PLASTICS, THEIR HISTORY AND USE

THESIS

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CHAPTER I

INTRODUCTION

Since the civilization, population and living standards of the peoples of the world have increased in such gigantic proportions, especially in the last fifty years; and since the supply of natural resources cannot meet the demand, we have of necessity had to find new materials to take their place. These new materials must fulfil two purposes; namely, to take the place of the natural resources so wantonly destroyed and to meet requirements that the natural materials are not able to meet. Foremost among these new materials are the synthetic resinous materials known as plastics.

Since the beginning of civilization the peoples of the world have been ingenious, resourceful beings. There is no truer saying than "necessity is the mother of invention." Adam tasted the forbidden fruit, felt the need of clothing and the fig leaf became his raiment. The Indians learned to tan or soften the skins of animals and used it for their clothing. Sheep's wool, goats' hair, cotton, flax and silk were all used in turn for clothing fabrics. Now today we find most of our fabrics and clothing, due to the shortages of materials and discovery of synthetic materials are either partially or wholly made of synthetic materials; or they have been treated with synthetic materials to make them crease-resisting, moth-proof, or water-repellant.

Our American homes today are vastly different from those of the cave-dwellers and tents of the nomads. With the population gathering is masses in the cities, new complications such as health and sanitary conditions have arisen and must be coped with. The early Americans, with their vast forests and other natural sources of materials to draw upon, saw no need for conservation. Therefore they did as we of today are doing in the natural gas situation: they wantonly destroyed or allowed to be destroyed their forests and abundant supplies of natural resources. So when today this generation needs materials with which to build, furnish, and fit our homes and industrial and business establishments in the intricate way which our living conditions demand, we are of necessity having to turn to synthetic materials.

In the progressive era we are living in, the things that were the greatest luxuries only a short while ago are necessities today. Synthetics or plastics are not only taking the place of other materials, but are finding their own place in the manufacture of building materials and household utilities and appliances. These run the gamut from plastic-plywood for interior walls, to wiring insulations, to the toothbrush (bristles, back and all) on the bathroom shelf.

Transportation likewise has advanced along with other forms of civilization. When there were few peoples the need of transportation facilities were limited. In Bible times the ass was the beast of burden. Columbus came to America in a sailboat and found Indians carrying their possessions on poles fastened on the sides of horses. The colonists built carriages of fine wood and wrought iron; then came "Fulton's Folly," the steamboat, and the steam engine, both powered by steam generated with wood. The horseless carriage, later called the automobile, powered by gasoline, found its place in our transportation system. The manufacture of the first automobiles used quantities of fine woods, metal and rubber. These materials are still being used, but other materials have been added to make the automobile a more serviceable vehicle.

These added materials were required to have such properties as high impact strength, heat resistance and electrical qualities. Those materials that replaced the inside appointments were of necessity to have beauty of appearance and strength. Through scientific research, materials with these qualifications were found in plastics. Synthetic fabrics have also replaced leather for upholstery; synthetic rubber has replaced natural rubber in tires and the body is covered by a synthetic plastic coating. The peoples of the earth were not satisfied even to have fast transportation on land and sea; they encroached on the field of the birds and fish and took to the air in planes and below the water's surface in submarines. These new appliances, too, had to have their parts fashioned to suit their requirements. So, new materials had to be compounded and new molds made; parts of plane wings and, in some cases, whole fuselages, were made of bonded plywood. Thus again we see plastics marching hand in hand with modern civilization.

Along with progress in shelter and clothing and transportation, has come change in our eating habits. We no longer eat food in season, but are demanding fresh meat, fruit and vegetables, the year round. Here again we find plastics playing a big role. Whole beeves are placed in plastic bags to keep them free from contamination and odors. The meat is then placed in a refrigerator whose component parts are plastic. Fruits and vegetables are quick-frozen, placed in frozen lockers; they are enclosed in sealed, transparent plastic sheets for protection; thus they can be displayed to advantage. Fruits and vegetables that are not quick-frozen are also sealed in plastic bags to prevent deterioration from exposure to bacteria in the air or dehydration. One of the latest shopping conveniences is a plastic bag that will keep frozen vegetables from melting for several hours.

Our communications system has been one of the greatest causes for the expansion and advancement of civilization. Moses carved the Ten Commandments on stones; the ancient Chinese invented the printing press; Samuel Morse invented the telegraph, Alexander Bell the telephone. Then, by leaps and bounds, came the radio with all its devices that have taxed the ingenuity of the scientists to keep up in finding materials and designs for this exacting and exciting industry.

CHAPTER II

DEFINITIONS AND SOURCE OF MATERIALS

Plastics are one way of getting around the fact that Nature has not thought of everything. The ability of man to imagine things that he does not see and to fashion these things from what he finds around him is responsible for what we call progress -- and for plastics.

Plastics are synthetic materials -- that is, they do not occur in Nature but have been put together (synthesized) by man. They are, therefore, artificial materials, for which reason some people seem to think that they are substitutes and in some vague way inferior to wood or metal.

There are two reasons for this misconception. One is the sinister meaning that has come to be attached to the word "artificial." Artificial does not mean "fake" or cheap or inferior. It is derived from the Latin words *ars* (art or skill) and *facere* (to make), and in its primary sense can be translated as "made by art" or "skillfully made."[1]

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[1] "Why We Have Plastics," *Everyday Plastics*, pp.1-2

The second reason is that people are so familiar with materials like steel and glass and paper and aluminum that they forget that they, too, are artificial. They are not plucked from trees or dug out of the ground, but they are made by man, just as plastics are, from elements found in Nature.

