

# **Plastics** **edition 8**

## **Thermoplastics and Thermosets**

**desk-top data bank®**

**D.A.T.A., INC.**  
a Cordura Company

# Plastics

## edition 8

### Thermoplastics and Thermosets

江苏工业学院图书馆  
藏书章

**desk-top data bank®**

**D.A.T.A., Inc.**  
**A Cordura Company**

Property values reported in this publication should be used as a guide to the performance of the materials, not as specification data upon which designs can be based. In all cases, we recommend that you consult with the manufacturer before final selection of the plastic is made.

# **Plastics edition 8**

## **Thermoplastics and Thermosets**

### **a desk-top data bank®**

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## **PUBLISHER'S FOREWORD**

I.P.S. has actively sought out, researched, and compiled technical data from leading U.S. producers of thermoplastics & thermosets. This information, currently residing in our data bank, is presented here in book form as a convenient reference source. By utilizing the appropriate index(es), or ranked listing, or principal property section you will be able to locate additional relevant information on the plastic you require.

Please read the "How to Get the Most Out of This Book" section. This will help you determine the best starting point for your search. We also suggest that you read the introductory paragraphs before each main section of the book to get a more complete understanding of how the information is presented.

All of the data in this publication is in our computer data base. Please call 619/578-3910 for information on leasing magnetic tapes of the data, or on how to access and search the file via an on-line computer system.

We invite all subscribers to this publication to contact us with any new or revised industry data that can be incorporated into the next edition of Plastics. Thank you.

# How to Get the Most Out of this Book

Are you interested in . . .	Turn to this section!	Page
. . . <i>physical, mechanical, thermal and electrical properties of individual grades of plastics?</i>	The <b>Principal Properties</b> section lists property values as reported by the manufacturers for over 9000 commercially available plastics.	..... 1
. . . <i>locating a plastic that meets a specific property value or falls within a range of property values?</i>	The <b>Ranked Properties</b> section sorts values (from highest to lowest) for 22 properties. They are grouped by generic type so you can find, for example, a Nylon 6 that has the necessary tensile strength.	..... 769
. . . <i>a brief description of the various generic types of plastics?</i>	The <b>Survey of Generic Types</b> discusses the development of each plastic, its chemistry, its advantages and its disadvantages.	..... A-1
. . . <i>property ranges of generic types of plastics?</i>	The <b>Properties of Generic Types</b> presents tables of generic types of plastics and the range of values that may be expected for key properties. The <b>Bar Charts</b> section gives a quick visual comparison of property values for various generic types of plastics.	..... A-15 ..... A-29
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. . . <i>a qualitative summary of chemical resistance data?</i>	The <b>Chemical and Environmental Resistance</b> section reports the qualitative effects of acids, bases and other environmental factors.	..... A-101
. . . <i>how plastics are tested and evaluated?</i>	The <b>ASTM Test Description</b> gives summaries of the 60-plus procedures to determine the full range of plastics' properties.	..... A-113
. . . <i>how plastics can be machined?</i>	The <b>Machinability Section</b> reviews the sparse data on shaping plastics after they are formed.	..... A-109
. . . <i>knowing what the generic type or manufacturer of a plastic is when you only have the commercial name?</i>	The <b>Commercial Name Index</b> lists alphabetically every plastic, giving the manufacturer and the generic type.	..... 1331
. . . <i>knowing what types of plastics a certain manufacturer makes?</i>	The <b>Manufacturers Index</b> groups all of the plastics by their manufacturer, listing the commercial name and generic type of the plastic.	..... 1289
. . . <i>what commercially available plastics there are of a given generic type?</i>	The <b>Generic Type Index</b> lists each plastic by its generic type, plus its manufacturer.	..... 1247
. . . <i>how to contact the manufacturer for additional information?</i>	The <b>List of Manufacturers and Suppliers</b> gives the principal place of business of the 180 plus producers or distributors.	..... 1391

