VOLATILE ORGANIC COMPOUNDS, NANOSTRUCTURED MATERIALS FOR CATALYTIC REMOVAL

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ABSTRACT
Using catalytic oxidation to remove volatile organic compounds (VOCs), which pose a major danger to human health, is becoming more popular because of its favourable properties, such as cheap cost, operational safety and environmental friendliness, which make it an attractive option. There has been an explosion in research into the synthesis and use of diverse nanostructured materials over the last several decades, resulting in both huge potential and considerable challenges in the application of these materials for highly effective catalytic removal of VOCs. There are two principal kinds of VOC catalysts now in use: noble metals and metal oxides. We want to highlight the most recent research breakthroughs in nanostructured materials for catalytic degradation of VOCs in order to offer the reader with a cohesive picture of the subject. For the removal of pollutant pollutants from the surrounding environment, this review will concentrate on the synthesis, manufacturing, and processing of nanostructured noble metals, metal oxides, and basic and technological techniques in catalytic removal of volatile organic compounds.

INTRODUCTION
The study of phenomena at the nanoscale scale is known as "nanoscience." Nanometers are the standard unit of measurement for the size of atoms, whereas molecules are measured in the tenths of nanometers or less. In the past, and in the future, we'll be able to create structures with dimensions of only a few nanometers. This is because the resultant When just the structure has a diameter of just a few nanometers and contains only a few atoms close to one another. Transistors, memory components, lights, motors, sensors and pumps are some of the components in these small devices, all of which work together of which are merely a few nanometers in diameter.
In terms of mechanical qualities, carbon nanotubes (CNTs) are extraordinary, notably in terms of tensile strength and weight. The performance of nanotube reinforced composites would be superior to that of conventional carbon fibre composites, which is an obvious application for this technology. An issue preventing CNTs from being widely used in composite materials is the difficulty of organising nanotube tangles enough to take use of their strength. For example, strong CNT-matrix bonds are needed to provide high overall performance and retention during wear or erosion. Smooth and generally unreactive surfaces of CNTs allow them to glide through the matrix under stress. This slippage may be prevented by attaching chemical side-groups to CNTs, thus creating 'anchors.'" The high cost of manufacturing CNTs is a further stumbling block. In spite of this, additional research is anticipated to focus on light, high-strength materials in several transportation applications. Sheets of sp2-bonded carbon organised in a honeycomb crystal lattice make up graphene, an allotrope of carbon. Carbon atoms and their bonds make graphene seem like chicken wire the stack of graphene sheets that make up graphite's crystalline or "flake" form.

Graphene's The length of a carbon–carbon bond is about 0.142 nanometers in length. Because the interplanar space between Graphene sheets is approximately 0.335 nanometers, it would only take one millimetre to stack three million Graphene sheets side by side in a single millimetre. Carbon allotropes include graphite and charcoal, to name a few of examples. Fullerenes and carbon nanotubes are two more carbon allotropes that exist, include graphene as their primary structural component. Flat polycyclic aromatic hydrocarbons may alternatively be thought of as an infinitely big aromatic molecule. Prize winners As a result of their research, Konstantin Novoselov and Andre Geim were awarded the Nobel Prize of Physics in 2010 in quantum gravity "for pioneering investigations into two-dimensional substance graphene." There is a lot of hype around nanoscience, maybe because of the technology's importance (or perhaps because of it). It's been said that computers would become quicker, commodities will be produced more cheaply, and medical discoveries will occur. Tennis rackets, self-cleaning automobiles, paint, food, and cosmetics are all examples of products that are environmentally friendly are just a few of the potential applications for nanotechnology.

Everywhere you look, it's a little bit of everything. Atoms are the building blocks of manufactured goods. The arrangement of the atoms affects the qualities of such products. Diamonds are created by rearranging the atoms in coal. We can create computer chips by rearranging Slightly contaminating the atoms of sand is a good way to do this. Groundwater, air, and water atoms may be used to make grass. Physics, chemistry, biology and medicine all have a role to play in nanotechnology. The natural sciences have their origins in physics. Everything that occurs at the nanoscale may be explained in theory by physics. Nanomechanics, quantum computing, quantum teleportation, and artificial atoms are all active areas of physics study. When it comes to nanostructures, physics can explain everything, but in some cases, The molecular interactions may be better explained in terms of bonds and electron affinity in chemistry.

