CATALYTIC PROCESSES IN THE AUTOMOTIVE AREA

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Abstract: This article analyzed heterogeneous catalysis by a literature review, focusing on its use in the automotive sector. The central application of this study is in the preparation of catalytic converters for automobiles with electronic injection. The catalysis process, homogeneous or heterogeneous, is paramount because it provides the feasibility of chemical reactions in the laboratory or industrial field. Although it is still a new mechanism, since the first automobile prototype with an internal combustion engine powered by liquid fuel was patented in 1884 by Siegfried Markus, catalytic converters represent a significant milestone for research on catalysts.

Keywords: Catalysis; Automobiles; Mechanism; Pollutants; Converter.

ESTUDO DE PROCESSOS CATALÍTICOS NA ÁREA AUTOMOTIVA.

Resumo: O presente artigo tem por objetivo propor uma análise, por meio de uma revisão bibliográfica, da catálise heterogênea, tendo como foco a sua utilização no setor automotivo. A principal aplicação dessa vertente de estudo é na preparação de conversores catalíticos para automóveis com injeção eletrônica. O processo de catálise, sendo esta homogênea ou heterogênea, é considerada de suma importância, seja no campo laboratorial ou industrial, pois sua utilização propicia a viabilidade de reações químicas. Apesar de ainda ser um mecanismo bastante novo, visto que o primeiro protótipo de automóvel com motor a combustão interna alimentado por um combustível líquido foi patenteado em 1884 por Siegfried Markus, os conversores catalíticos representam um grande marco para pesquisas onde o objeto de estudo são catalisadores.

Palavras-chave: Catálise; Automóveis; Mecanismo; Poluentes; Conversor.

1. INTRODUCTION

Catalysts are chemical species that aim to increase the speed of a reaction; they act in the area of kinetics, amplifying the reaction kinetics. They do not interfere with the thermodynamic parameters of the reaction (Gibbs free energy, entropy/enthalpy variation and equilibrium constant). In simple terms, it is a substance added to a given reaction with the purpose of increasing the execution speed. Their characteristic point is that despite being part of all stages of the production process, they are not consumed at the end of the reaction, thus maintaining their initial mass.

In a historical context, the discovery and use of catalysts began together with the mastery of fermentation techniques known in gastronomy, thus characterizing an enzymatic catalysis, the main ones being: beer production (the first dated beer is the Weihenstephan Brewery, this was produced by monks in a monastery in Germany), the production of cheese (using enzymes or acid) and the production of bread. Countless reactions with great notoriety for the study and conception of the chemistry that we have nowadays were propitiated by the use of catalysts.

Catalysis is of vital importance for the chemical industry: more than 80% of industrial chemical products undergo at least one stage of their manufacture through a catalytic process. Catalysis is particularly important for the petroleum refining, petrochemical, polymers, agrochemicals, flavors and fragrances and pharmaceutical industries. An already very important and growing application is that of catalysts for the reduction of pollutants, mainly in the automotive industry.

1.1. Environmental legislation

The phrase: “I am what surrounds me. If I don't preserve my surroundings, I don't preserve myself”, by journalist and political activist José Ortega y Gasset (1883-1955), points precisely to a very important point of debate for today's society: the need to reassess processes that cause great negative impacts on the environment. A research motive for scientists and an agenda for politicians, numerous lines of research emerged with the objective of correcting processes that attenuated the emission of polluting gases into the atmosphere.

This statement can be proven when it is cited, for example, the "Big Smoke" or "The great fog" that occurred in the city of London, in 1952. This is considered one of the worst environmental impacts recorded in recent years, and its reason was the burning of fossil fuels in industry and transport. This fog may have killed over 10,000 Londoners. [1]

To mitigate the existence of events, such as the one mentioned above, some world authorities began to structure solutions to control the emission rates of polluting gases, the most famous attempt in this regard was the Kyoto Protocol, promoted by the UN (united nations organization) in 1997, signed by about 175 countries. However, new treaties, laws and guidelines are created and discussed every year, which seek to align the parameters between countries and change the emission reduction targets.

In Brazil, this need for process optimization began on the agenda in 1976, when the first laws and guidelines were drafted, the first approaches cited carbon monoxide and sulfur dioxide as the main exhaust gases to be controlled. After several studies in the sector, in 1986 the first law that encompassed this issue was enacted and was also focused on air quality control. And in support of this law, a federal program was

created, PROCONVE - Air Pollution Control Program by Motor Vehicles, developed by the National Environmental Council (Conama). It is the pioneer in its sector, as it directly affected the problem of motor vehicles. [2]

2. METHODOLOGY

This article was initially carried out through a literature review, characterized as a bibliographic research. According to Severino (2007), this style of research is characterized from the available record, which results from research already carried out, in books, articles, theses and printed documents. The construction of the article was carried out over a period of six months.

