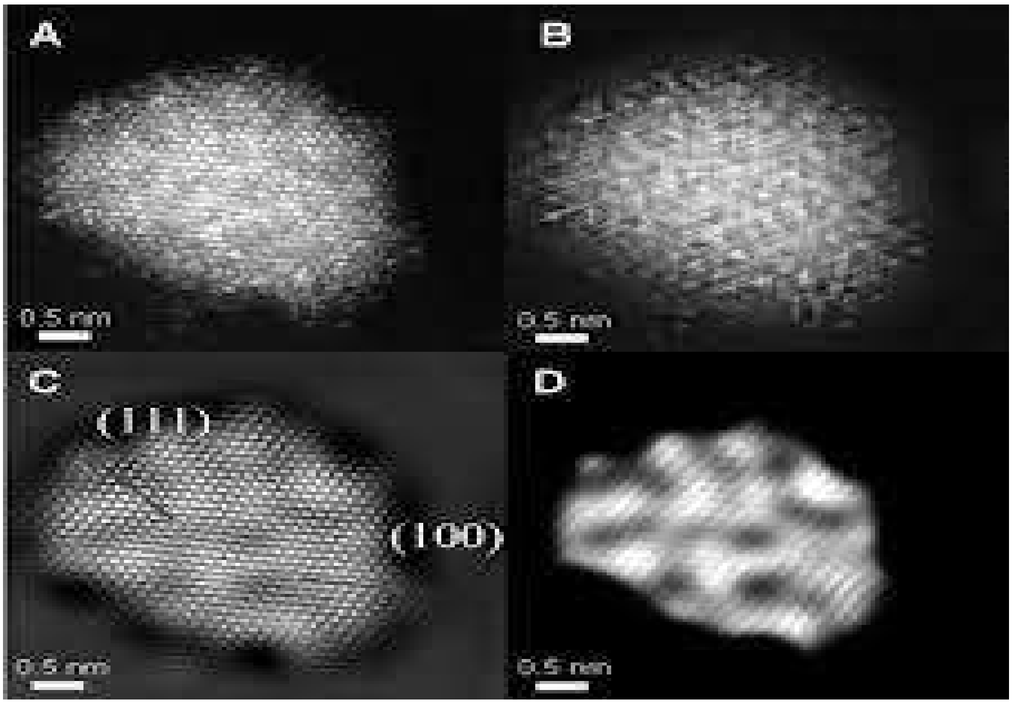

Figure 2. Atomic activity of nano-particles

Catalysis involves the modification of a chemical reaction rate, mostly speeding up or accelerating the reaction rate by a substance called catalyst that is not consumed throughout the reaction [Twigg, 2006]. Usually, the catalyst participates in the reaction by interacting with one or more of the reactants and at the end of process; it is regenerated without any changes [Ritchie et. al., 2009]. There are two main kinds of catalysts, homogeneous and heterogeneous. The homogeneous type is dispersed in the same phase as the reactants. The dispersal is ordinarily in a gas or a liquid solution. Heterogeneous catalyst is in a different phase from the reactants and is separated by a phase boundary. Heterogeneous catalytic reactions typically take place on the surface of a solid support, e.g. silica or alumina. These solid materials have very high surface areas that usually arise from their impregnation with acids or coating with catalytically active material e.g. platinum-coated surfaces [Ferrando et. al., 2009]. Metal nano-catalysts are being used in automobile emission control systems and in other pollution control and treatment applications, to facilitate petroleum extraction and production, and to produce chemicals and chemical products. It is expected that the increased affordability of the use of precious metals in these applications, due to the minute amount needed for each process, will increase overall demand for these metals [Mansoori, 2003]. Catalysts usually have two principal roles in nanotechnology areas: (i) In macro quantities, they can be involved in some processes for the preparation of a variety of other nanostructures like quantum dots, nano-tubes, etc. (ii) Some nanostructures themselves can serve as catalysts for certain chemical reactions. Automotive catalysts use platinum, rhodium and palladium to speed up chemical reactions of pollutants such as nitrogen oxide, carbon monoxide and hydrocarbons, to create non-toxic emission [Foss et. al., 2008]. By using nano-particles of the precious metals instead of larger particles; less metal is needed to produce the same surface area over the ceramic base of the catalyst [Rickerby et. al., 2008]