The word "plastic" in the dictionary means "soft," "pliable, easy to bend." The Dictionary of Technical Terms gives a new meaning. It defines "plastic" as, "capable of being molded or modeled." It defines "plastics" as "non-metallic moldable compounds and the articles made from them."[2] Committee D-20 of the American Society for Plastics has defined a plastic as "any one of a large and varied group of materials wholly or primarily organic in composition, which may be formed into useful shapes by the application, singly or together, of heat and pressure." [3]

Plastics today come from two sources, the natural resins that are found in the form in which they are used, and the artificial or synthetic resinoids, which must be

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[2] Harold Cherry, General Plastics, p. 7.

[3] Everyday Plastics, op. cit., p. 2

separated from the compound in which they are found and combined with others.

Natural resins have been used for ages, and some are:

1. Pitch. Pitch was used by Noah in Bible times to calk his Ark, and paraffin is found in great quantities in oil. Both of these are of mineral origin.

2. Lac. Lac, from which we get shellac, is produced by the excretion of a tiny insect and deposited on trees; beeswax is produced by bees, and glue and gelatine are the by-products of the slaughter houses. These are known as animal resins.

3. Rubber latex, colopony, and caranaba. These are obtained from living vegetables; amber and the copals are obtained from fossilized plants and are known as the vegetable resins.

According to the definition given for plastics, the natural resins are not true plastics, but bear a close resemblance to them.

The synthetic or artificial resinoids are compounds which are produced by chemical combinations of other compounds and are the result of chemical reaction. The table which follows shows how the compounds, those that are common to us, are broken down so that they can be recombined to form plastics.

TABLE 1

COMPOUNDS AND CHEMICALS USED IN PRODUCING SYNTHETIC PLASTICS

Air	Petroleum
Oxygen	Ethylene
Nitrogen	Ketene
Ammonia	Propylene
Nitric acid	
Coal	Vegetable by-products
Coke	Wood
Carbon	Cotton
Lamp black	Bagasse (fibers from cotton stalks, sugar cane)
Tar	
Alizarin	
Aniline (dye)	Sisal
Benzene	Cocoanut
Coumarone	
Indene	
Naphthalene	Salt
Phthalic anhydride	Chlorine
Naphtha	Hydrochloric acid
Phenol	Sodium Hydroxide
Xylenol	Sulphur
	Sulphuric acid
Limestone	Water
Calcium carbonate	Oxygen
Calcium carbide	Hydrogen
Acetylene	Ammonia
Acetic acid	Menthanol
	Formaldehyde

Plastics can be in many forms to meet innumerable conditions. They may be rigid or flexible, heavy or light, liquid or solid; they may be of any color, translucent, opaque, or transparent. They may be shaped into articles like flash light cases or dishes, or woven into fabrics of many weights, from sheer dress fabrics to automobile brake linings. Or they may be used in liquid form as paints, varnishes, protective coverings and adhesives.

No one plastic is capable of serving all purposes; each one is made to fit a specific purpose and if properly handled will give long and efficient service.

CHAPTER III

HISTORY OF PLASTICS

In 1833 a French chemist Braconnet succeeded in forming a cellulose nitrate in his private laboratory, but, typical of the scientist, he was not interested in the commercial possibilities of his work, so his discovery lay dormant for nearly seventy years.

The first synthetic organic plastic is generally conceded to have been styrene, cellulose-nitrate. This material was produced in a chemical laboratory in 1839. In 1845 it was described accurately by Blythe and Hoffman. In 1846 Schoenbein, an English teacher of science, discovered a nitro-cellulose compound while teaching in Switzerland. Work on the resinoid was done while the materials were in solution, and no commercial significance was attached to them.[1]

In about the 1850's the world began to feel the shortage of ivory. The reason was, as is true today, conservation had not been thought necessary and the African elephant herds had been slaughtered unmercifully. By

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[1] Dale E. Mansberger and Carson W. Pepper, <u>Plastic Problems and Processes</u>, p. 7.

1868 the ivory shortage situation was so critical that Phelan and Collander, New York producers of billiard balls, offered a $10,000 prize to the person who could invent a satisfactory substitute for ivory for the purpose of manufacturing billiard balls.

John Wesley Hyatt, a printer of Albany, New York, began experimenting and by adding camphor to Parkesene, a cellulose nitrate already developed by an Englishman, Alexander Parkes, Hyatt produced the first plastic to be used commercially.

Hyatt, working with his brother Isaiah, took out several patents on this invention and later improvements. Approached in 1879 by Charles A. Seeley, who had had experience in collodion and was trying to find a substitute for hard rubber in denture plates, John Hyatt mixed ground celluloid -- for so he called his new material -- with coloring, found it satisfactory, and organized the Albany Dental Plate Company. So great was the demand for this and other uses, the Celluloid Manufacturing Company was organized in 1871 to take over production and sales. In 1872 the plant was moved to Newark, New Jersey, still the home of its successor, the Cellanese Celluloid Corporation of America.[2]

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[2] B. H. Weil and V. J. Anhorn, Plastic Horizon, p. 5.

The plastic celluloid was available in rods, sheets and tubes, in all colors and shades of color, as well as mixtures of colors and crystal clear. It could imitate the more expensive materials of coral, agate, marble, ivory and tortoise shell, and was adapted to many and varied uses.

Celluloid was used in transparent sheets for side curtains for the first automobiles; it was flexible and not fragile, but the ultra-violet light resulted in rapid deterioration. Later, cellulose nitrate was used for bonding material for the manufacture of laminated glass, but was soon replaced by more lightweight, stable, transparent plastics.

