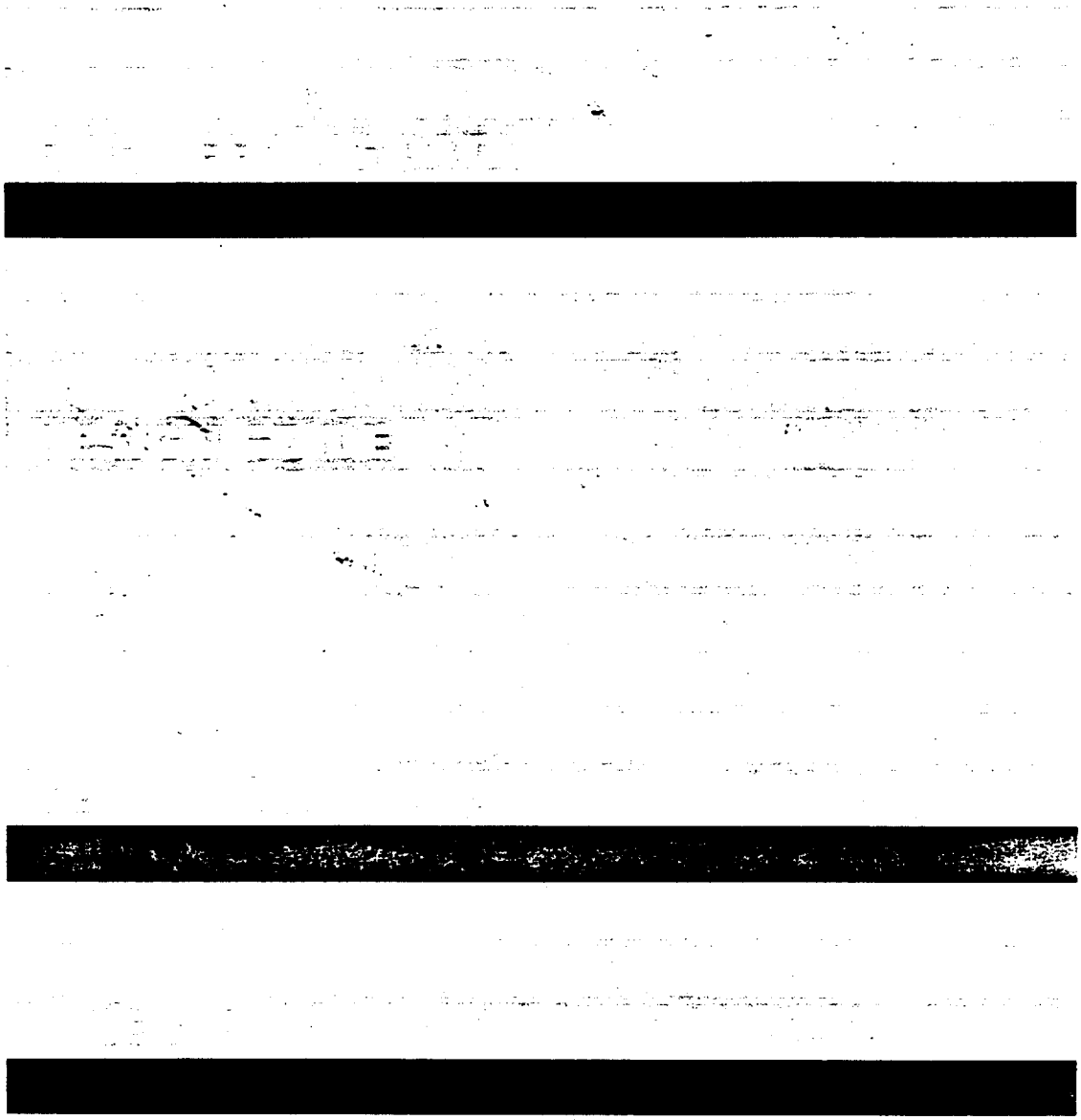
MODERN PLASTICS ENCYCLOPEDIA



HOW TO USE THE MODERN PLASTICS ENCYCLOPEDIA

The Encyclopedia is organized into four basic sections, each planned to serve a different need:

1 For broad and general information about materials and processes, The Textbook (pp. 4-477) : What is high density polyethylene? How do antioxidants work? What is stretch-blow molding? These are the types of questions the Textbook is designed to answer.