Molecules and their interactions with each other are the focus of chemistry. Chemistry can be used to practically all aspects of nanoscience since molecules are so small. Carbon nanotubes, self-assembly, DNA-based structures, and supermolecular chemistry are some of the chemical subjects being explored in nanotechnology. When describing a nanostructure's function, a chemical description may not always be sufficient. A virus, for example, is the ideal illustration explained in biological terms. There are occasions when it's compared to nanotechnology that really works. There are a lot of tiny, highly efficient motors in biological systems. Cells include more than 50 different types of motors. Astonishing control systems are created by biological systems. Complex flight patterns are controlled by an insect's small but powerful brain. DNA in a cell the size of a micron can store one gigabyte of information. They are self-sustaining. They build sturdy and durable products. Nanotechnology draws influence from a variety of fields, including biology. Biomimetics is the practise of taking biological principles and applying them to the design of new materials and technology. The use of nanotechnology in medicine is called "nanomedicine." Medical uses of nanomaterials, such as nanoelectronic biosensors, as well as prospective future applications of molecular nanotechnology, are all included in nanomedicine. Nanomedicine is now dealing with challenges linked to nanoscale materials' toxicity and environmental effect.

1.1 Nanomaterials

These materials are called nanomaterials if at least one of its components has a size of less than 100 nm. One-dimensional nanomaterials, such as thin films or surface coatings, have two dimensions in the macroscale but only one in the nanoscale. This category includes some of the characteristics of computer chips. Nanowires and nanotubes are two examples of Materials that are two-dimensionally nanoscale yet also one-dimensionally extensible. Examples of nanoscale materials contain particles such as precipitate, colloids, and quantum dots in three dimensions (tiny particles of semiconductor materials). For instance, nanometer-sized granules may be found in certain of these materials, such as nanocrystalline minerals. These resources range from the long-standing to the really fresh. Due to their greater surface area and quantum effects, nanomaterials have a distinct advantage over other materials. It is possible that these elements will alter or improve such traits as reactivity, strength, and electrical properties. The number of atoms on the surface of a particle increases as its size decreases. These percentages are consistent over the range of nanometers, with 30 nanometer particles having 5 percent of their atoms on their surface, 10 nanometer particles having 20 percent, and three nanometer particles having 50 percent. When dispersing materials, The surface area per mass of nanoparticles is higher than that of bigger particles. Surface-based reactions make nanoparticles significantly more reactive than larger particles because they allow for growth for catalystic chemical reactions to take place.

1.2 Properties of nanomaterials

Quantum effects may take over the characteristics of materials at the nanoscale in combination with surface-area effects. Materials' optical, electrical, and magnetic properties may be altered by these processes, especially when the size of the structure or particle decreases toward the nanoscale. These materials optoelectronics should include quantum dots and quantum well lasers, which leverage these properties. There is a large amount of contact area in materials such as crystalline solids, which may have a significant impact on their mechanical and electrical characteristics. For instance, the boundaries between the grains in most metals restrict or stop the spread of flaws when the material is strained, providing it strength. Most metals. In order to boost the strength of the material, it is necessary to reduce the size of the grains to the nanoscale. Nanocrystalline nickel, for example, has the same strength as hardened steel.

NANOCATALYST: EFFECT OF SIZE REDUCTION

The energy, chemical process, and environmental sectors all depend on catalytic technology now and in the future. Carbon dioxide (CO), hydrocarbons (HC), and nitrogen oxides (NOx) emission control all rely on catalytic reactions. A catalyst must also be present in the electrodes of An electrolyte fuel cell that uses either ionic or polymeric proton electrolytes. The use of low-cost raw materials to produce high-value goods, the use of energy-efficient and ecologically friendly chemical conversion processes, and the implementation of stricter environmental regulations are just a few examples standards are driving the development of enhanced catalysts.