The contributions of this first synthetic plastic to the plastic industry have been extensive and lasting. It not only paved the way for the advances which have been made in the formulation and pigmentation of all thermoplastics, but it also supplied much of the mechanical means of manufacture and fabrication. It was the real pioneer in the development of the market for plastics and, in many cases, their uses.[3]

Celluloid remained supreme in its field until the beginning of the nineteenth century when casein, developed from

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[3] "History of Plastics," <u>Modern Plastics Magazine</u>, (July, August, September, 1940).

skimmed milk and formaldehyde, made its appearance in Europe. Casein was used extensively for small items such as buckles, buttons, and jewelry. Its use for other things was limited, however, because of its poor resistance to water, acids, and alkalis.

The next plastic to become important in this country was shellac molding. Shellac, as has been stated, is of animal origin, being produced by a tiny insect and deposited on certain trees in India and Southern Asia. It had been used for centuries for various purposes, such as a component for sealing waxes, varnishes, and polishes. Some shellac patents were issued as early as 1868. The first application of considerable size for shellac molding composition was when Emil Berliner used it in 1895 for phonograph records. He used both cellulose nitrate and hard rubber, but neither of these materials was satisfactory for his purpose. He then turned to a plastic composition with shellac as a binder, and soon the technique of molding shellac phonograph records was in full development. It is still the largest single outlet for shellac in the molding field (1940).

The third plastic material to become industrially important in this country was the bitumen plastic, most commonly known as cold molded (Earl Hemmingway, 1900). The raw materials used in cold molded plastics are asbestos, asphalts, coal tar, stearin pitches, natural and synthetic resin and oils. The proportion is seventy to eighty per cent asbestos and twenty to thirty per cent resinoid. Because of its volatility, the preparation and molding has to be done in the same plant.

Leo Hendrick Baekeland was a chemist as well as an inventor.[4] George Eastman can testify to that, as he paid Baekeland $1,000,000 in 1889 for the rights to the process for the well-known "Velox" photographic paper. In trying to find a substitute for shellac, Baekeland, in about 1900, began to experiment with phenol (carbolic acid) and formaldehyde. He was unable to prepare a substitute for shellac, but with phenol and formaldehyde heated to high temperatures in the presence of a catalyst, he created a resinous plastic that could be cast or molded under heat and pressure. This compound was hard, infusable, chemically resistant and machinable. Furthermore, it could be mixed, before final heating with innumerable fillers and pigments to yield products of many characteristics and uses.

Baekeland began commercial production of "Bakelite," as his new plastic was called, in his Yonkers laboratory in 1907, and was issued the first plastics patent in 1909. In 1919, he organized the General Bakelite Company. About

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[4] Weil and Anhorn, _op_. _cit_., p. 17.

this same time, J. W. Aylesworth and L. V. Redman each began independent manufacture of related phenolics. In 1916, controversy concerning patents arose among these manufacturers and the decision was granted in favor of Baekeland. In 1922, the three companies merged to form the Bakelite Corporation. In 1939 this corporation became a unit of the Union Carbide and Carbon Corporation, the second largest chemical concern in the United States.

In 1925 there were only five plastics on the market, cellulose, shellac, bituminous, phenolic and casein.

In 1927 cellulose acetate, which had previously been used as safety photographic film, started active development with the appearance of cellulose acetate rods, sheets, and tubes. Since cellulose acetate will not burn (it will only char), it could be used in many places where the celluloid nitrate was not suitable. Some of its uses are: protective goggles, miners' lamp housing, steering wheels and oil gauges. Toughness causes it to be excellent for saw and tool handles.

Urea-formaldehyde plastics, which came on the American market in 1929, meant the extension of unlimited color possibilities in thermosetting molding compounds. Hanns John tried to obtain a transparent urea formaldehyde plastic which would not be as fragile as glass. This organic glass was impractical because of a tendency to break soon after casting. Carlton Ellis found that the adding to the resin of a slightly hydroscopic filler produced a molding compound which could be formed into stable articles.

These materials are identical in nature with those used in molded light fixtures. They are efficient in producing a diffused light, are light in weight and shock resistant.

Cast phenolic plastics made its appearance in 1928 in the form of viscous syrup. It is poured into lead or rubber tubes and is hardened by heating. It is colorless, transparent or opaque and can be sanded and polished to a bright finish. It is popular on account of its beauty and decorative value and is often referred to as "gem of modern industry." It is easy to fabricate.

Bonding agents for various materials opened up an entirely new field of development, and molded and laminated canvas, paper, and especially plywood augmented phenolic resin utility, as did advances in moldability, speed of cure and improvement in finish, particularly noticeable in deep draw pieces such as radio cabinets.

It was also in 1939 that cellulose esters were announced. They expanded at a rapid rate and in eighteen months the automotive industry began to use them for inside hardware and appointments. By this time, polystyrene was being used extensively in electric insulation in the refrigerator industry. Methyl Methacrylate, because of optical properties and non-fragile character was used for airplane windshields, lenses, highway reflectors, illuminated signs and displays. The vinyl family claimed their share of attention in the form of interlayers for safety glass, electric wire insulation, industrial adhesives for sealing paper containers, floor tile boards, water proofing for raincoats and artificial leather. The evolution of the plastic "trade" into full scale industry was complete when the first salvos of plastic accomplishment struck the public consciousness at the 1939 New York World's Fair and San Francisco Treasure Island Exhibition. Plastics even then were indissolubles blended with every expanding force in American industry.[5]

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[5] Plastics Catalog, p. 11

CHAPTER IV

PLASTICS AT WAR

The national defense and war program mobilized the plastics industry's resources and energies, during the years 1940 to 1945. Government regulations and agencies were established to control allocation of materials, machinery and supplies.