# Notes on Properties, Units, and How Data are Listed

<u>Property</u>	<u>Significance/Comments</u>	<u>Units</u>		<u>ASTM Test</u>
		<u>English</u>	<u>Metric</u>	
Processing Methods	The kind of processing (extruding, molding, casting, etc.) techniques recommended by the manufacturer.			
Processing Temperature	An average value is given rather than the temperature range often specified by the manufacturer.	°F	°C	
Injection Molding Pressure	The pressure applied to the cross-sectional area of the molding cylinder.	lb/in <sup>2</sup>	kg/cm <sup>2</sup>	
Linear Mold Shrinkage	The difference between the size of the part and the size of the mold cavity. Values given are often the average of a range.	in/in		D955
Melt Flow	Rate of extrusion of molten resin through a die of a specified length and diameter. The conditions of the test (e.g. temperature and load) should be given. Frequently, however, the manufacturers' data lists only the value, not the condition as well.	g/10 min		D1238
Density	The equivalent property to specific gravity; measured by displacement.	lb/ft <sup>3</sup>	g/cm <sup>3</sup>	D792
Tensile Strength, Yield	The maximum stress that a material can withstand without yielding when subject to a stretching load.	lb/in <sup>2</sup>	kg/cm <sup>2</sup>	D638
Tensile Strength, Break	The maximum stress that a material can withstand without breaking when subjected to a stretching load.	lb/in <sup>2</sup>	kg/cm <sup>2</sup>	D638
Elongation, Yield	The increase in distance between two gauge marks at a yield point divided by the original distance between the marks. A zero value in the field indicates that it measured less than one.	%		D638
Elongation, Break	The increase in distance between two gauge marks at the break point divided by the original distance between the marks. A zero value in the field indicates that it measured less than one.	%		D638



<b><u>Property</u></b>	<b><u>Significance/Comments</u></b>	<b><u>Units</u></b>		<b><u>ASTM Test</u></b>
		<b><u>English</u></b>	<b><u>Metric</u></b>	
Tensile Modulus	(Also called modulus of elasticity). The ratio of nominal stress to the corresponding strain below the proportional limit of a material.	lb/in <sup>2</sup>	kg/cm <sup>2</sup>	D638
Flexural Strength, Yield	The measure of resistance of the material to fracture during bending.	lb/in <sup>2</sup>	kg/cm <sup>2</sup>	D790
Flexural Modulus	The ratio, within the elastic limit, of the applied stress on a test specimen in flexure to the corresponding strain in the outermost fibers of the specimen.	lb/in <sup>2</sup>	kg/cm <sup>2</sup>	D790
Compressive Strength	The ability of a material to resist a force that tends to crush it.	lb/in <sup>2</sup>	kg/cm <sup>2</sup>	D695
Izod, Notched, RT	The energy required to break specimens in which there is a v-notch to create an initial stress point (The value 999 in the tables indicates that the specimen did not break.)	ft lb/in	kg cm/cm	D256
Izod, Notched, LT	The energy required to break specimens in which there is a v-notch to create an initial stress point but measured at low temperature (minus 40°C). (The value 999 in the tables indicates that the specimen did not break.)	ft lb/in	kg cm/cm	D256
Hardness	The resistance of a material to compression, indentation and scratching. There are several scales, and the data in the book gives both the scale used and the value on it.			
Thermal Conductivity	The rate of heat flow under steady-state conditions through unit area per unit temperature gradient in a direction perpendicular to an isothermal surface.	BTU in/ hr ft <sup>2</sup> °F	cal cm/ sec cm <sup>2</sup> °C	C177
Linear Thermal Expansion	The fractional change in length of a material for a unit change in temperature.	in/in °F	cm/cm °C	D696
Vicat Softening Point	The temperature at which a flat ended needle will penetrate a specimen under a specified load using a uniform rate of temperature rise.	°F	°C	D1525
Brittle Temperature	A measure for judging the relative merits of materials for low temperature flexing or impact - i.e., the temperature at which materials rupture by impact under specified conditions.	°F	°C	D746

