CHEMISTRY

Expanding World of Plastics

Plastics can no longer be regarded as merely economical substitutes for metal, cloth and leather—they are an indispensable basic material without which man cannot live.

By RUBY YOSHIOKA

➤ PLASTICS have shown their worth. Man can no longer do without them.

Long considered cheap substitutes for metal, cloth or leather, plastics have now become so highly developed, with inherent special characteristics not found in other substances, that they have become recognized as an entirely separate group of basic materials on which mankind depends.

Plastics enter into every aspect of our lives, from baby's first toy to equipment in space vehicles, from kitchen utensils to building materials, and from textiles to satellite skins.

A most versatile material, plastics can be as soft and fine as the finest of silks, harder than the hardest of metals and as clear as the purest glass.

As raw material, plastics take all possible forms. They may be liquid, powder, foam or solid.

Research in Plastics

Much is yet unexplored in the field of plastics chemistry and possibilities seem limitless. As research progresses, more and more varieties of plastics are being produced to satisfy needs as they arise. The qualities of plastics that make them so versatile and so widely applicable are their pliability, strength, corrosion resistance and range of color and textures.

The history of plastics is almost 150 years old and may be said to have originated with the studies of Henri Braconnot, a professor of chemistry at Nancy, France, who experimented with cellulose and nitric acid in attempts to produce synthetic films.

Plastics may be defined as products, usually of synthetic origin, made up of organic substances of large molecular weight that are shaped during processing with or without heat. The term "resin" is also used in reference to plastics, but usually plastics of cellulosic origin are not referred to as resins.

Chemically, plastics consist primarily of carbon, hydrogen, oxygen and nitrogen which have been polymerized, or formed into polymers. Polymers are chemical compounds composed of many single molecules of the same structure that joined together in a long chain form large molecules of the substance. The length of the polymeric synthetic linkage of monomers (single molecules) into polymers is a result of treatment under heat or pressure or both together, and also by chemical catalysts. The length of the polymeric molecule and the composition of the simple molecules determine the characteristics of each polymer.

The 1963 Nobel Prize in Chemistry awarded to Profs. Giulio Natta and Karl Ziegler was given in recognition of their work on plastics chemistry. Dr. Ziegler did fundamental work on new catalysts which made possible countless varieties of plastics, while Dr. Natta through his research produced new plastic polymers including polypropylene.

Thermosets, Thermoplastics

Plastics, in general, are divided into two groups—those that can be remelted and those that cannot. Plastics such as phenolics and epoxies when heated become cross-linked and form three-dimensional networks of polymer molecules. Such plastics cannot be remelted and are called thermoset plastics. Other plastics are thermoplastic. These polymer materials which include polystyrenes and vinyls can be remelted and cooled to the solid state after having been molded and shaped. This can be done repeatedly without changing the nature of the plastic.

Not only can simple molecules of a single organic compound be formed into a long chain, but two simple molecules of different chemical structure can be combined in a chain. Linkages such as these are known as copolymers, and they form an entirely new series of plastics with a wide variety of characteristics. "Vinyon" fiber is a typical copolymer.

To achieve the properties desired in a plastic, chemists vary the composition and the number of monomers in a polymer chain. By these methods at least 17 major classes of plastics have been created. Including subdivisions of these types, there are now more than 50 kinds of plastics in commercial use.

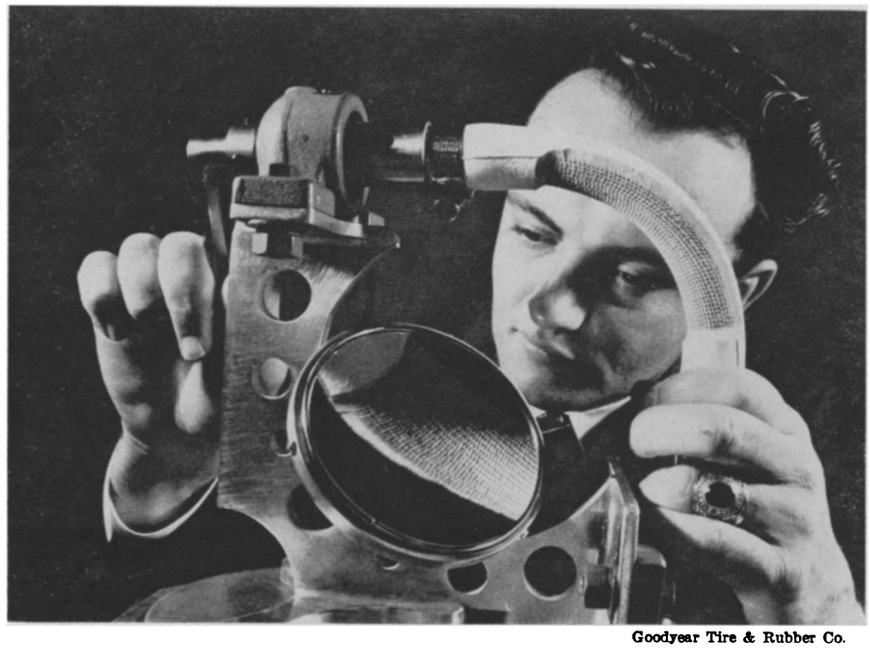
The different types include acrylics, alkyd resins, cellulosics, epoxy resins, nylons, phenolics, polyolefins, polyurethanes, vinyls and others.

Plastics can also be combined with glass fiber, paper and metals. Glass fiber impregnated with resins makes a filament of great tensile strength and is used for rocket cases, tank cars, pipes and similar applications. Resin-treated paper produces a polymer-fiber material, manufactured under the name of Polyfibron. The skin of Echo I satellite balloon, now in orbit, is made of Mylar plastic covered on both sides with a thin coat of aluminum only a few molecules thick.