In the initial phase, the industry concentrated on the task of tailoring existing materials to the measurement of the military form, re-tooling and marshaling its equipment and technique; but as the war expanded and limitations were recognized, the industry created entirely new materials, styled and fabricated to fit the specifications written by the services; perfected its machinery, adapted its processes to meet the high geared production demands and enlarged its capacities.[1]

No really new materials appeared in 1940, but the outstanding rise in volume was credited to the vinyl ester resins and to cellulose acetate butyrate. Nylon became prominent in the industrial fields as bristles for brushes, parachutes and the textile-printing trade.

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[1] *Plastics Catalog*, 1945, p. 12.

The aircraft industry used plastic plywood for molding airplane wings and fuselages, and resin bonded plywood was used for temporary houses. Refrigerator cars of plastic-plywood were reported to be 6,000 pounds lighter. Small plastic-plywood boats were simpler and more economically fabricated, and were superior in weather resistance. Jigs and fixtures were produced from laminates, and many laminated bearings and cams for high-speed machinery were produced.

New molded plastic parts put in their appearance, ranging from phenolic bilge pump for marine use to urea louvers for fluorescent lighting fixtures to cellulose acetate Christmas tree decorations. Styrenes were vying with each other in such productions as automotive accessories and aircraft enclosures. The acrylics produced injection molded brushes while the styrenes placed high in radio insulations and dash board accessories.

Because of shortage of formaldehyde and the phenolics in 1941, the utilization of the non-strategic and extender materials was experimented with. Ligin, which was available at low cost, yielded a molding compound that compared favorably with some of the phenolic formulations.

Aircraft manufacturers used molded, laminated, and fabricated plastics for radio antenna masts, aileron control quadrants, cabin paneling, flooring and ventilators. Fluorescent and luminescent laminates were used to illuminate aircraft instrument boards for night and blackout flying. Urea molded parts were used in weather indicators and urea windows were used for the observation of wounds.

Thermoplastics relieved the metal shortage by replacing them in machine parts; but the most extensive use was transparent acrylics for aircraft enclosures, light filters for blackout lights, molded gas mask parts, vinyl cable insulations, ethyl cellulose lacquer and coatings for shells. Styrene was requisitioned by the government for synthetic rubber.

Ethyl cellulose and the vinyls were used for raincoats, gun covers, boots and wire insulation, taking the place of rubber. A new allyl type, thermosetting transparent rosin, was used for lenses and aircraft parts.

Postforming of thermosetting laminates, first described in 1943, became an important factor in production of large parts of army bombers, including fairings, ammunition boxes, ejection chute scoops, lighting brackets and deflector rings.[2] These postformed laminate parts require approximately one third the number of tools necessary for forming of metal, cost about fifty per cent less, and are

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[2] *Plastics Catalog*, 1945, p. 18.

from twenty-five to fifty per cent lighter. The outstanding application of plastics for military purposes in 1944 was the rocket launching tube. Another noteworthy development was the production of the six by forty-two combat binocular. Aircraft safety glass of improved design and streamlined eyes for the B-29 are other outstanding 1944 transparent products. In the field of textiles and coated fabrics, more and more resins were employed, both synthetic fibers and coated fabrics, for army and navy demands. In addition to clothing and upholstery, glass fabric coated with vinyl resins produced flexible aircraft hangar doors and portable water tanks.

Some articles used by the armed forces other than those mentioned are: helmet, trench mortar fuse, tank periscope lenses, clothing for service men, ammunition boxes, destributor housing, bomb rack, life raft equipment,barrage balloon gas release valve, navigation indicator, dehydrator plugs, grips for guns, foot tubs, gas masks, whistles, water bags, water spigots, uniform insignia, safety razor, typewriter housing, radio housing, telephone equipment, cable reels and innumerable others.

The plastic industry not only gave the best of what it had to the war effort but worked overtime putting their best workmen, chemists and experienced engineers to work in all fields of research in order to develop new materials and equipment that were imperative to war needs. Through this sustained effort, more than twenty new plastics were created, subjected to rigid tests, and used in their specific place before the end of the war.

CHAPTER V

PLASTICS IN PEACE

With the advent of World War II plastics had just reached the status of a full-scale industry. The war effort gave impetus to the industry, not only by increasing the output, but by demanding new and better materials to meet specific needs. These demands and strict specifications placed upon the plastics industry by the War Department, caused the industry to expand and become more strongly unified than could have been accomplished by any other means.

Standards set for peace time are high. The plastic must fit better than any other material the purpose for which it is applied, and must either be cheaper or have such specific advantages that a higher cost can be justified. The Society of Plastics Industries with about 650 plastic manufacturers as members is endeavoring to have all plastics labeled so that consumers will know exactly what they are getting. The rate of progress in plastics since peace was declared is related as follows:

> Mr. W.S. Landes, in his address before the Society of Plastics Industries, April, 1946, pointed out that at the beginning of 1947, production of molding and

> extrusion materials should be 490 per cent of 1939 or approximately 500,000,000 pounds a year. That is nearly twice as much as 1944. If the raw materials producer can double production of molding materials in two such years as 1945 and 1946, what can they do when more equipment becomes easily available?-- by the end of 1947 --Competitive materials will probably be in much greater supply than now.[1]

Since the materials for plastics are available and the machines are converted for peace time products, just what are they going to produce? That is up to the American public. On the counters, in every room in the home, in magazine and newspaper advertisements, nearly every way we turn we find plastics in one form or another. They are made into useful articles for every day living, into decorations that are beautiful, into tile floors to walk upon, into light fixtures for diffusion of light, for coatings for the wires that bring electricity into our homes and for so many other purposes it would be impossible to name them all.