To speed up chemical reactions in solids, gases, or liquids, the right kind of adsorption, reaction, and desorption site must be provided. Catalytic particle size must be lowered to increase the number of sites on the catalyst in order to enhance surface area. Modern laboratories often utilise nanometer-sized particles as active catalysts supported by structural or porous nanometer-sized elements. Individual catalytic particles may be assisted by these multi-component active phases to improve their structure or properties. Reduced particle size influences catalytic efficiency in ways that go beyond just increasing surface area, according to catalysis research. Developing and preparing catalysts in the most efficient manner is another goal.

Nanotechnology has the potential to be used in almost every field imaginable. Any industry that uses electronics, health, or manufacturing, or even fashion, stands to gain from using nanotechnology. The most exciting use of nanoscale technology, however, is the utilisation of nanocrystals as catalysts. Understanding nanocrystal catalysis relies heavily on the concept of surface area to volume ratio. As an object's size increases, the surface area to volume ratio drops. To put it another way, when it comes to volume, smaller items have more surface area than larger ones do. Chemical reactions will be affected by this. Chemical processes benefit from high surface-to-volume ratios. Starting a fire using kindling is similar to starting a campfire. The surface area per unit volume of smaller logs is higher than that of bigger logs.

The sooner the kindling is ignited, the faster the fire will burn. If you toss some sawdust into the flames, you'll get an enormous flare. Chemically, this process is equivalent to the burning of wood, although it happens quicker. Catalysts are often used to speed up a chemical process. The chemical system's thermodynamic characteristics are unaffected by this process, which is carried out by kinetics. It is possible to improve reaction rate in three ways: lowering the activation energy, acting as an intermediary to facilitate the assembly of reactive species, or boosting the yield of a single species when multiple products are produced. One or more of the methods outlined above may be used to include nano-catalysts. For two reasons, they outperform conventional catalysts. Surface area to volume ratio is high because to their small size (10–80 nm on average). It is possible to make materials at the nanoscale may attain qualities that are not present in their macroscopic counterparts. Nanocatalysts' adaptability and efficiency may be attributed to any of these two factors.

2.1 Applications of nanocatalysts

Several chemical processes benefit from the employment of nanoscale catalysts in the age of nanotechnology, which involves shrinking objects' sizes while simultaneously improving their qualities. In this area, we're attempting to gather all of the recent literature on the use of nanocatalysts.

2.1.1 Carbon nanotubes

NCMs, in particular carbon nanotubes (CNTs), have piqued researchers' curiosity because of their remarkable mechanical and physical properties. Field emission sources Batteries made of lithium ion (Li-ion), electric double-layer capacitors, fuel cells, and molecular sieves are all examples of this type of technology are all examples of where they've been used. Additionally, CNTs have recently been used to adsorb hydrogen in a device because of their high porosity, low weight, stability, and cost-effectiveness in this application. Hydrogen may easily be taken up by their tubular structure. In the near future, hydrogen may be extensively used as an ideal High energy density and low environmental impact make it an excellent energy carrier. CNTs' hydrogen storage capability has been shown in studies is greatly affected by the material parameters controlled by the production methods. It has been developed by Chang et al. (2008) to prepare NCMs using the Metal Dusting (MD) technique. It hasn't been studied in the literature, but the CNTs created might be used as a hydrogen storage material. CNTs' microstructure and hydrogen storage performance are also examined when acid post-treatment is carried out. To test for hydrogen discharge capacity, an electrochemical technique was used at room temperature and pressure on the manufactured 600 C multi-wall CNTs. For the as-prepared CNTs, it was discovered that 4 hours of post acid treatment in a boiling acid solution efficiently removed metal particles and the formed amorphous carbon. It's possible to get a 104 mAh/g hydrogen discharge capacity as a consequence of this method. Even while it reduces crystallinity, extending the etching time also degrades the CNTs' tubular structure, reducing their hydrogen storage capacity and efficiency. The experimental findings show that MD-produced NCMs might be used to store hydrogen.