Exposure to radiation to change the characteristics of the plastic and electrostatic precipitation around a mold are other areas of development just beginning to be explored.

Essential in Daily Living

Plastics are an essential part of daily living and are becoming more and more so. Production in the plastics industry has tripled in the last decade—from 2.78 billion pounds in 1953 to an estimated 8.58 billion



Goodyear Tire & Rubber Co.

"TEST TUBE" FIBERS—New fabrics made of synthetic fibers for use in tires are tested for stress and strain by W. C. Gallagher, Goodyear Tire and Rubber Company, Akron, Ohio. Polyester fibers have greatly improved tire mileage by reducing the squirming of the tread on the road surface. Other new fibers being tested are polyolefins and polycarbonates.

in 1963, and the value of plastics sold increased from $1.3 billion to $4.5 billion during the same period.

There are now more than 5,700 companies in the United States that deal in plastics and 200 plastics materials manufacturers, according to the Society of the Plastics Industry, Inc.

Considered with reference to related industries, such as equipment and machinery for the production of plastics and the manufacture of consumer goods, the extent and the importance of plastics to the nation's economy can be realized.

The automotive industry is among the largest users of plastics in such items as shatterproof acrylic lenses for signal lights, plastic seat covers, electrical parts, gaskets, and tires.

Durability Questioned

Structural adhesives, pipe linings, insulation and film coatings for walls are new developments in the building industry. However, the use of plastics in building construction is hindered by building codes in some areas that make it difficult to use plastic pipes, insulation and other plastic construction materials, partly because the outcome of long term usage of most of these materials is still unknown. One of the major obstacles to the use of plastics is selling the customer, since people are somewhat suspicious of the durability of synthetics.

However, in other areas, plastics have been accepted and a vast amount of research is underway. Naval uses of plastics include non-magnetic mine cases, radomes, sonar domes, buoys and floats, and pressure tanks.

In non-structural products, such as floorings, counter tops, decorative paneling, electrical applications, adhesive coatings and sealants, plastics have become familiar to everyone.

Rigid polyvinylchloride (PVC) is resistant to fire, corrosion, impact, weather and chemicals, and has design flexibility making it most attractive as a building material where load-bearing is not required. In a new type of insulation, plastic foam replaces air in the space between the structural panels.

Boost to Appliances

In the field of appliances, the uses of plastics are too numerous to name. The industry has grown to 175,000,000 pounds per year because of improved process techniques and better end results.

In the space program, the synthetic polymers are used in a wide number of applications, from simple seals and gaskets to possible inflatable space stations.

Knowledge of polymeric materials for high temperature applications is fairly well advanced, but little is known about which plastics are suitable for cryogenic conditions.

Medical uses of plastics are also on the increase. Plastic sutures replace gut and steel wires in many operations, orthopedic bows of plastic are replacing those made with steel; plastics have been applied in plastic surgery; while in the hospital proper, as in the home, many of the items for daily use are made of plastics or packaged in plastics. Plastic containers for medicines and for sterile instruments are routine.

The use of vinyl dispersions and the establishment of the so-called "plastisols concept" revolutionized products and industries. There was no liquid molding compound before the advent of vinyl dispersion resins. By this method new processes and products unavailable before were made possible.

Since the plastic is in liquid form, it will penetrate to every little crevice in a mold and thus intricate products such as lace doilies and tiny tools and mechanical parts can be produced with ease.

The concept makes possible the molding of a gasket directly onto irregular surfaces such as clay sewer pipes and bottle tops, insuring tight fit and saving time and labor.

Plastisols can be applied in many different ways—by air spray, electrostatic spray, airless spray, dip coating, molding, extruding and casting—making them useful for a wide diversity of processes.

Plastics packaging is a 20-billion-dollar industry. Practically everything we buy comes in some form of packaging, and much of this in plastics materials. Transparent packaging materials such as polyethylene, saran and polystyrene, are all familiar to us, while among the newer packaging materials are the shrink film and plastic bottles for household chemicals. Both flexible and rigid foam materials are widely used for transporting breakable objects.

Plastics for Space

Plastics packaging for space use must be able to withstand pressures, be tough, flexible and crease resistant.

Much research is being done in this relatively new field, and with the man-to-the-moon program in the offing, this research gains in importance.

However, any research in plastics has value only if the product can be used, and in space systems this involves structural scientists, propulsion scientists, and aeronautical engineers as well as designers.

There is virtually no industry that plastics has not penetrated in some way, and in future years, the industry is expected to grow and expand and produce more materials at less cost.

Around the World

In foreign countries as well as the United States, plastics has played an important role in helping raise the standard of living.

Especially in the developing countries the effects of the plastics revolution can be seen everywhere, from the rice fields of the Far East to the depths of the African jungle. From toys to clothes, plastics have made many items within the reach of those who otherwise would have had to do without.

From the first American commercial plastic known as celluloid and used for the first photographic film by Eastman, to Bakelite made in 1909 by Dr. Leo Henrik Baekeland, to nylon first produced by du Pont 25 years ago, plastics has developed to such an extent that we may expect to see in the not too far future, houses built of premolded plastics, plastic automobiles, and many new materials yet undreamed of.

To see and own samples of some of these new plastics, ask for THINGS of science kits, No. 278 on Space Materials and No. 279 on Polymer-Fiber. Send 75¢ for each to SCIENCE SERVICE, 1719 N St., N.W., Washington, D. C. 20036.