Property	Significance/Comments	Units		ASTM Test
		English	Metric	
Continuous Service Temperature	The highest temperature at which a material can perform reliably in a long term application - long term being, however, inconsistently defined by the manufacturers.	°F	°C	
Deflection Temperature, 264 lb/in <sup>2</sup>	The measure of temperature at which a specimen deflects 0.01 inches under a load of 264 lb/in <sup>2</sup> .	°F	°C	D648
Deflection Temperature, 66 lb/in <sup>2</sup>	The measure of temperature at which a specimen deflects 0.01 inches under a load of 66 lb/in <sup>2</sup> .	°F	°C	D648
U.L. Temperature Index	The maximum temperature below which a material maintains its electrical and mechanical integrity over a reasonable period.	°C/mm		
Volume Resistivity	The measure of ratio of the potential gradient parallel to the current in the material to the current density.	Ohm cm		D257
Surface Resistivity	The ratio of the potential gradient parallel to the current along its surface to the current per unit width of the surface.	Ohm		D257
Dielectric Strength	The voltage that an insulating material can withstand before dielectric break-down occurs.	V/10 <sup>-3</sup> in	V/mm	D149
Dielectric Constant	The ratio of the capacity of a condenser made with a particular dielectric material to the capacity of the same condenser with air as the dielectric. Measured at a frequency of 10 <sup>6</sup> cycles per second.	Constant		D150
Dissipation Factor	The ratio of the power dissipated in watts in an insulating material to the product of the effective voltage and the current. Measured at a frequency of 10 <sup>6</sup> cycles per second.	Constant		D150
Refractive Index, Sodium D	The ratio of the velocity of light in a vacuum to its velocity in the material.	Constant		D542
Water Absorption, 24 hours	The percentage of water absorbed by a material when immersed in water for 24 hours; water absorbed in a material chiefly affects its electrical properties.	%		D570
Effect of Strong Acids	A descriptive notation to indicate the material's performance.	Text		D543

Note 1 - Please see the fuller descriptions of ASTM tests for more information on test procedures (pages A113).

Note 2 - Please note that a given plastic in this publication will have data presented on only 23 of the above 30 properties.

Note 3 - We list average values rather than ranges in order to make comparisons more easy to make, both visually and in computer-based search systems. Frequently we take a manufacturer's range and give its average value.

Note 4 - Frequently it is clear from the property values of a plastic that a filler is present, even though the manufacturer does not list what it is. In these instances we have indicated that the material contains "Unspecified Filler".