2.1.2 Water purification

The chemical industry accounts for 40% of hydrogen's usage, making it the most recent in a long line of energy sources that have benefited society, the economy, and the environment. This shows how valuable H2 is and how high its demand will be, both now and in the future. The reduction of metal catalysts, which is a step in many hydrogenation and other reactions, consumes a lot of hydrogen, apart from the hydrogen used in the reactions themselves. It is thus useful if preparation procedures are available how oxidic or other catalysts may be converted to their metallic forms without the need of hydrogen. Creating nano-metallic silver particles to keep the hydrogen economy strong using innovative electro-chemical deposition methods on carbon-coated alumina substrate was reported by Shashikala and colleagues in 2007. To produce a silver catalyst that is particularly effective in suppressing microorganisms in water, this approach is used. In addition, it is clear that the Ag-supported catalysts may be used again and again. Designing a highly active AgCCA catalyst using Al_2O_3 and carbon has been made easier because to the combination of these two materials' mesopores in the carbon covering, low acidity, and high mechanical strength.

MECHANISTIC STUDIES ON METAL NANOPARTICLE SYNTHESIS AND CATALYSIS

In both the scientific and the industrial worlds, heterogeneous catalysis has garnered a great deal of attention. As a pioneer in the application of surface science approaches to heterogeneous catalysis, Prof. Ertl has helped us understand more about how chemical reactions occur at the surface of materials, was granted the 2007 Nobel Prize in Chemistry demonstrates this point. Because catalysts are used in more than 90% of chemical production processes, heterogeneous catalysis has a significant influence on the global economy. For example, in the exhaust system of a car, catalysts are crucial in the conversion of toxic waste into less damaging compounds. Catalyst design is therefore a major aim, and one that promises to outperform the current trial-and-error procedures. Advances based on basic research in catalysis may have a profound influence on society, even if they are tiny in scale. Progress in catalysis may benefit the economy and the environment because of the vast number of commercial applications. Catalysis discoveries will have the greatest impact on the automotive and power generation industries, respectively, in the near future.

Nanocatalysis is one field of catalysis that is rapidly evolving. In comparison to bulk catalysts, nanoparticle (NP) catalysts have shown strikingly improved reactivity and selectivity as well as new, innovative catalytic characteristics. A thorough knowledge of the nanocatalysts' increased performance is required in order to exploit their full potential. Nanocatalysts have received a lot of attention in experimental research because of their small size. Many additional parameters than particle size and content influence the reactivity of NPs. System dependence may make it difficult to draw firm conclusions on how these characteristics relate to NP catalytic performance, thus more research is needed. It's obvious that avoiding trial and error procedures means having a firm grasp of the parameters that influence catalyst reactivity and selectivity.

For catalysis researchers, gold NPs represent an intriguing model system. For numerous processes, such as low-temperature CO oxidation, partial hydrocarbon oxidation, the water-to-nanometer-sized gold particles have been shown to be very effective in the gas shift process and the reduction of nitrogen oxide when scattered over particular oxides and carbides. It is still unclear how Au NP reactivity works after much research, with the major focus on the oxide substrate's potential function. The following are some recent examples of similar debates in the literature. The reactivity of NPs is mostly determined by the Au atoms in the NPs, according to Lopez et al., whereas the substrate is of little importance. Neither charge transfer from the support's oxygen vacancies nor adsorbate interactions with the interface between nanoparticles and the support are considered important contributors to this activity, according to the researchers. A bilayer of Au on $TiO_2(110)$ is equally as effective for CO oxidation as Au NPs, according to Chen and Goodman's findings in this study. Campbell, on the other hand, contends that the oxide/metal contact may be important even if the Au bilayer does not fully wet the oxide surface. Ultrathin (bilayer) gold films formed on a decreased TiO_2 substrate exhibit activity comparable to those of gold nanoparticles, as was recently reported in a paper by the Goodman group. In this group's view, the essential structural parameter impacting the catalytic capabilities of metal clusters height, rather than diameter; other characteristics such as nanoparticle–support interactions may also have an impact.