Among the war-time applications of plastics that have a definite place in every day living are the plastic optical elements successfully employed by military aviation. These plastic lenses make projection-type televisions, producing a picture the size of a newspaper page, feasible at popular prices.[2]

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[1] Modern Plastics Magazine, (June, 1946), p. 7.

[2] "Plastics in Peace," Illustrated Science Magazine, (May, 1946), p. 87.

The light-weight type low-pressure resin impregnated laminates will probably be used for all types of mobile vehicles, such as station wagons, trucks and trailers, as well as passenger cars. These same materials are the source for exterior and interior panels, scuff and scratch resisting light-weight luggage, as well as for comfortable and easy-to-move furniture.

> In the minds of a great majority of people, models and model-making is related to spare-time activity. To some, it means toy trains or small airplanes, or mantel piece models of ships. While it is true that model-making is fast becoming one of the leading hobbies of this country, this work is also playing an increasing part in industry. Industry, in general, has many uses for models.
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> In the field of advertising and sales, models have a place all to themselves. A well made model, even of the most humble objects, becomes at once a thing of interest. There is just enough of the little boy in all men to make them want to stop and look.[3]

A new plastic that will glow for several hours after it has been exposed to sunlight or other illumination is being used for street markers and house numbers. Stage scenery and costumes are resplendent with plastics, glowing and glittering in beautiful and ever changing colors. Mannequins of plastic are gracing the windows of department stores dressed in the sheerest of plastic fabrics. Plastic packaging is not only an attractive decoration,

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[3] A. H. Jennings, "Transparent Models," Modern Plastics Magazine, (June, 1946), p. 130.

but is valuable in protecting merchandise while in storage and on display. It has been used for some time in department stores but has recently been adopted by the manufacturers of tools. These wrappings have a two-fold purpose; first, the manufacturer saves by not having to put a heavy protective coating on his wares and, sceond, the consumer saves time, labor and material by not having to remove the coatings.

The buyers who attended Toy Fair in New York last March (1946) found one toy out of every four made of plastics and many others had plastic parts. The Toy Fair presented such plastic toys as: toy circus train, child's dinner plate, a picture story told on a phonograph record, and toy dishes in sets of six to fifty-five pieces. Toy trucks with such realistic features as detachable trailers, hinged doors and movable loading sections, and a boat propelled by dropping a seltzer tablet in an underwater chamber, kaleidoscopes, toy irons that resemble electric ones, cowboys, horses, men and Indians molded of plastic, fell into parade. Baby's toys displayed were designed especially to suit his majesty's requirements: unbreakable ones, light and easy to clean ones; those that come in lovely colors and those that make pleasant sounds.

When we think of all the useful qualities of plastics and look at the beautiful and ever-increasing array of articles in their lovely colors and transparent crystals, we begin to wonder if the old saying, "there is nothing new under the sun," is really true. Then, we allow our imaginations to run riot and begin to vision such things as clothes that need no laundering, bathtubs that will not soil, plastic houses that are always at the right temperature, machines that are absolutely noiseless, automobiles with plastic bodies and fenders that will neither bend nor break and will always stay polished, plastic airplanes available to everyone and vehicles in which we can visit the moon and the planets at will.

Now that we have taken a ride on the magic carpet, let us come down and consider the real future of plastics.

> Fantastic predictions by artists and designers that plastics will replace metals, wood, leather and glass in the coming 'Plastics Age' are being discouraged by conservative members of the Industry in favor of looking upon plastics as the partner of these other materials. Plastics have color; they are lighter than metals and glass; they do not rust as metal does; many of them are resistant to acids and alkalies which affect metals. They are water-resistant; they are insect-proof. Most plastics are superior to glass in their shock-resistant properties; and finally, all of them are capable of being molded into shapes impossible to obtain in these other materials or possible only through expensive machining operations.
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> Beyond these considerations, plastics have their limitations in which metals, woods, glass and leather will excel them. To the extent that these other characteristics are more important to the particular product, then plastics, as we know them, cannot hope

to replace these other materials.[4]

But plastics, as plastics, have achieved a place of honor as one of America's great industries, an industry that will expand as civilization advances.

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[4] Coated Abrasives in the Plastic Industry, p. 3.

CHAPTER VI

MANUFACTURING PROCESSES

Since plastics come from air, coal, limestone, petroleum, salt, vegetable products and water, we would like to know how plastics are manufactured. These compounds go through a series of transformations in the big chemical plants and are broken down into their various parts. For instance, from coal we get coke, coke oven gas, coal tar, and light oil; the coal tar and light oil are broken down into chemicals like benzine, analine (from which we get dye), phenol, creosotes, tuolene, naphtholene and pitch. These chemicals are combined with each other and with other chemicals in prescribed amounts according to the kind of plastics desired by the plastics manufacturer. After they are dried and reduced to powder or granular form, to make measuring easier and for convenience, the powdered or granular form is pressed into the shape of pills, tablets and in other forms; these are called "preforms." The material in powdered, granulated or preform condition is called raw material, resins or resinoids.

These resins are only a part of the finished plastics articles. They are combined with many other materials such as fillers of cotton, asbestos, chopped fabric, wood flour, cotton and sugar cane stalks. The combined raw material is now placed in drums in warehouses. The work of the plastic manufacturer is now complete as his part of the industry is just to manufacture the plastics materials.