The Textbook contains 169 articles that provide information in the areas of Materials, including resins, foams, films, sheeting, alloys; Composites, including laminates and reinforced materials; Chemicals, additives, fillers, property enhancers, and reinforcements; Primary processing, including testing, tooling, and auxiliary equipment; and Fabricating and finishing. Arrangement of articles is in alphabetical sequence by subject within each category. See listing of Contents, p. 2.

2 For systematic guidelines to the meaningful use of plastics properties in material selection, The Design Guide (pp. 479-512) : What are the key steps in choosing a polymer for a plastics application? What is the meaning of "creep strength" and how can this property be related to my design requirements? What are the effects of elevated temperature exposure on electrical properties, for example, or on chemical resistance? These are the types of questions the Design Guide is designed to answer.

The Design Guide provides the conceptual background and the practical considerations involved in making a product that works, and in making it at the lowest cost. Designing products for rigidity and strength under load and selecting materials for elevated temperature performance and for chemical, impact, and fatigue resistance are covered. Other sections describe proper use of creep data and the torsion pendulum test. See the Design Guide Contents, p. 479.

3 For precise design and specification data on materials and equipment, The Engineering Data Bank (pp. 513-824) : What specific material will meet my service temperature requirements of 200°F. continuous? Is there a transparent plastic that can be used in a mildly alkaline environment? What material would meet Underwriters Laboratories' V-0 rating and also have good weatherability? What types and sizes of RIM equipment are available? These are the types of questions the Engineering Data Bank is designed to answer.

The Engineering Data Bank provides detailed information on properties and characteristics of specific plastics materials, chemicals for plastics, and processing machinery arranged in tabular form, with most products keyed to individual suppliers and trade designations. Lists also are keyed to advertisements containing additional product information. The Machinery specifier gives detailed specifications on more than 4200 machines. See the Engineering Data Bank Contents, p. 513.

4 To reach individual suppliers of products and services, The Directory of Suppliers (pp. 825-938) : Looking to locate . . . Someone who sells high density polyethylene in powdered form? Complete extrusion-blow molding systems? Is in your area and can custom injection mold a thermoplastic part? These are the types of questions the Directory of Suppliers is designed to answer.

The Directory of Suppliers lists products and services for more than 4800 companies. Complete addresses, including phone numbers when possible, are given for each company. Boldface listings are keyed to advertisements which offer additional product and services information. See the Directory of Suppliers Classified Index, p. 826.

TEXTBOOK

MODERN PLASTICS ENCYCLOPEDIA

OCTOBER 1981 VOLUME 58, NUMBER 10A

DESIGN GUIDE

ENGINEERING DATA BANK

Flammability data and numerical flame spread ratings presented in the Encyclopedia are not intended to reflect hazards presented by the materials under actual fire conditions.

DIRECTORY OF SUPPLIERS

 ISSN 0085-3518/81$0.00+1.50.

Modern Plastics Encyclopedia is published annually by McGraw-Hill Inc., 1221 Ave. of the Americas, New York, NY 10020. Executive, editorial, and advertising offices, 1221 Ave. of the Americas, New York, NY 10020. Phone: 212-997-1221. Teletype: TWX-710-581-4879. Cable: McGraw-Hill, N.Y. Please mail all circulation correspondence, subscription orders, and change of address notices to: Modern Plastics, Fulfillment Mgr., P.O. Box 430, Hightstown, NJ 08520. Modern Plastics has no connection with any company of similar name. Modern Plastics Encyclopedia printed in U.S.A. Modern Plastics issued monthly, 1221 Ave. of the Americas, New York, NY. Modern Plastics Encyclopedia issue published as second issue in October. Modern Plastics Encyclopedia is distributed to Modern Plastics subscribers as part of subscription service. Modern Plastics subscription rates (including Modern Plastics Encyclopedia issue) for manufacturing, engineering, and R & D companies, also government and schools, in the U.S. and its possessions, 1 year $24, 2 years $36, 3 years, $51; in Canada, 1 year $CDN 35, 2 years $CDN 52; 3 years $CDN 74. Rates for other companies in the U.S. and its possessions $30 per year; Canada $CDN 42 per year. Single copies (except for Encyclopedia issues) $4.50 each, $CDN 5. For subscriber service, call collect 609-448-8110 in the U.S. except Alaska and Hawaii. The name 'Modern Plastics' is Registered (R), U.S. Patent Office.