NEWLY DEVELOPED ORGANIC VOLATILE CATALYTIC REMOVAL USING NANOSTRUCTURED MATERIALS COMPOUND

A broad variety of health problems, including eye, respiratory tract, and skin irritation, migraines, and pneumonia, may be triggered by long-term The inhalation of VOCs, such as benzene, phenols, formaldehyde, and toluene. Concerned about VOCs, a rising number of individuals are looking for ways to decrease or remove them. A wide range of industrial and commercial enterprises, including gas stations and printing presses, shoemakers, food processors, automobile industries, textile and furniture manufacturers, and chemical plants, are key emitters of volatile organic compounds (VOCs). Volatile organic compounds (VOCs) also make up the majority of chemical contaminants found in indoor air. Solvent, glue, insulation, and cooking and cigarette smoke all emit volatile organic compounds (VOCs) that are frequent indoor sources, according to the Environmental Protection Agency (EPA). In terms of purification, adsorption and degradation are the two most often used approaches. Secondary contamination may occur if the spent adsorbent is discarded. It is possible to use a variety of techniques to degrade materials. Catalytic degradation is the best method for reducing volatile organic compounds (VOCs) because it can oxidise them into CO2 and H2O at considerably lower temperatures, resulting in much more quickly and completely. For the advancement of catalytic degradation, more efficient and long-lasting catalysts are required.

Nanostructured materials are increasingly being studied for their potential to remove volatile organic compounds (VOCs) from the air through catalysis. Researchers are looking at the relationship between performance and the physicochemical properties To reduce the temperature necessary for full oxidation of volatile organic compounds (VOCs) by using nanomaterials. Nanomaterials, such as supported noble metals and transition-metal oxides, aid in the oxidation of volatile organic compounds (VOCs). In spite of their strong catalytic activity for VOC oxidation, nanostructured noble metals are limited in their use owing to the costly cost. In order to lower the overall metal loading on supporting substrates, the catalytic performance per unit of noble metal is becoming increasingly important. In contrast, nanometer-scale transition metal oxide catalysts for VOC oxidation, which are becoming more and more efficient, are being replaced by noble metals. Catalytic oxidation of volatile organic compounds (VOCs) at room temperature has been significantly improved because to the hard efforts of scientific communities throughout the globe. For the sake of providing readers with an organised and unified picture of this topic, we have chosen to concentrate our review on the synthesis, characterization and possible uses of supported noble metal and transition-metal oxide materials that have various nanostructures. In the last several years, a great number of these studies have been done, particularly by the writers working in diverse laboratories. Some insights on how future improvements in the use of nanostructured noble metals and transition metal oxides for VOC removal will be impacted by the accumulation of major potential and issues. Improved environmental cleanup technologies are expected as we get a better grasp of VOC catalytic oxidation's fundamentals.

METHODS FOR THE SYNTHESIS OF CATALYSTS

5.1 Creating nanostructured noble metals is possible using these techniques.

5.1.1 Reduction of metal salts

The reduction of metal salts is the most common method for producing metallic nanoparticles. An important factor in particle production occurs throughout the synthesis process and includes the use of various synthesis media. These include organic solvents, microemulsions, aqueous solutions, appropriate reducing agents, and surfactants. The final particle size, morphology, homogeneity, and dispersion are all strongly influenced by the synthesis medium used throughout the process. Examples include Yang et aluse's of To produce nanoparticles with Pt and Ag cores stellated in a regular pattern and increased activity in the oxidation of methanol, researchers used oleylamine as a reduction agent and capping surfactants as capping agents. Particle size and response time are significantly affected by reducing the number of agents. When reducing agents like hydrogen (H2) and sodium borohydride (NaBr) are used to break down benzene, the resulting TiO_2-supported Pt nanoparticles (Pt/TiO_2) have shown a wide range of catalytic activity ($NaBH_4$). The surface of the Pt/TiO_2 catalysts generated by the reduction of sodium citrate at roughly 160°C has a high concentration of negative charges and chemisorbed oxygen. enabled almost complete benzene oxidation. $NaBH_4$, hydrazine, hydrogen, sodium citrate, certain organic ammonium salts, and polyol are popular reducing agents. When used with a conventional hydrogen electrode at a pH of 14, the reducing potential of $NaBH_4$ is -1.24 V, whereas at a pH of 0, the reducing potential is 0.48 V. For metal salt reduction at any pH, it may be used with either wet or dry medium. When water (H_2O) is the result of the reduction process, one $NaBH_4$ mole may contribute eight electrons, making $NaBH_4$ a very efficient reducing agent. Standard reduction potentials for hydrazine, another extensively used reductant, are -0.23 V in an acidic media and -1.23 volts in a simple medium. In alkaline environments, hydrazine is often used since metals have a standard reduction potential of -1 to any positive number, and a pH of 11 or above is required for maximum hydrazine reduction efficacy. Surfactants, such as polyvinylpyrrolidone, are widely employed to manage particle size and shape, as well as to change or passivate their surface characteristics, in order to avoid agglomeration.

