Chemistry Is a Central Science & Catalysis Is a Central Chemistry

Takashi Tatsumi
National Institute of Technology & Evaluation, Tokyo, Japan
*E-mail: tatsumi-takashi@nite.go.jp

Chemistry is a central science

In 1985, a book titled Opportunities in Chemistry, a report of "Committee to Survey Opportunities in the Chemical Sciences" was published. By the National Research Council, USA, the Committee was given a mission of assessing the status of chemistry. It states "Chemistry is a central science that provides fundamental understanding needed to deal with many of society's needs, including many that determine our quality of life and our economic strength." Chemistry is a central science since it bridges other natural sciences, including physics, geology, and biology

Thus chemistry is fully responsive to human needs. Truly, chemistry has become a crucial element in the economic well-being of Japan. The chemical industry of Japan makes annual shipments of JPY42 trillion and adds value of JPY2.5trillion. Both these rank closely second to transportation machinery industry.

Chemistry also contributes immensely to the enrichment of culture. Questions about the nature of life are thoroughly absorbing. Since all life processes are demonstration of chemical changes, understanding chemical reactivity is absolutely fundamental to our ultimate understanding of life.

Protecting the environment is our mounting concern in the face of climate change, air and water pollution, etc. Chemistry plays a crucial role in attacking acute environmental problems.

Catalysis is a central chemistry

Catalysis is a cross-disciplinary field of chemistry, covering a very wide area of chemical disciplines such as physical inorganic, organic, analytical, material, and bio- chemistries, chemical engineering, etc.

Mankind succeeded in his attempt to feed the world population by means of chemical technology, which dramatically enhanced the production of food. In 1913, NH_3 was first manufactured by the Haber-Bosch process on an industrial scale in Oppau, Germany. Its main use is the manufacture of fertilizers. The heart of the process is the reaction between H_2 and N_2 that is promoted by a catalyst found by Mittasch and composed of Fe_3O_4, K_2O and Al_2O_3. Since then, the world population has been increasing by ca. 1.4% a year and it is no accident that the increase in tonnage of NH_3 has made just about kept pace. Surprisingly, catalysts similar to the Mittasch's catalyst are still in use. However, NH_3 manufacturing is extremely energy-consuming, accounting for several percent of world energy use. Recently, research has been focused on finding improved catalysts to enable the process to take place at lower pressures and temperatures.

Catalysts are used in most of the processes in the chemical industry. Catalysts are able to not only speed up reactions but also enhance selectivity for desired products. Widely diverse catalysts are used because catalysts are often specific for one particular reaction. Although naphtha thermal cracking plant is the heart of any petrochemical complex, recently, much attention has been focused on naphtha catalytic cracking, which occurs at lower temperature and can increase the product propylene/ethylene ratio. The first commercial plant was built in Ulsan, Korea in 2010.

Catalysts are highly important in protecting the environment. Most of vehicles are equipped with three-way catalytic converters that reduce CO, hydrocarbons, and NOx in the exhaust gas. Power plants comply with NOx emission standards by retrofitting a selective catalytic reduction system. Catalytic processes are widely used for removing S contaminants from natural gas and petroleum products.

Fine chemicals such as pharmaceuticals, cosmetics, liquid crystals, etc. are produced by mainly employing homogeneous catalysts. Meanwhile, almost all metabolic processes in the cell need enzymes, biological catalysts.

Most chemical products are now derived from petroleum. However, we must develop a sustainable system of utilizing renewable resources such as biomass instead of depleting fossil resources. The ultimate resource would be CO_2, if we could obtain CO_2-free H_2; currently H_2 is made from fossil resources with accompanying CO_2 production. We need to exert every effort to produce "solar H_2" by photocatalytic water splitting with sunlight.