The objective of the research is to promote an elucidation about the functioning of catalytic converters and the heterogeneous catalysis reaction that occurs for its perfect functioning, when installed in vehicles that have electronic injection.

The basis for the attached chemical principles was based on the book "Heterogeneous Catalysis" by Martin Schmal (2011). The laws and regulations presented are based on Conama resolutions published in the Official Gazette (Conama nº 18, of May 6, 1986).

2.1 Mechanisms associated with heterogeneous catalysis

Two mechanisms are crucial for the study of heterogeneous catalysis, they are: Langmuir-Hinshelwood and Rideal-Eley.The Langmuir-Hinshelwood mechanism postulates that: The molecules must first be adsorbed and then undergo the reaction. Given this statement, the catalyst has the property of increasing the reaction speed through its ability to absorb the reactants in such a way that the activation energy is significantly reduced compared to the same without a catalyst.

It also has an internal classification into two types: single site and dual site. The Eley-Rideal model, on the other hand, considers the reaction between two molecules, one being absorbed and the other not. In general, a single reactant adsorbed on the catalyst and the other free reactant reacted by means of effective shocks. This mechanism is a decomplication of the Langmuir-Hinshelwood mechanism and its use is generally for gas phase reactions. The decisive factor in defining which mechanism occurs in the reaction is the total pressure in the system.

3. RESULTS AND DISCUSSION

When you have a combustion engine, the process of use requires a reaction of a fuel with oxygen, generating gaseous by-products, some of which are: CO (highly toxic carbon monoxide) and C (pure carbon, called carbon black , produces soot). The most reactive hydrocarbons found in exhaust gases are: Ethylene, toluene, xylenes and propylene. [3]

The type and composition of fuel used in automobiles significantly influence the different forms of contamination to which the environment is subject. Cars powered by alcohol, for example, produce high emissions of aldehydes (mainly formaldehyde and acetaldehyde) compared to those powered by gasoline. Vehicles powered by 20% ethanol-gasoline (v/v) blends emit more total aldehydes and nitrogen oxides than gasoline. [3]

The heterogeneous catalysis present in the catalytic converter is a surface phenomenon. Therefore, it is a clear example of an adsorption reaction, as it must be adsorbed onto the metal surface for the reaction to take place. Considered as chemical adsorption in the classification of this reaction, the metal will act as a Lewis acid (electron acceptor) and the reactant molecules bind to the metal as a lewis base (electron donor).

The catalytic converter or catalytic converter is a component of the vehicle exhaust system, formed by a ceramic or metallic core that transforms a large part of the engine's toxic gases into non-toxic gases, from the human point of view, through chemical reactions that occur within these components.

There are two types of classification for heterogeneous catalysts, namely: the mass (which is only made up of the noble metal in question, however, this choice makes the process very expensive and possibly makes it infeasible, as the reaction only occurs on the surface of the material the inside of the metal is unnecessary) and the most common process that is used in catalytic converters (it is a support, which can be composed of some materials, namely: an oxide, alumina or silica. Preferably with a porous surface. [3-4]

The interior lining of the catalytic converter is produced with a ceramic or metallic material, its appearance refers to a format similar to a beehive formed by several porous channels. The beehives are coated with aluminum oxide,known as alumina, (Al_2O_3) and the catalyst is fixed on it, the two most common being: an alloy of palladium and rhodium or palladium and molybdenum. [5-6]

The system that represents the way the catalytic converter works is represented by the following steps: toxic gases enter the catalytic converter system; they are retained and end up fixed in the hives; the gaseous molecules are prevented from moving and start a molecular agitation, enabling the weakening of their connections and allowing parallel reactions between the molecules of gases that circulate in the environment, thus enabling their conversion into substances with a lower degree of toxicity. As shown by the below:

