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TO STUDY THE NANOCATALYSIS APPLICATIONS IN CHEMICAL INDUSTRY

Ishwar G. Nannaware
Assiatant Professor
Anandrao Dhonde Alias Babaji Mahavidhyalaya,
Kada, Tal-Ashti Dist-Beed, Maharashtra India.

Abstract:- *Nanocatalysis as an immerging research topic has attracted much more attention in the past years. The functionalized materials with a nanodimension displayed a more significant and dramatically powerful catalytic capability than traditional catalysts in chemical reactions. Due to the increased surface area and multiple catalytic centers, nanocatalysts are plays an important role in enhancing the yield. Nanocatalyst in industry consists of nanoparticles with variable crystallite sizes, shapes, and compositions and its catalytic performance .The aim of this paper is to study the various applications of nanocatylysis in chemical reactions*

Kewords:- Nanocatalyst, organic reactions, construction, Green Chemistry, nanocomposite, mesoporous, nanoscale, Industrial Interaction.

Introduction:- Nanocatalysis is a rapidly growing field which involves the use of nanomaterials as catalysts for a variety of homogeneous and heterogeneous reaction. The heterogeneous catalysis represents one of the oldest commercial practices of chemical science. The nanoparticles of metals, metal oxides, and other compounds have been widely used for important chemical reactions [1]. Although surface science studies have contributed significantly to our fundamental understanding of catalysis, most commercial catalysts, are still produced by mixing, shaking and baking. The mixtures of multi-components of nanoscale structures are not well controlled and the synthesis-structure-performance relationships are not poorly understood [2]. Due to their complex physico-chemical properties at the nanometer scale and even characterization of the various active sites of most commercial catalysts are difficult to identify. [3]. The main aim of nanocatalysis research is to produce nanocatalyst with 100% selective, extremely high active, low energy consumption, and with long lifespan [4]. This can be achieved only by precisely controlling the size, shape, spatial distribution, surface composition, electronic structure, thermal and chemical stability of the individual nanocomponents [5]. The field of nanocatalysis has undergone an explosive growth, both in homogeneous and heterogeneous catalysis [6, 7]. Since the nanoparticles have a large surface-to-volume ratio compared to bulk materials, So they are attractive candidates for use as catalysts [8].

Perspectives of Nanocatalysts:-

The field of nanocatalysis is not new as could be expected [9]. Actually, its concept is known since the 1950s when the term nanotechnology was not even known [10]. Nanocatalysis combines the advantageous characteristics of both homogenous and heterogeneous catalysis, while reducing their respective drawbacks [11]. In homogeneous catalysis, the starting materials and the catalytic substance are brought together in the same phase, which ensures high catalytic activity and selectivity [12]. However, the practical application of homogeneous catalysis is limited by the difficulties to separate the catalyst from the product after completion of the reaction [13]. In heterogeneous catalysis, the starting materials and the catalytic substance remain in different phases [14], therefore reducing the separation problem of products and catalyst. A main drawback of traditional heterogeneous catalyst systems compared to their homogeneous counterparts is the reduced surface area that is accessible to reactant molecules, thereby limiting their catalytic activities [15] and leading to an unnecessarily high consumption of expensive catalyst materials [16]. One possible way to solve this problem is to increase the surface to volume ratio by decreasing the size of the catalytically active material [17]. A high surface to volume ratio can be achieved by synthesizing specifically engineered catalysts on the nanoscale. Nanosized materials show additional unique properties compared to the macroscale [18]. A prominent example is the unexpected catalytic activity of gold nanoparticles, which is not found with bulk gold [19]. Nanocatalysis, gives targets that are follow with close to 100% selective reactions, extremely high activity, and excellent yield [20]. In contrast to them, to define nanocatalysis as a distinct category, because it closes the gap between hetero and homogeneous catalysis [21], while it also require totally new synthetic approaches [22] which display unique characteristics [23]. As nanocatalysis are further expected to contribute to lower energy consumption prossess, longer lifetime of the catalyst systems and enhanced possibilities to isolate and re-use the active nanomaterials, they are prominent efforts towards "green chemistry" for which catalysis is regarded as one key element [24]

Nanocatalysis in Green Chemistry:-

Green chemistry is generally accepted as "the design, development, and implementation of chemical processes and products to reduce or eliminate substances hazardous to human health and the environment" [25]. The idea of performing this kind of chemistry is gaining prominence amongst the players in the chemical industry, as today's major challenges are to achieve sustainable production processes, having lower energy consumption and less environmental impact. Additionally, greener production processes might also prove to be economically beneficial for the companies [26]. However, the total impact of this new way of doing chemistry is still slight compared to the conventional industrial processes [27]. The reason for that is that the companies maximize profitability within the current policy limits. The established processes are often good enough to comply with the regulations, greener processes although less polluting might not be considered for implementation: "new green chemistry processes will be introduced only if they can provide a payback quickly enough to be attractive to managers and investors". Thereby it should be noted that green chemistry is not merely targeted to lower energy consumption [28], but also includes broad concepts regarding for example, waste minimization, usage of nontoxic reagents. The principles of green engineering were proposed [29] guidelines of green chemistry and engineering with regard to nanocatalysis**.**

