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HETEROGENEOUS CATALYSIS-DRIVEN CHEMICAL INDUSTRIES

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Abstract

Today, our Nation faces a lots of challenges in creating alternative energy fuels, reducing harmful by-products in manufacturing, cleaning up the environment and preventing future pollution, dealing with the causes of global warming, protecting citizens from the release of toxic substances and infectious agents, and creating safe pharmaceuticals. Catalysts are needed to meet this advancement, but their complexity demand a revolution in the way catalysts are designed and used for industrial purposes. The success of the chemical industry is in large part merit of the enhancement and development of catalysts, and industrial catalysis is essential for most modern, cost and energy efficient means for the production of a broad range of chemical products, petroleum refining, and pharmaceuticals and for environmental protection. In the industrial applications, catalysis has reached in the last decades a trustworthy degree of maturity and continues to produce innovation that is reflected in the significant contribution to the development of the advanced society. This goal is achieved thanks to the closest synergy of the scientific understanding of catalytic phenomena and the scale-up of the gained knowledge into commercial field of applications. Much basic and applied research is done by industrial applications and university research laboratories to find out how catalysts work and to improve their efficiency. If catalytic activity can be improved, it may be possible to lesser the operating temperature or the pressure at which the process operates and thus save energy which is one of the major problems in commercializing a large-scale chemical process. Since, it may be possible to reduce the amount of reactants that are wasted forming unwanted by-products thus it means to prefer us higher selectivity in chemical reaction.

Index Terms: *Catalysis, Chemical Engineering, Modelling, energy efficiency etc.*

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1. INTRODUCTION

This revolution is become reality through the fundamental application of new methodologies for synthesizing and characterizing molecular and material systems. Opportunities to understand and predict how catalysts work at the microscopic scale and the Nano scale are now appearing, made possible by breakthroughs in the last decade in computation, measurement techniques, and imaging and by new developments in catalyst design, synthesis, development, advancement and evaluation.

Catalysts have been used by mankind for over 2000 years [1]. The first use of catalyst observed in making of wine, cheese and breads etc. A catalyst is a substance that speeds the rate of a reaction by participating chemically in intermediate stages of reaction and is ultimately released in a chemically unchanged form. Many catalysts have specific actions in that they suggest only one reaction or group of definite reactions. The outstanding example is the living cell in which there are several hundred catalysts, called enzymes, which are nothing but amines present in our body, each one favouring a specific chemical process. When a reaction can proceed by more than one path, a particular catalyst may favour one path over another and thus lead to a product distribution different from an unanalyzed reaction. A catalytic reaction requires a lower energy of activation, thus permitting a reduction of temperature at which the reaction can proceed favourably. The equilibrium condition is stayed constant throughout the reaction since both forward and reverse rates are accelerated equally. For example, an industrial hydrogenation catalyst also is a suitable dehydrogenation accelerator but possibly with a different most-favourable temperature [2].

1.1 Literature Survey

In recent years, various researches are carried out in science of catalysis. For this, the mechanism of catalytic reactions on its surfaces, advancement in the base materials of catalyst, preparation of catalyst with desired properties for example Recent advancements in Pt and Pt-free catalysts for oxygen reduction reaction and Shape-selective catalysis and process technology via molecular inclusion in zeolites etc. Promising advancement and research takes on the revolution that will result from our emerging ability to achieve an atom-by-atom understanding of matter and the subsequent masterly ability to design and build new materials with properties that are not found under our nature. To establish the full potential of catalysis for energy saving applications, scientists must develop an indeed understanding of catalytic transformations so that they can design and build effective catalysts with atom-by-atom precision with accuracy and convert reactants to products with molecular precision with desired selectivity [3]. Moreover, they must build tools to make real-time, spatially resolved measurements of operating catalysts. Ultimately, scientists must use these tools to achieve a fundamental understanding of catalytic processes occurring in multistage, multiphase nature.

1.2 Heterogeneous Catalysis in Chemical Industries

In chemistry, heterogeneous catalysis refers to the field of catalysis where the phase of the catalyst is different from that of the reactants in any reaction. Phases here refer not only to solid, liquid, gas, but also immiscible liquids, e.g. any organic material and water. The great majority of practical heterogeneous catalysts are solids and the great majority of reactants are gases or liquids, sometimes gases also involved as catalyst. Heterogeneous catalysis is of priority importance in many areas of the chemical and energy industries. Many researchers and scientist got excellent work in heterogeneous catalyst and attracted Nobel prizes for Fritz Haber in year of 1918, Carl Bosch in 1931, Irving Langmuir in 1932, and Gerhard Ertl in 2007.

2. GENERAL STEPS IN HTEROGENEOUS CATALYSIS

Reaction in heterogeneous catalysis takes place in following manner as shown in Fig. 1:

1. Diffusion of reactant from the bulk of fluid to the external surface of catalyst pellet.
2. Diffusion of reactant molecule from the pore mouth through the catalyst pores to the immediate vicinity of the internal catalytic surface.
3. Adsorption of reactant into the catalyst surface.
4. Reaction on the surface of the catalyst.
5. Desorption of product from the surface.
6. Diffusion of product from interior of the pellet to the pore mouth at the external surface.
7. Mass transfer of the product from external surface of pellet to the bulk fluid [1].

Table-1: Important processes where catalysis used and year of discovery

Year	Process	Catalyst
1750	H2SO4 lead chamber process	NO/NO2
1817	Oxidation of methane	Pt catalyst
1895	Fritz Haber : Production of small amount of NH3 from N2 and H2	Fe
1900	Fat hydrogenation	Ni

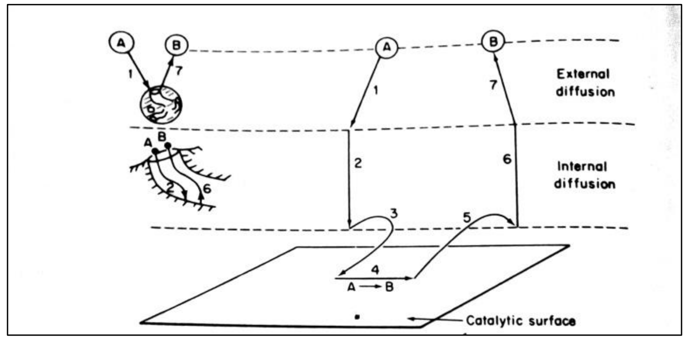

Fig-1: General Steps in Heterogeneous catalysis

The majority of industrial catalytic processes involve heterogeneous catalysis. There are several factors in the selection procedure of catalyst described as follows

- The selectivity of the catalyst to the desired product
- How often the catalyst needs renewing
- The reaction conditions such as reaction temperature and operating pressure
- Measure of active sites or the intimate area for reactants on catalyst
- Separation process of product from catalyst

These are the effective measures on which every catalytic reaction are depending upon. Heterogeneous catalyst consists of these properties and can be able to operate the reaction on the large extent of reaction variables.

3. CONCLUSION

We are entering a new era in catalysis research. During the coming decade, we will encounter and surmount new barriers. The 21st century demands technology ensuring cleaner and more sustainable production methods. We can gain inspiration from the natural environment we want to protect. Catalytic processes in nature are often more reliable than exactly in industry. There is number of rooms for improvement and betterment of catalyst. Our dream is to bring about chemical production methodologies in which all aspects are fully controlled and coordinated with proper interpretation, with no by-products and no excess or wastage energy, using small chemical plants that automatically adjust to the conditions in which they operate for sustainable production, located in close proximity to users. Energy consumption could approach the minimum required to bring about the chemical reactions which is nothing but future need.

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