Figure 1. Catalytic Converter Mechanism

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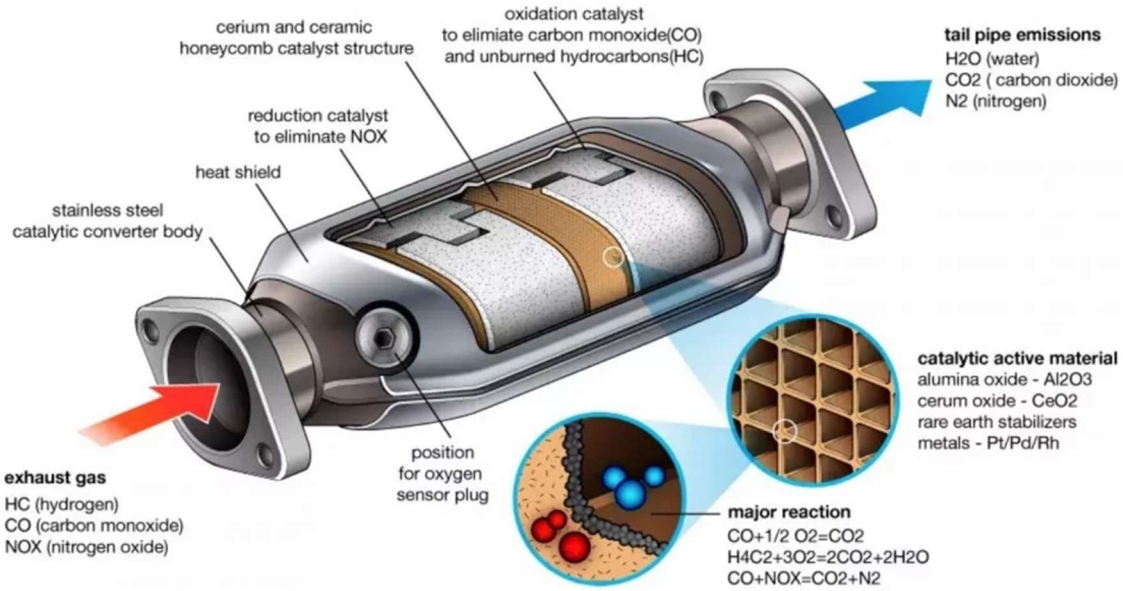

Source. Car Blog India, 2021.

3.1 Catalytic Converter Actuation Steps

Reduction catalysis is the first stage of the catalytic converter: it uses rhodium and platinum in order to reduce (NO) emissions. When NO or NO2 molecules come into contact with the catalyst, it breaks the bonds of the nitrogen atoms in the molecules, absorbing them on their surface and leaving the oxygen atoms free to form. [7]

Oxidizing catalysis is the second stage of the catalytic converter: it oxidizes uncombusted hydrocarbons and carbon monoxide by passing through a catalyst bed of platinum and palladium.

The third stage is a control system that monitors the exhaust gases and uses the information to control the fuel injection system: an oxygen sensor mounted in the gas stream between the engine and the converter tells the engine how much oxygen, through the air/fuel ratio, which will allow working in a relationship close to the stoichiometric ratio.

3.2 Converter poisoning

Several factors can cause the poisoning of the converter, including: poisoning (a chemical phenomenon where there is strong chemical absorption of chemical species in the sites), deposition (as the name indicates, it is the deposition of species on the catalytic surface), thermal (occurs when the temperature reaches very high levels, generating the loss of active sites and metallic area available for the reaction), among others. [6-7]

The biggest problem when it comes to heterogeneous catalysts is the sintering phenomenon. This can be defined as a physical process, thermally activated, which makes a set of particles of a certain material, initially in mutual contact, to acquire mechanical resistance. During sintering, the porosity of the structure is closed. In the area of catalysis, this is a totally unwanted situation, as, as mentioned earlier, the reactions take place on the surface. [8]

As previously stated, the catalytic converter composes the base of parts/tools of automobiles that have electronic injection. Using a catalytic converter with defects or with its useful life already completed will release highly harmful gases into the atmosphere, in addition to emitting smoke in the exhaust, the car will lose performance, will consume more fuel, increase the engine speed when idling , If the catalytic converter is completely clogged, the engine may stop running after a few minutes.

Understanding how the sintering phenomenon occurs and how to avoid it is still a subject of considerable research by scientists, since when the catalyst's useful life (“average” life of around 100,000 miles = 160.934 km) comes to an end, the only option is the discard. To meet this need to avoid this amount of waste, there are studies focused on the search for catalysts that have the property of making this reuse.

“Smart catalyst technology points to a new future in automotive catalysis and appears as a promising replacement for conventional catalysts. Understanding the main factors that lead to self-regeneration of these catalysts is a fundamental step in the process of evolution of this technology. self-regeneration is directly responsible for the considerable increase in the useful life of these catalysts compared to conventional ones. Consequently, its cost is much lower compared to the conventional one”. SANTOS (2014).

There are ways to take care of this equipment and prolong its useful life, such as: avoid parking in a place with tall grass and/or dry vegetation (since the converter works at high temperatures, thus generating a fire), keep the system ignition in order, avoid having the tank in reserve and pay attention to the quality of the fuel placed in the car.

4. CONCLUSION

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It was possible to notice, during the construction of the article, that catalysis is a phenomenon that can be present in several areas. Its insertion in the automotive industry was initially made possible by catalytic converters; they managed to unite the principles of automotive chemistry and mechanics in order to develop a system for reducing exhaust gases.

The converters proved to be extremely functional in terms of reducing the emission of polluting gases, as presented in the Conama report, reinforcing the need to expand and promote research on catalysts. The catalyst sector is constantly looking for economically and technologically viable alternatives.

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