# Common Acronyms

<b>ABS</b>	Acrylonitrile-butadiene-styrene	<b>FDA</b>	Food & Drug Administration	<b>PA</b>	Polyamide (nylon)	<b>PP</b>	Polypropylene
<b>ACS</b>	Acrylonitrile chlorinated polyethylene and styrene	<b>FEP</b>	Fluorinated ethylene-propylene	<b>PAI</b>	Polyamide-imide	<b>PPO</b>	Polyphenylene oxide
<b>API</b>	Addition-reaction polyimides	<b>FR</b>	Fiber reinforced	<b>PAN</b>	Polyacrylonitrile	<b>PPS</b>	Polyphenylene sulfide
<b>ASA</b>	Acrylic-styrene-acrylonitrile	<b>FRP</b>	Fiber-reinforced plastics	<b>PB</b>	Polybutylene	<b>PS</b>	Polystyrene
<b>BMC</b>	Bulk-molding compound	<b>HDPE</b>	High-density	<b>PBT</b>	Polybutylene terephthalate	<b>PTFE</b>	Polytetrafluoroethylene
<b>CA</b>	Cellulose acetate	<b>HIP</b>	High-impact polystyrene	<b>PBTP</b>	Polybutylene terephthalate	<b>PU</b>	Polyurethane
<b>CAB</b>	Cellulose acetate-butyrate	<b>HM</b>	High-modulus	<b>PC</b>	Polycarbonate	<b>PVC</b>	Polyvinyl chloride
<b>CAP</b>	Cellulose acetate-propionate	<b>HMC</b>	High-strength molding compound	<b>PCTFE</b>	Polychlorotrifluoroethylene	<b>PVDF</b>	Polyvinylidene fluoride
<b>CPE</b>	Chlorinated polyethylene	<b>HME</b>	High-vinyl modified epoxy	<b>PE</b>	Polyethylene	<b>PVF</b>	Polyvinyl fluoride
<b>CPI</b>	Condensation-reaction polyimides	<b>HMW</b>	High molecular weight	<b>PEC</b>	Polyphenylene ether copolymer	<b>RH</b>	Rockwell hardness
<b>CPVC</b>	Chlorinated polyvinyl chloride	<b>IPN</b>	Interpenetrating polymer network	<b>PEEK</b>	Polyetherether ketone	<b>RH</b>	Relative humidity
<b>CTFE</b>	Polymonochlorotrifluoroethylene	<b>LCP</b>	Liquid crystal polymer	<b>PEH</b>	Polyphenylene ether homopolymer	<b>RIM</b>	Reaction injection molding
<b>DAP</b>	Diallyl phthalate	<b>LDPE</b>	Low-density polyethylene	<b>PEI</b>	Polyetherimide	<b>RP</b>	Reinforced plastics
<b>EC</b>	Ethyl cellulose	<b>LIM</b>	Liquid injection molding	<b>PEO</b>	Polyethylene oxide	<b>RTM</b>	Resin-transfer molding
<b>ECTFE</b>	Ethylene-chlorotrifluoroethylene	<b>LLDPE</b>	Linear low-density polyethylene	<b>PES</b>	Polyethersulphone	<b>SAN</b>	Styrene-acrylonitrile
<b>EMA</b>	Ethylene-methyl acrylate	<b>LMC</b>	Low-pressure molding compound	<b>PET</b>	Polyethylene terephthalate	<b>SMA</b>	Styrene maleic anhydride
<b>EP</b>	Ethylene propylene	<b>LMW</b>	Low molecular weight	<b>PETP</b>	Polyethylene terephthalate	<b>SMC</b>	Sheet molding compound
<b>ESCR</b>	Environmental stress crack resistance	<b>MA</b>	Maleic anhydride	<b>PF</b>	Phenyl-formaldehyde	<b>TFE</b>	Polytetra fluoroethylene
<b>ETFE</b>	Ethylene-tetrafluoroethylene	<b>MBS</b>	Methacrylate-butadiene-styrene	<b>PFA</b>	Perfluoroalkoxy (resin)	<b>TMC</b>	Thick molding compound
<b>EVA</b>	Ethylene-vinyl acetate	<b>MDPE</b>	Medium-density polyethylene	<b>PI</b>	Polyimide	<b>TPE</b>	Thermoplastic elastomers
		<b>MMA</b>	Methyl methacrylate monomer	<b>PIB</b>	Polyisobutylene	<b>TPU</b>	Thermoplastic polyurethane
		<b>MW</b>	Molecular weight	<b>PIE</b>	Polysiobutylene	<b>UF</b>	Urea-formaldehyde
				<b>PMMA</b>	Polymethyl methacrylate	<b>UHM</b>	Ultrahigh-modulus
				<b>PMS</b>	Paramethylstyrene	<b>UHMW</b>	Ultra-high molecular weight
				<b>PMT</b>	Polymethylpentene	<b>UL</b>	Underwriter's Laboratories
						<b>UV</b>	Ultraviolet
						<b>VAE</b>	Vinyl acetate-ethylene

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# Survey of Generic Types

This section presents brief descriptions of generic types of plastics that are commonly used in molding and extruding applications. Each description includes the history of the plastic's development, its chemical structure and a summary of the plastic's advantages and limitations.

The following generic types of plastics are described, or made reference to, in this section. There is a close but not exact correspondence between these descriptions and the generic types used in the main sections of the book.

