Making Plastics Ecologically Friendly - Introduction of Biorenewable CO_2 into the Polymerization Process With the Help of Micromeritics Materials Characterization Instruments - 10/04/2010

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For many who grew up in the 1960's, the classic 1967 film, "The Graduate," illustrated the growing gap between the educated, unfulfilled youth of the post World War II baby boom generation and the perceived greedy, materialistic older generation. An unforgettable scene in the movie occurs when Dustin Hoffman's character, Benjamin, is pulled aside at a party by one of his parent's friends and the following exchange takes place.

<u>Mr. McGuire</u>: I want to say one word to you. Just one word.
<u>Benjamin</u>: Yes, sir.
<u>Mr. McGuire</u>: Are you listening?
<u>Benjamin</u>: Yes, I am.
<u>Mr. McGuire</u>: Plastics.
<u>Benjamin</u>: Just how do you mean that, sir?

In this context 'plastics' became a symbol for the superficial pursuit of monetary wealth and everything phony in American life. Needless to say, not all publicity is good publicity. Despite this negative reference, Mr. McGuire was right in one respect. The plastics industry has become one of the top manufacturing industries in the United States. Plastics are used in products ranging from food packaging to automotive parts and have become a necessity of life.

The increasing volume of plastics, its production costs, heavy use of exhaustible resources, and environmental ramifications have caused much concern. Currently, it takes large amounts of volatile chemicals and fossil fuels to create synthetic plastics. It is estimated that plastics production accounts for between 5% - 10% of worldwide oil and gas consumption. The rising costs of oil and fossil fuel coupled with the introduction of cheap plastic from Middle Eastern producers is putting pressure on the industry to lower production costs in the near term. In addition, some of the advantages of plastics – its strength, light weight, durability, and resistance to degradation – can also be defined as environmental weaknesses. Millions of tons of plastic end up in landfills every year. Their incineration or unwanted dispersal leads to ecological problems. Needless to say, there is growing interest in biodegradable and recyclable polymers.

As plastics continue to grow in volume each year, economic and environmental concerns are driving governments and private industry to take significant interest in applying biorenewable resources to plastics production. A very promising alternative to the fossil fuel intensive method of manufacturing plastics involves the capture of industrial waste CO_2 and its subsequent conversion into a major component of the resin used to make the final product. The use of CO_2 as an inexpensive biorenewable resource could potentially solve a number of problems associated with plastics production. There has been extensive research devoted to capturing CO_2 and using it as a biorenewable resource in industrial applications. A number of materials can be used to react with CO_2 to form stable compounds at one set of operating conditions and be regenerated at another set of conditions to liberate the adsorbed CO_2.

The catalytic coupling of CO_2 and epoxides to generate carbonates or polycarbonates has proved to be a very promising technology in the utilization of CO_2 as a major component in a wide variety of plastic products. Although researchers found a way to make biodegradable plastics from CO_2 in the late 1960's, the process was costly requiring expensive catalysts, high temperatures, and high pressures. Recently, classes of proprietary zinc-based catalysts have been developed that allow this chemical reaction to take place in less time, at low pressures and temperature, with the use of significantly less fossil fuel. As a result, it may soon be possible to manufacture biodegradable, competitive, low-cost plastics while reusing captured waste CO_2 as a feedstock. Due to the low cost and accessibility of CO_2,the appealing properties of polycarbonates, and significant public interest in producing environmentally friendly plastics, developing new catalysts for the polymerization process has garnered a great deal of scientific interest.

Research scientists require methods that cannot only characterize adsorbents for CO_2 sorption and separation, but also help with the design of new classes of catalysts developed for the CO_2 polymerization process. Knowledge of surface area, total pore volume, and pore size distribution is important for quality control of industrial adsorbents and in the development of separation processes. Porosity and surface area characteristics determine the selectivity of an adsorbent.

Optimum design and efficient utilization of catalysts require a thorough understanding of the pore structure, surface structure, and surface chemistry of the active material. Chemical adsorption analysis, or chemisorption, provides much of the information necessary to evaluate catalyst materials in the design and production phases as well as after a period of use. The pore structure and active area of catalysts have a significant influence on production rates. The design of supported, recoverable polymerization catalysts is a very complex process with demanding requirements. The pore structure of the support must allow transport of the reactants to and polymers away from the active sites.

Since 1962, Micromeritics has supplied analytical tools to provide such analytical information. Micromeritics' extensive line of research grade gas adsorption instruments, that include the ASAP 2020 and ASAP 2420 Accelerated Surface and Porosimetry Systems, can be used to characterize adsorbent surface area and porosity characteristics. Micromeritics' ASAP 2020 and AutoChem II 2920 can perform a comprehensive array of highly precise chemical adsorption and temperature-programmed reaction studies respectively. Catalytic activity is evaluated by measuring the amounts and types of reactive gas adsorbed. This volume of gas, along with an understanding of the reaction stoichiometry, is used to calculate metal dispersion, active surface area, size of crystallites, and surface acidity. Micromeritics' AutoPore Mercury Porosimeter uses mercury intrusion to determine total pore volume, pore size distribution, percent porosity, density, and transport properties.

Today, it could be possible to hear an older and wiser baby boomer, Benjamin, tell a recent college graduate, "I want to say three words to you. Are you listening? Biorenewable, biodegradable plastics!" In the not too distant future, plastic materials may retain all of its strengths without the ecological downside. With the help of scientific developments in CO_2 capture and its integration into the polymerization process, plastics may become a 'green' consumable. Micromeritics' expertise along with its innovative materials characterization instrumentation will be instrumental in providing important measurements required for the development of environmentally friendly plastics.