These materials when heat and pressure are applied are plastics. All plastics are divided into two general classes: (1) thermosetting materials are permanently set or hardened into shape by the application of heat and cannot be softened again and molded into other forms; (2) thermoplastic plastics are those materials that can be formed into desirable shapes under heat and pressure and become solids on cooling. They can be molded again.

The raw materials are now sold to the molding manufacturer who takes it and molds it into the shape required of the finished article, or makes it into the forms from which the fabricator can fashion it into the finished product.

Following are the methods by which plastics are molded:

1. Compression molding, in which the raw plastics material is placed in a heated mold and it hardens or forms while it is in the mold.

2. Injection molding, in which the thermoplastic material is heated until it is in fluid form and injected under pressure into a closed mold where it hardens into a finished product.

3. Jet molding, i. e., a method of injected molding suited to thermosetting plastics used for injection of small parts or parts carrying inserts.

4. Transfer molding, in which the thermosetting compounds are made soft by heating and then injected into the cavity of the mold through suitable openings. This method of molding has made possible the production of many complicated and intricate parts.

5. Cold molding or extrusion molding, in which the raw plastic materials are fed continuously into a heated horizontal cylinder through which they are carried along and compressed by the rotation of a screw, similar to a sausage grinder. The plastic is forced through a heated die and emerges in continuous lengths (nylon threads) and is carried away on a conveyor.

6. Laminate molding, i. e., the molding or pressing of sheets of material into a designated form or shape at the time the resin, heat, and pressure are being applied to the sheets of material.

Very few compression or injection molded plastic objects are ready for use without some kind of finishing operations. From compression molded objects, fins and flash must be removed, and although injection and transfer moldings have no fins or flash, they do have a small protrusion, known as a gate, through which the material enters the mold. These irregularities must be removed before the object is finished. The flash can be removed by tumbling (placing in tumbling barrel with abrasives); fin removal is by hand filing, and gate removal is by machining (band saw). Some need miscellaneous machining operations, such as sanding; drilling, counter-boring and counter-sinking before tapping; tapping threads and the cutting of grooves. Then the natural finish must be restored by sanding, tumbling, buffing and polishing. Now the plastic part is finished and ready for printing, stamping and marketing.

There are other plastics that are not molded in the sense of becoming solid or hollow-shaped forms. They are the coatings such as paint, varnish, lacquer, and the plastics used in the manufacture of textiles. Their raw material is the plastic resin which is heated to form a liquid state, then sealed away from the air until the time it is ready for application. When it is applied it hardens in the air and forms a protective shell or coating over the material to which it has been applied.

CHAPTER VII

PLASTICS -- THEIR CHARACTERISTICS, PROPERTIES, APPLICATION AND TRADE NAMES

The confusing factor for the reader or student in plastics, in the beginning, is the terminology and names by which plastics are called. In reading a magazine article a plastic may be called by several names. For instance, one plastic may be called cellulose acetate;in the next sentence it may be referred to as a cellulose or as an acetate; then,it may be called a thermoplastic, or finally, by one of these names: Fibestos, Lumapane, Lumarinth, Nixonite, Macite, Protectoid, Kodapak, Plastacele, Tenite I, Vinlite, Vuelite, Vuepack, or Cenaco Cellulose Acetate.

To clarify this situation, cellulose acetate would be the name of the chemical compound of which the article is made; cellulose is the family name of all compounds containing cellulose; thermoplastic is the name depending on the way a plastic is formed when heat and pressure are applied, and finally, the manufacturer labels his product made from cellulose acetate with his own trade name.

A list of plastics materials is given here, to be used as a reference, giving their chemical compositions, something about them and either their characteristics or properties, their application and trade names.

Phenolic Resins (Molding Type)

Resistant to heat, water, organic solvents, acids and mild alkalis.

Lack of color stability.

Will shrink around metal inserts and hold tightly.

General purpose shock resistant, heat resistant, high frequency insulation material.

Application.--Ammunition fuses, electrical insulation, telephone equipment, rifle bayonet, machine tools parts.

Trade names.--Bakelite, Durez, Durite, Heresite, Indur, Inruok, Makalot, Neilite, Resinox, Textolite.

Furane Resins

Prepared from oat hulls and corn cobs.

Application.--Adhesives, some forms of plastic and rubber coatings, impregnants.

Trade names.--Resinox, Duralon.

Phenol -- Furfural Resins

Made from waste farm products: rice hulls, oat and cotton seed hulls, also corn cobs.

Application.--Abrasive grinding wheel, frictional stocks, bayonet scabbards, helmet liners.

Trade name.--Bakelite.

Phenolic Resin Boards and Blanks

A medium high impact material, used where small molded parts, cams for instance, must have high mechanical strength.

Application.--Radio communications equipment, machete handles, electrical insulation for aircraft, binocular frames, cafeteria trays.

Aniline-Formaldehyde Resin

Its low-loss properties and exceptional electrical stability under the influence of moisture and at ultra-high as well as commercial frequencies suit aniline-formaldehyde resins for applications in radio fields and in the expanding television industry.

Trade names.--Cibanite, Dilectene, Lucite and Plesiglass.

Resorcin-Formaldehyde Resin

Able to cure at low temperature, dark color cannot be used for decoration.

Application.--Large moldings, heavy laminated sections, thick plywood structures, large grinding wheels, adhesive and coatings.

Trade names.--Pencolite, Bakelite resourcin-formaldehyde.

Phenolic Sisal Plastics

Long cordage fibers, sisal as filler.

Application.--Engine covers, abrasive desks, helmets, furniture, Jettison tanks.

