Journal of Thermodynamics & Catalysis
ISSN: 2157-7544

Zacconi and Arias, J Thermodyn Catal 2013, 4:1
DOI: 10.4172/2157-7544.1000e116

Editorial · Open Access

Innovation and Catalysis

Flavia Zacconi[1] and Hugo R Arias[2]*

[1]*Departamento de Química Orgánica, Facultad de Química, Pontificia Universidad Católica de Chile, Vicuna Mackenna 4860, 7820436 Macul, Región Metropolitana, Santiago, Chile*

[2]*Department of Medical Education, California Northstate University College of Medicine, Elk Grove, CA 95757, USA*

Innovation and catalysis, two words that describe the synergistic process produced between the advancement of the latter as an inevitable consequence from the former. Through the years it has been shown that reality may reach fiction when technological innovation allows impossible ideas to be achieved, and innovation in catalysis is not different.

Catalysis can be defined as the acceleration of the rate of a chemical or biochemical reaction produced by a substance, the so-called catalyst, which is not consumed during the reaction and can theoretically continue indefinitely in a cyclic manner. Besides this description, catalysis is a science that depends on many other disciplines, including chemistry, physics, biochemistry, electronics, design modeling, engineering, and biology, where the combined use of these disciplines is crucial for the development of innovative catalytic processes. All Chemistry Nobel awardees in the past 100 years have been innovative in their subjects of research such as development of new catalytic processes and methods and catalysts. There is currently a deep understanding of the critical mechanical steps in the different catalytic processes and of the potential factors that can cause inactivation. This understanding triggered the development of novel catalytic methods and the characterization of catalysts that reduce the process time and improve product yield significantly.

Since the ammonia synthesis process, considered the beginning of industrial catalysis, scientific innovation has been driven by society needs to improve all aspects of life. Scientific and industrial innovation has been paramount for the progress of major industrial sectors, including energy, pharmaceutical, chemistry, food, and petroleum. These industries are involved in the development of new energy sources, environmentally friendly processes, clean and efficient methodologies, novel chemical products, waste treatment, recycling, and in the production of most of the useful materials known today. In particular, investigations on catalytic processes using environmentally clean technologies and heterogeneous catalysts have shown to be a fertile area for drug discovery. For instance, the innovative use of nanostructured heterogeneous catalysts, drug multiscale designs, surface science (e.g., seamless capsules), and alternative energy sources (e.g., dye-sensitized solar cells), may reduce the environmental impact while maintaining high productivity.

An important tendency in the last decade has been the use of new chemical catalytic reactions to increase the energy levels produced from biomass or to transform raw materials into valuable chemicals. For example, green chemistry processes using photoelectrochemical cells where hydrogen gas is produced by photocatalytic water splitting can be used to produce energy in a more efficient manner [1]. The use of novel catalysts has also increased the durability of fuel cell stacks and permitted the development of catalytic membrane reactors where syngas can be converted to liquid hydrocarbons. A new iron modifying catalyst that removes carbon dioxide from seawater, a natural resource that exists in large quantities, has been used to obtain hydrogen in a clean and safe manner [2]. These processes are important to accomplish some of the quests associated with the depletion of fossil fuel resources and coping with global climate changes.

Biocatalysts (e.g., enzymes) are other interesting classof catalysts that accelerate fundamental biological processes in living cells. The innovative use of enzymes has been crucial to remove organic material from wastewaters [3]. Recent progress in the enzymatic production of biologically active phospholipid derivatives using an organic salt solvent that is environmentally friendly, increases selectivity, and simplifies the isolation and purification process, has attracted significant interest for the cosmetic, food, and pharmaceutical industries.

The use of laccase-like multicopper oxidase pigments from Aspergillus sp. for the heterogeneous biocatalysis of phenols has opened the door for the development of biosensors [4]. A biosensor consists of a biological unit capable of interact specifically with a target and a transducer able to transform a change in the property of the solution or surface into a registrable signal.

Another important advance is in the area of biomarkers (substance that can be related to the physiologic and pathologic activity of organs, tissues, or cells). For instance, considering that catalytic iron has been associated with oxidative stress during vascular injury, its early detection in serum facilitates the diagnosis and therapy plan for coronary syndromes [5].

Moreover, complete microbes have been used for a variety of processes, including removal of harmful chemicals and heavy metals based on their bioadsorbent properties, electricity generation due to its resemblance to fuel cells, stereoselective synthesis of bioactive compounds [6], and production of green concrete. Bacteria can be also used as biosensors, for instance, to test biochemical demand oxygen as an important parameter for water pollution monitoring.

In the future, the field of catalysis will be deeply influenced by new innovative technologies to solve long-lived problems. Several examples can be included, for instance, the use of chelating molecules to catch pollutants, the manufacture of extremophiles (microorganisms that can grow in extreme environments) as biocatalysts, and the development of engineered enzymes to treat heart diseases.

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***Corresponding author:** Hugo R Arias Department of Medical Education, California Northstate University College of Medicine, Elk Grove, CA 95757, USA, E-mail: hugo.arias@cnucom.org

Received April 12, 2013; **Accepted** April 20, 2013; **Published** April 23, 2013

Citation: Zacconi F, Arias HR (2013) Innovation and Catalysis. J Thermodyn Catal 4: e116. doi:10.4172/2157-7544.1000e116

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