MOPLAY 58 (10A) 1-942 (1981)

Polystyrene

By L.J. McCrann

Polystyrene (PS) is the fourth-largest volume thermoplastic. Commercially developed in the 1930s, PS can be produced by mass (bulk), suspension, emulsion, or solution polymerization. Mass polymerization is the most commonly used method in commercial production but suspension polymerization also is widely used, especially in the production of expandable beads. Polystyrene grades can be grouped into the following categories: crystal PS, rubber-modified impact PS, expandable PS, and specialty grades. Styrene copolymers and terpolymers, such as styrene-acrylonitrile (SAN) and acrylonitrile-butadiene-styrene (ABS), are discussed separately in other articles.

Polystyrene is an odorless, tasteless, rigid thermoplastic that has good dimensional stability, colorability, electrical insulation properties, and resistance to most ordinary chemicals. However, it does exhibit relatively poor resistance to ultraviolet radiation and is readily attacked by most aromatic and chlorinated hydrocarbons. Most grades begin to soften or distort between 160 and 195° F.; some high heat grades have softening points under load at slightly over 200° F. Physical properties are greatly affected by the molecular weight and molecular-weight distribution. These two factors can vary greatly and generally are dependent upon the polymerization process.

Crystal PS is a clear water-white rigid material. Typical physical property values include specific gravity of 1.05, tensile strengths of 6000 to 8000 p.s.i., tensile modulus of 400,000 to 500,000 p.s.i., Izod impact of 0.2 to 0.5 ft.-lb./in. of notch, and elongation of approximately 2%. About 40% of all homopolymer PS production is in the crystal grades, but their brittleness prevents use in many applications. Brittleness is overcome by dissolving polybutadiene rubber in the styrene during the polymerization process. This rubber-modified version commonly is called impact PS. Rubber modifiers also can be added after styrene polymerization to crystal and impact PS to further change the polymer's properties. Impact PS is a translucent to opaque white material with a specific gravity of 1.05, tensile modulus of 250,000 to 350,000 p.s.i., tensile strength of 2000 to 5000 p.s.i., Izod impact of 0.6 to 4 ft.-lb/in. of notch, and elongation of 10 to 50%. Clarity and some gloss generally are sacrificed in the impact grades.

Expandable PS is generally produced by a suspension-type polymerization process. Usually an organic blowing agent is introduced during the polymerization process. The blowing agents can also be added to crystal and impact grades by steeping to manufacture EPS products.

EPS when expanded results in a low density cellular structure. Expanded EPS is available in a wide range of densities, depending upon pneumatogen content and molding and/or extrusion conditions. All properties are influenced by the degree of fusion. Mechanical strength of EPS generally increases with increase in density as cushioning properties decrease. EPS does not become brittle at sub-zero temperatures but may expand or blister when exposed to elevated temperatures. Generally, EPS has the same resistance to chemical reagents as crystal PS; however, chemicals which only affect crystal PS to a minimal degree may collapse the foam cells of EPS. EPS is opaque and white in its natural state and coloring generally is limited to pastel-type colors, with a few exceptions.

Specialty grades

Polystyrenes are modified in many ways to meet the specific needs of the applications. Product modifiers such as flame-retardant additives, UV inhibitors, antistatic agents, chemical blowing agents, extenders, and reinforcing agents are added during polymerization, by specialty extrusion compounding or during final processing. Often when modifying PS to achieve or improve a specific property it is done at the expense of another property value.