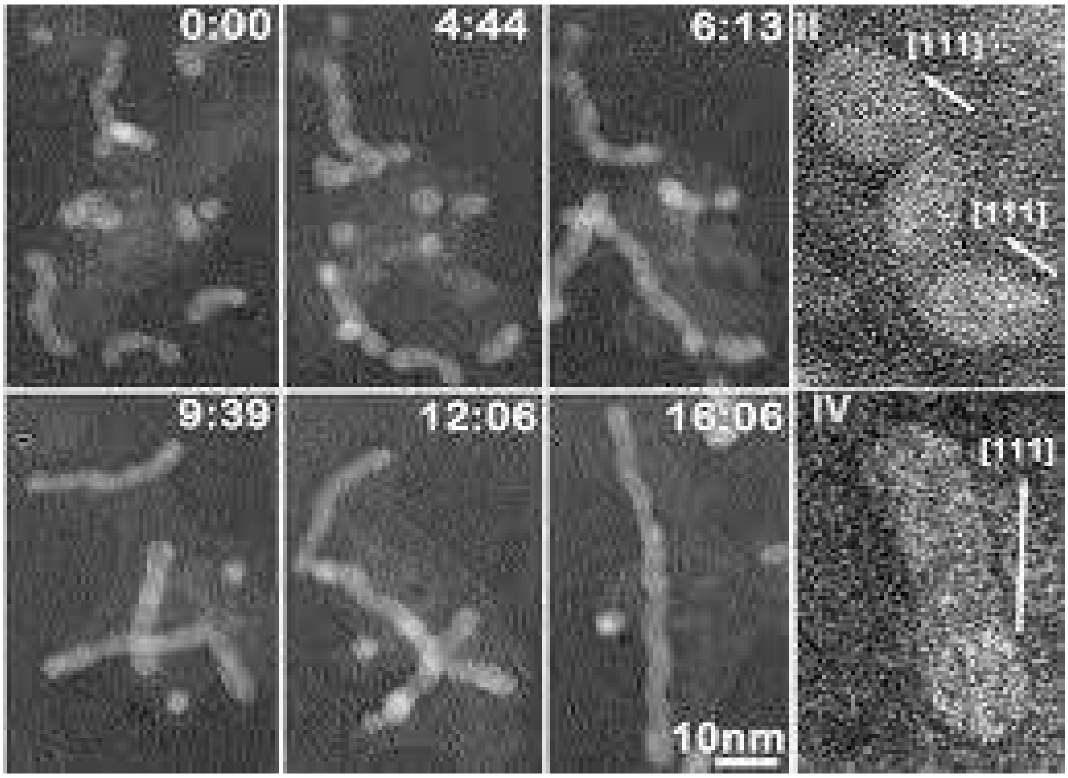

Figure 3. Catalytic activity

CONCLUSIONS

High surface area metal oxides are one of the main components of automotive exhaust catalysts. These metal oxide materials are utilized to physically and chemically enhance the performance of active precious metal particles as support material. These materials are designed to have large surface area, high oxygen exchange capacity, and high thermal stability. The traditional metal oxide materials are prepared through liquid phase precipitation reactions. Traditional liquid phase methods rely on natural crystallization process at or near room temperature conditions to form metal oxide particles. This process is extremely difficult to control. Also, the resulting materials do not maintain high surface area when they are exposed to the extreme temperatures and gas atmospheres present in automotive exhaust. Flame combustion techniques for producing nano-particles also exist. However, flame synthesis can only operate under oxidizing conditions, and at a lower temperature than the plasma based processes described in this invention. Both of these features introduce limitations in the array of materials that can be created. With this novel invention a new technique is introduced to generate metal oxide nano-particles for use as catalyst supports, preferably for use as automotive exhaust catalyst, using a microwave plasma torch. This technology involves passing solid or liquid phase precursor material carried as a wet or dry aerosol by a carrier gas through plasma created from Ar, He or other noble gases.

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