5.1.2 Metal salts decompose in the presence of heat

Deposition-precipitation (DP) and thermal breakdown of Metal salts at high temperatures are another frequent method for creating supported noble metal nanoparticles for the removal of VOCs. For impregnation processes, nitrates rather than chlorides or other metal salts are used since they are rapidly degraded. The precipitant concentration and reaction speed of the DP process will influence the final particle size and shape of noble metals. Shi and coworkers created two kinds of Au/CeO_2 nanoparticles (Au/CeO_2) for using DP for transmission electron microscopy for the oxidation of formaldehyde (HCHO), use urea or NaOH as precipitant. Even at room temperature, it is feasible to obtain a 100% conversion of HCHO into CO_2 and H_2O. when water is present and the gaseous hourly space velocity is large, if urea is used as a precipitant. This is true even when water is present (GHSV, 143,000 h^{-1}). Strong alkali, ammonium hydroxide, and carbonate are other typical precipitants.

5.2 Nanostructured metal oxides may be made using a variety of techniques

5.2.1 Sol-gel method

It is possible to make solid things out of molecules using the sol-gel process. Metal oxides may be made using this approach, in particular silicon and titanium oxides. Colloidal solution is used to create an interconnected network of discrete particles, or network polymers (sol). To generate a progressive solid-phase network, hydrolysis and polycondensation of appropriate molecular precursors are coupled. Metal alkoxides are often used as precursors. Physical variables like as pH, substituent, and solvent influence the reactions. The organic components of the gel must first be removed by drying and calcining it before the final sample can be collected. Alumina (Al_2O_3) and TiO_2 sols were first synthesised separately, then combined, dried, and calcined to produce the final Al_2O_3-TiO_2 substrates for full ethanol oxidation. Al_2O_3-TiO_2 anatase crystals were found to be very stable due to the addition of 5 weight percent Al_2O_3 to the TiO_2 crystals, which was proven to have a significant influence in this. Because of the Al-O-Ti chemical connections, which It is evident that Pd/Al_2 O_3-TiO_2 has a higher activity for total ethanol oxidation than does TiO_2/Pd, and this might be achieved by efficiently dispersing Pd on the Al_2O_3-TiO_2 substrate surfaces.

5.2.2 Combustion at a high temperature

Nanostructured noble metals may be made via the thermal breakdown method, as can metal oxides. By impregnation or DP, metal salts were deposited on suitable surfaces, and then calcined at high temperatures to produce the final metal oxide products. Glycine was used as a fuel for chemical combustion by Babu et al. to produce nanoparticles of CeO_2. In double-distilled water, cerium nitrate and glycine were dissolved. A heated plate was used to evaporate the mixture, resulting in a fine powder. The mixture was then heated to 300°C to ignite the fuel, causing the decomposition process to begin. To produce CeO2 nanoparticles, the resultant powder was centrifuged, cleaned, and dried. For the first time, the catalysts Pt/SiO2 were synthesised using flame spray pyrolysis (FSP) utilising the precursor SiO2 tetraethoxysilane (TEOS). TEOS and platinum acetylacetonate toluene to form then dispersed with flames to initiate reaction within reaction chambers containing a precursor solution. A vacuum pump and a glass fibre filter were used to remove Pt/SiO2 particles from the sample. FSP can be easily scaled up since it doesn't need washing, filtering, or drying in the production process.