Trade names.--Co-Ro-Lite, Co-Ro-Felt.

Phenolic Pulp Products

Application.--Refrigerator doors, typewriter and adding machine housing, radio cabinets, serving trays, dishes.

Trade names.--Kysite, Hawley Resin Fibre.

Cast Phenolic Resins

High tensile and impact strength, unlimited color ranges, excellent water resistant, good dimensionable stability, excellent machining qualities, tasteless, odorless; by employing split molds the range of possible designs in castings is almost unlimited and the resulting molds are ready for use with minor finishing operations; cast shows negligible shrinkage on aging; non-inflammable, rigid.

Application.--Automobile parts, clock cases, jewelry, sign letters and buttons, hose nozzles.

Trade names.--Bakelite Cast Resinoids, Baker-Cast-Resinoids, Catalin,Catavar,Catabond, Dures Cast-Resins, Gemstone, Margelette, Opalon, Prystal.

Urea Resins

All resins are truly synthetic since all basic raw materials are derived from gases, ammonia, carbon dioxide, hydrogen and carbon monoxide. They are water-clear, water soluble and fusible, unlimited colors, odorless and tasteless, rigid, hard-surfaced and are thermosetting.

Application.--Closures, display boxes, tableware, lighting reflectors, electric wiring devices, impregnating paper, illuminated instrument dials, baking enamels any color, textile finishes, surgical items, plywood and veneer bonds.

Trade names.--Bakelite Urea, Beetle, Plaskon, Sylplast, Ufomite.

Melamine Resins

Thermosetting, arc resistant, odorless and tasteless, heat and abrasion-resistant, resistant to hot water, organic solvents, alkalis and weak acids.

Application.--Paper impregnation and coating, telephone handsets, panel board, circuit breakers, baking enamel, bonding materials for laminates, paper, asbestos.

Trade names.--Malamac,Catalin, Melamine, Plaskon-Melamine, Melatin,Resimene.

Allyl Resins

Cures without pressure, dimensional stability, hardness abrasion resistance, heat distortion resistance, solvent resistance,moisture resistance, colorability, transparency, good electrical properties, adhesiveness.

Application.--Laminated sheets and parts, molding, coating compositions, lenses, aircraft parts, plywood and veneer board.

Trade names.--MR 1-A Resins.

Cellulose Acetate

Truly thermoplastic, mechanical strength, transparency, colorability, fabricating versatility, high electrical strength.

Application.--Packaging foils, military cap and collar insignia, toilet accessories, transparent machine guards, paintbrush bristles, electrical insulations, toys, oxygen tents.

Trade names.--Fibestos, Lumapane, Lumarith, Nixonite, Macite, Protectoid, Kodapak, Plastacene, Tenite 1, Vimlite, Vuelite Vuepack, Chemaco Cellulose Acetate.

Cellulose Acetate Butyrate

Low water absorption, high dimensional stability, good weathering resistance, high impact strength, availability in colors, improved finish.

Application.--Army insignia, bomber visor, bugles, counter nosing, hinges, housings, name plates, steering wheels, surgical instruments, vacuum cleaner parts, sink strainers.

Trade name.--Tenite II

Cellulose Nitrate

Water resistance, ease of fabrication, ease of cementing, toughness, colorability, flammability.

Application.--Mallet heads, drawing instruments, guide card tabs, airplane propeller covers, mechanical pencils, airplane windshields, belting interliner, pipe line wrappings, dominoes, plumbing fixtures, piano keys.

Trade name.--Amerith, Celluloid, Hercules, Cellulose, Nitrate Flakes, Nitron, Nixonoid, Pyralin, Kodaloid.

Ethyl Cellulose

Water resistant, toughness, high impact, cold temperature resistance, colorability, dimensional stability, heat resistance, surface hardness, low density, resistance to weathering, solubility in cheap and available solvents. Alkali resistance, good electric qualities.

Application.-- Airplane and truck parts, trim moldings, moisture proof match box, cable cores, strippable coatings, electric appliances, paper and wire coatings, drill jigs and forming dies.

Trade names.--Ethocel, Ethocel PG, Chemaco Ethyl Cellulose, Lumarith E.C., Nixon Ethyl Cellulose, Dow Q-310.

Benzyl Cellulose

Softer than any other common cellulose derivatives.

Application.--Hot melted coating extruded on wire for electrical insulation.

Trade name.--Hercules Benzyl Cellulose

Cellophane (Regenerated Cellulose)

Application.--Sealing wrappers, food protectors, packaging for machinery to protect in place of heavy coatings of grease and oil, used for electrical equipment from "walkie-talkie" to heavy battleship cables, protection from grease and oil.

Trade names.--DuPoint, Cellophane, Sylvanio Cellophane.

Sodium Carboxymethylcellulose

Powder readily soluble or dispersed in hot or cold water.

Application.--The formation of boiler compounds, creaming latex, oil drilling muds, ceramics, leather finishes and insecticides.

Trade name.--C. M. C.

Alkyd Resins

Color and gloss retention under severe conditions, ease of application, ready solubility, varied compatibility, good film building, excellent adhesion to metals and other surfaces, wide range of properties, quick drying.

Application.--Air drying enamels, tin decorations, printers' ink, metal primers and finishes, aircraft lacquers, automobile finishes, coated fabrics, marine paint.

Soft modified alkyds trade names.--Amberlac, Aquaplex, Arochem, Aroplaz, Bakelite C-9, Bedkosol, DuLux, Duraplex, Dyal, Dymal, Esteral, Falaloid, Falkyd, Gypral, Myrasol, Paraplex, Rezyl, Synleex.