Flame-retardant PS grades with Underwriters Laboratories' V-0 ratings are readily available. The addition of flame-retardant additives sometimes means a decrease in UV stability and a slight increase in specific gravity. Most flame-retardant grades are in impact PS and only opaque colors are commercially available.

Modified crystal PS grades currently are used for the manufacture of phonograph record compounds. High-heat crystal and impact grades can be manufactured with a heat deflection temperature (ASTM D648-72) that exceeds 210° F. Generally these higher molecular-weight grades have lower melt flows and may require some end-use processing modifications. Weighted or heavy PS is manufactured; billiard balls are a typical application. Densified PS is also being used where the feel and weight of previously metal products is desirable.

Processing

Polystyrene can be processed by every common thermoplastic processing method. Under normal conditions, it does not absorb or retain moisture so

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predrying usually is unnecessary. Polystyrene is amorphous and does not have a distinct melting point; processing temperatures generally range between 360 and 450° F.

Slightly greater than half of all solid PS is injection molded. Fast setup, low shrinkage, and good dimensional stability are some of the factors that make the material ideal for rapid molding. Product design characteristics and injection molding equipment and techniques are the key factors in determining the final molding cycle. Crystal and impact PS are structural foam molded, utilizing either high- or low-pressure techniques.

Extrusion is the second-largest method for processing PS.

Because of its inherent easy processibility, crystal PS, impact PS, and EPS are suitable for sheet, profile, and pipe extrusion. Two different grades of PS can be successfully coextruded into sheet to yield a finished product that utilizes an important property of each grade. An example is the coextrusion of impact PS with crystal PS into sheet that has the needed impact, toughness, and deep-draw capabilities of the impact grade and the high gloss of crystal. With processing, labor, and energy costs becoming increasingly important, in-line sheet extrusion/thermoforming processing methods are quite often used.

EPS beads generally are processed in one of three ways: 1) gravity or air-fed into closed molds and heated to expand up to 50 times their original volume; 2) pre-expanded by heating and then molding in a separate processing operation; 3) and extruded into sheets of various thickness.

Most techniques for post finishing, assembling, and decorating thermoplastics are successful with PS. Ultrasonic, solvent and spin welding, gluing, and nailing are common methods of assembly. Electroplating, vacuum metallizing, painting, and hot stamping are common decorating techniques. Certain solvents and paints may attack and distort the PS surface.

Applications

Polystyrene is used in applications in the following major markets (listed in order of consumption): packaging, consumer/institutional goods, electrical/electronic goods, building/construction, furniture, industrial/machinery, and transportation.

For packaging, most PS grades comply with the requirements of the U.S. FDA Food Additive Regulation 177.1640. Most ingredients are exempt from regulatory requirements on the basis of Prior Sanction, Generally Recognized as Safe (GRAS) categorization. These regulations generally apply to natural grades. Colors must be analyzed separately.

Crystal PS biaxial film is formed into meat and vegetable trays, blister packs, and many other foodstuff packages where clarity is required for effective marketing. Extruded foam sheet is formed into egg carton containers, meat and poultry trays, and fast food containers where hot or cold insulation is required. Solid PS sheet is formed into drinking cups, lids, and disposable packaging of edibles. Injection molded grades are used extensively in the manufacture of cosmetic and personal care containers, jewelry and photo equipment boxes, and photo film packages.

For the consumer/institutional goods market, impact PS sheet is formed into refrigerator door liners. Household items such as toys, audio and video cassette cartridges, flower pots, picture frames, and kitchen utensils are manufactured from PS. Disposable drinking tumblers and cutlery consume a large volume of the material.

Television cabinets are injection molded of flame-retardant impact PS. Radios, electronic games, home smoke detectors, and computer housings are other examples where the material can be used.

In building/construction, EPS board is being used extensively as a low-temperature insulator. Extruded profile moldings are used throughout the construction/home-building industry.

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