CONCLUSION

Recent years have seen exponential progress in the fields of homogeneous and heterogeneous nanocatalysis (the catalytic utilisation of nanoparticles). Compared to bulk materials, nanoparticles have a high surface-to-volume ratio, making them ideal catalysts. Catalysts are essential to the multibillion-dollar chemical industry throughout the globe, as well as essential environmental protection technologies, since they accelerate and amplify hundreds of chemical processes every day. The creation of novel catalysts is predicted to be greatly impacted by research in nanotechnology and nanoscience. The logical and cost-effective creation of new A deep understanding of nanostructure chemistry and the ability to control materials on a molecular scale will guarantee that more competent catalysts for chemical processes may be developed. As a result of the utilisation of catalytic oxidation of volatile organic compounds (VOCs), low-temperature purification systems offer several benefits, such as lower energy costs, improved operational safety, and lessened environmental effect. In instance, transition-metal oxide-Metal oxides and noble metal nanostructures are among the most effective catalyst materials currently available. In catalytic oxidation of volatile organic compounds (VOCs), the supported noble metal was more active even at room temperature. The features of the supports and noble metals, as well as the particle size and shape, all have an effect on supported noble metals. Numerous research studies have been carried out to investigate the impacts of different catalyst factors, such as support and metal quality; precursors; production techniques; reaction settings; etc. on VOC oxidation performance, as a result of this.

REFERENCES

1. He Z, Li G, Chen J, Huang Y, An T, Zhang C. Pollution characteristics and health risk assessment of volatile organic compounds emitted from different plastic solid waste recycling workshops. Environ. Int. 2015, 77, 85–94.
2. Villanueva F, Tapia A, Amo-Salas M, Notario A, Cabanas B, Martinez E. Levels and sources of volatile organic compounds including carbonyls in indoor air of homes of Puertollano, the most industrialized city in central Iberian Peninsula. Estimation of health risk. Int. J. Hyg. Environ. Health 2015, 218, 522–534.
3. Zhang Z, Wang X, Zhang Y, Lu S, Huang Z, Huang X, Wang Y. Ambient air benzene at background sites in China's most developed coastal regions: exposure levels, source implications and health risks. Sci. Total Environ. 2015, 511, 792–800.
4. Le Bechec M, Kinadjian N, Ollis D, Backov R, Lacombe S. Comparison of kinetics of acetone, heptane and toluene photocatalytic mineralization over TiO2 microfibers and Quartzel® mats. Appl. Catal. B Environ. 2015, 179, 78–87.
5. Barroso F, Tojo C. Modelling of nano-alloying and structural evolution of bimetallic core-shell nanoparticles obtained via the microemulsion route. J. Colloid Interface Sci. 2011, 363, 73–83.
6. Yadav OP, Palmqvist A, Cruise N, Holmberg K. Synthesis of platinum nanoparticles in microemulsions and their catalytic activity for the oxidation of carbon monoxide. Colloid Surface A 2003, 221, 131–134.

7. Yu X, He J, Wang D, Hu Y, Tian H, He Z. Facile controlled synthesis of Pt/MnO2 nanostructured catalysts and their catalytic performance for oxidative decomposition of formaldehyde. J. Phys. Chem. C 2012, 116, 851–860.
8. Garcia T, Solsona B, Cazorla-Amorós D, Linares-Solano Á, Taylor SH. Total oxidation of volatile organic compounds by vanadium promoted palladium-titania catalysts: comparison of aromatic and polyaromatic compounds. Appl. Catal. B Environ. 2006, 62, 66–76.
9. Rui Z, Chen L, Chen H, Ji H. Strong metal-support interaction in Pt/TiO2 induced by mild HCHO and NaBH4 solution reduction and its effect on catalytic toluene combustion. Ind. Eng. Chem. Res. 2014, 53, 15879–15888.
10. Huang H, Leung DYC, Ye D. Effect of reduction treatment on structural properties of TiO2 supported Pt nanoparticles and their catalytic activity for formaldehyde oxidation. J. Mater. Chem. 2011, 21, 9647–9652.