Progress in Preparation of Nanocatalysts :-

The traditional synthesis methods are not allows for a precise control of nanocatalyst size and shape [30] and therefore "The field of catalysis science is often criticized as being ad hoc and empirical". Today activity, selectivity, durability, and recoverability can be influenced owing to the advances in nanoscience. The size, shape, and surface compositions of nanocatalysts are designed and synthesized in a more precise way by adjusting the reaction conditions, such as reaction time, temperature and reactant concentrations [31]. In general, nanocatalysts can be synthesized by either a top-down or bottom-up approach. As the name implies, the idea behind the top-down approach is to break bulk material down mechanically, thermally, or chemically, into smaller and smaller particles. The top-down approach is criticized because of its inability to yield particles with uniform characteristics [32]. However, there are already improved procedures to control the size and surface composition more precisely. The bottom-up approach involves the formation of nanocatalysts by reaction or agglomeration of suitable starting molecules with or without structure-directing agents. This principle is used more commonly than the former approach, although it is rather disadvantageous both from an economical and environmental points of view, due to hard reaction conditions employed and the use of expensive precursors and structure-directing agents [33]. In 1850s, Faraday produced metal nanoparticles by the chemical reduction of the respective metal salts, which is still a common way in nanoparticle synthesis. Later, in the 1920s metal nanoparticles were introduced to catalyze chemical reactions [34]. In a desire to reduce costs of large-scale catalytic systems, for example, in the refinery industry, researchers in the 1950s began to produce smaller catalytic particles in order to profit from the resulting advantageous characteristic. Thereby, the size was lowered from 100 nm in the beginning to less than 1 nm today. Both, top-down and bottom-up approaches are conceivable for the synthesis of nanoparticle catalysts. Numerous methods were developed, including conventional techniques like mechanical grinding or chemical breakdown of bulk material or electrochemical or solvothermal processing of precursor solutions [35]. Further innovative alternatives, such as microwave irradiation processing, resulting in catalysts of more precisely defined size and shape.

Industrial Interest:-

After the study of the advances in nanocatalysis research, the question remains to what extent industrial companies are interested in nanocatalysts. This is a shed some light on recent developments in the industry by an extensive analysis of more than 1,500 nanocatalysis-related patents. These were retrieved by a search on the US Patent and Trademark Office Patent Database. The keywords nano, catalyst, nanoparticle, nanocomposite, mesoporous, nanoscale, particle, nanocatalyst, nanocatalysis and catalytic material were used in various combinations for full-text searches and the truncated terms nano$ and catal$ for abstract searches ($ indicates truncation for the search engine). 475 out of the more than 1,500 analyzed patents were found to comply with this working on nanocatalysts. To categorize these 475 patents according to the following categories: year of granting, application field, and assignee. The results of this search presented in the following show the general interest of industry in nanocatalysis but do not necessarily reflect the extent of application of such catalysts in industry.

Futuristic Applications of Nanocatalysts:-

The inner walls of carbon nanotubes can support for rhodium particles which are catalytically active in the production of ethanol from CO and H_2. They found that the overall ethanol formation rate inside the carbon nanotubes is an order of magnitude higher compared to the analogous reaction on the outer wall of the tubes [36]. In another example, single-step hydrogenations of benzene to cyclohexene or cyclohexane can be catalyzed by bimetallic nanoparticles anchored within mesoporous silica exhibiting high performance. These examples nicely show that the already superior activity of nanoparticle catalysts can even be multiplied when linking them to the advantageous characteristics of porous nanomaterials. Further promising approaches, which gained some prominence in recent research, are core-shell nanocatalysts, also showing high performance. A special property of this catalytic system is its resistance towards inactivation caused by strongly adsorbing molecules. A core-shell nanocatalyst like platinum core and a mesoporous silica shell particularly suitable for high temperature reactions. They synthesized a nanoreactor built from a Ni core protected from sintering at high temperatures by a SiO_2 shell, for the steam reforming of methane [37]. The core-shell catalysts can be effectively recovered from the reaction mixture by the application of an external magnetic field. It is obvious that all the nanocatalyst technologies have the potential to play a crucial role in various application fields, such as in the synthesis of widely used organic compounds, in the H_2 economy, in oil refining, in pollution control and in biological nanosensor applications. The portable fuel cells based on hydrogen generation from formic acid catalyzed by gold-palladium core-shell structures. The use of nanocatalyst for biofuel cells powered by glucose [38]. Biological applications of nanocatalysts can also be extended to the broad field of bionanosensors, for example, for diagnostic or therapeutic purposes. A totally new approach in the design and use of nanocatalysts is also related to biochemistry. A major challenge for the oil industry is the deteriorating quality of crude oil feedstock due to the increase in the percentage of long-chain hydrocarbons. Novel nanocatalysts able to cope with those heavy substrates are expected to solve this problem. Concomitantly, metal-free nanocatalysts are developed to counter the sharp rise in rare earth metal prices. Despite these visions of a bright future for nanocatalysis, it has to be emphasized that the risks posed to both the environment and human health are still poorly understood based on the currently available data [39]. Especially for the consumer market there is a need to explore toxicity and long-term effects of nanomaterials more thoroughly as soon as possible, because more than 600 nanoproducts are already on the market. Increased selectivity and activity of catalysts by controlling pore size and particle characteristics replacement of precious metal catalysts by catalysts tailored at the nanoscale and use of base metals, thus improving chemical reactivity and reducing process costs Catalytic membranes by design that can remove unwanted molecules from gases or liquids by controlling the pore size and membrane characteristics. The nanostructured catalysts have been the subject of considerable research attention in recent times. Many applications and patents have also been realized adopting such nanostructured catalysts leading to significant process.

Conclusion:-

The present paper provides a detailed insight into the field of nanocatalysis by reviewing current scientific literature on nanocatalysis. The advantages of nanocatalysis compared to the conventional catalysis is more beneficial to contribute to a greener chemistry. Thus we turned from future promises to the present by considering the technology situation of nanocatalysis. There are various companies hold a strong technology position in nanocatalysis. From the present review nanocatalysis still offers a wide variety of opportunities for researchers, both in academia and in industry, to increase catalyst performance and to develop innovative and green chemical processes.

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