High melting point trade names.--Sylkyd, Amberol, Bedkacites, Levisol, Paranols, Pentalyn, Pentrex, Teglac.

Acrylic Resins

Range from soft, sticky,semi-liquids to hard, tough thermoplastic solids. Superior transparency, permanence of dimensions, edge lighting, lightness, dielectric strength, colorability.

Application.--Aircraft and marine windows and clear enclosures, antenna housing, magnifying glass, dentures, teeth inlays, dresser sets, ink distributing rollers, illuminating instruments (medical), surgical and industrial, water pump parts, flashlight extension rods, gun turrets, ear plugs, laminated glass interlayer, adhesive and protective coatings, display and signs, pipe stems, furniture and trim, artificial eyes.

Polyvinyl Alcohol

Water solubility, resistance to oil and most organic solvents, impermeability to oxygen, nitrogen, and other gasses, emulsifying process, adhesive characteristics, film forming characteristics, moldable thermoplastic, high tensile and tear strength, excellent abrasive resistance, non-toxicity.

Application.--Adhesive, binder, used for sizing nylon, a size and coating material for paper.

Vinyl Acetate Resins

Interlayer sheeting for safety glass, molding compounds.

Application.--Safety glass, cloth coatings, bonding, resins, protective coatings by flame spraying, gas impermeable fabrics, boats and flotation gear.

Trade name.--Alvar,Butacite,Butvar, Formvar, Saflex, Vinylite X, Vynate.

Vinyl Ester Resins

Odorless, tasteless, non-toxic, slow-burning, lightweight, colorless thermoplastic which has low water absorbent characteristics.

Application.--Rigid sheets, laminating film, flexible sheeting and film, coated papers, record preforms.

Trade names.--Vinlite resins, Vinylseal adhesive solutions, Vinyon fiber, Koroseal, Korogel, Koron, P.V.

Acetate, Chemaco Vinyl Chloride, Gelva, Geon.

Vinylidene Chloride Resins

Good resistance to water, acids, alkalis and organic solvent.

Application.--Furniture webbing, transportation seat covers, fishing leaders and line, belts and suspenders, abrasive wheels.

Polyethelene

Resins are semi-rigid, waxy translucent plastics, high in electrical symmetry.

Application.--Cables, condensers, lacquers, hose linings for beverage containers, sutures, filter cloth, lamp shades.

Trade names.--Alkathene, Polyethylene

Styrene Resins

Crystal clarity, low specific gravity, excellent electrical properties, colorability.

Application.--Closures for chemical bottles, photographic equipment, colorability, medicinal equipment.

Trade names.--Bakelite Polystyrene, Chemaco Polystyrene, Loolin, Lustron, Polyfibre, Styramic, Styrannic HT, Styron Styraloy.

Nylon Molding Powder

Insoluble in common organic solvents, alkalis and weak mineral acids, molded either by injection or extrusion.

Application.--Coating of fabrics, wire covering, slide fasteners, faucet washers, ladies' hose.

Commarone -- Indine Resins

Available in viscous liquids, colors from water-white to almost black, water soluble emulsions.

Application.--Mastic floor tile, rubber compounding, printing ink, chewing gum, radio coils.

Polyterpene, Hydrocarbon Resin

Resistance to water, alkali, acid, brine and alcohol. Low specific gravity, solubility in petroleum solvents. Color stability.

Application.--Protective coatings, rubber adhesive, cold molding compositions, chewing gum.

Trade names.--Nyphene, Piccolyte.

Shellac

Arcing resistance, adhesion, hardness, high gloss resilience, ease of molding.

Application.--Electric insulations, protective coating, phonograph records, rapid-dry varnishes.

Silicone Resins

Clear white liquids that remain fluid at arctic temperatures, low rate of viscosity change over wide range of temperatures, neutral in reaction, chemically inert, non-corrosive to metals, makes glass, ceramics and metals water repellant, highly resistant to oxygen, oxidizing agents, mineral acids and corrosive salt solutions.

Trade name.--Silicones

Caseins and Other Protein Plastics

Non inflammable, ease of machining and polishing, colorability.

Application.--Buttons, novelties, trimming accessories.

Lignin Plastics

Lignin is the organic compound which cements the cellulose fibers together in wood and other plants. It is a natural compound and is available in large quantities.

Application.--Used as an extender for varnishes, molding resins and adhesives.

Plastics from Agricultural Products

Bagasse is the sticky, pulpy mass left after the sugar is extracted from sugar cane.

Resin is dark-brown, hard and brittle.

Trade names.--Valite, Noreplast.

Some by-products of the farm used as fillers in the manufacture of plastics are: oat hulls, corn cobs and cotton stalks. Other fillers are: wood flour, cotton, asbestos, glass fibers, walnut shell flour.

Other materials used in the manufacture of plastics that we hear much of are the Ion exchange resins, coloring material for plastics, which is a large field. Color blending and matching and the judging of color effects are arts requiring highly skilled colorists. Luminescent pigments are taking their place in the field of lighting; also the plasticizers are being used with plastics to make them less brittle or to make rigid materials more flexible. Then the solvents have their definite place in the field; some of them are: esters, alcohols, ketones, ether-alcohols, ester-alcohols and nitro parrafines.

We Americans have the vision and vitality of a free people. We have the precedent of a vast industrial achievement, and from the urgent necessity of production for war we have evolved new ideas, new methods, new materials to meet the future's inevitable demand for better things. Post-war plastics promise infinite possibilities.[1]

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[1] <u>Plastics Catalog</u>, 1944, p. 359.

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