ABS (ABS/PC, ABS/Polysulfone, ABS/PVC)

Acetal

Acrylic

Alkyd

Allylic Esters or Allyls (DAP)

Cellulosic Esters

Chlorinated Polyalkylene Ether

Cyanate/Cyanamide

Epoxy (Brominated Epoxy, Cycloaliphatic Epoxy, Epoxyimide)

Furan

Melamine-Formaldehyde, Urea-Formaldehyde,

Casein-Formaldehyde

Phenolic

Poly (bis-maleimide)

Polyalkylene Ether

Polyamide (Nylon)

Polyarylene Ether (Phenylene Oxide)

Polybutadiene (1,2)

Polybutylene

Polycarbonate

Polyester (Saturated) (PETP, Polyterephthalate)

Polyester (Unsaturated)

Polyethylene (C-1 Polyethylene, Ionomer, Polyallomer)

Polyfluorocarbon:

Fluorinated Ethylene-Propylene (FEP)

Perfluoroalkoxy (PFA)

Polychlorotrifluoroethylene (CTFE)

Polytetrafluoroethylene (TFE)

Polyvinylfluoride (PVF)

Polyvinylidene Fluoride (PVF<sub>2</sub>)

Polyimide (Polyamid -imide)

Polyphenylene

Polyphenylene Sulfide

Polypropylene

Polystyrene

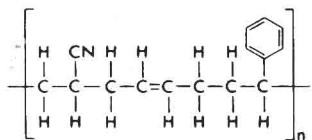
Polysulfone (Polyether Sulfone, Polyphenylene Sulfone)

Polyurethane

Polyvinyl Acetate

Polyvinyl Chloride

Polyvinyl Chloride-Vinylidene Chloride

**ABS**

This material is a terpolymer of acrylonitrile, butadiene and styrene. Usual compositions are about half styrene with the balance divided between butadiene and acrylonitrile. Considerable variation is, of course, possible. Many blends with other materials such as polyvinylchloride, polycarbonates and polysulfones have been developed and are the most common class of plastics used in electroplated metal coatings for decorative hardware.

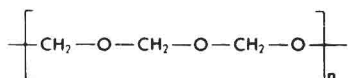
**ADVANTAGES**

- Good impact resistance with toughness and rigidity
- Metal coatings have excellent adhesion to ABS
- Formed by conventional thermoplastic methods
- A light-weight plastic

**DISADVANTAGES AND LIMITATIONS**

- Poor solvent resistance
- Low dielectric strength
- Only low elongations available
- Low continuous service temperature

**Typical Applications:** Automotive hardware, appliance cases, pipe, plated items.

**Acetal**

This polymer class was first introduced in 1956 and has achieved important application because of a good profile of properties. Two types of acetals are available including a homopolymer (Du Pont's Delrin) and a copolymer (Celanese's Celcon).

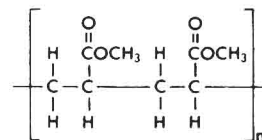
**ADVANTAGES**

- High tensile strength with rigidity and toughness
- Glossy molded surfaces
- Low static and dynamic coefficients of friction
- Retains electrical and mechanical properties up to 250°F
- Low gas and vapor permeability

**DISADVANTAGES AND LIMITATIONS**

- Poor resistance to acids and bases
- Subject to UV degradation
- Flammable
- Difficult to bond

**Typical Applications:** Automotive applications in place of die-cast metals, slides, rollers, gears and cams.

**Acrylic**

Most acrylics are polymers of methyl methacrylate (PMMA). The cost of acrylic is intermediate, with the average price falling between the more expensive cellulose and PVC.

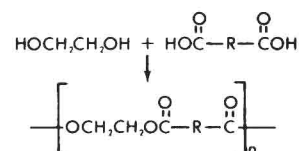
**ADVANTAGES**

- Excellent optical clarity
- Excellent weatherability and resistance to sunlight
- Rigid, with good impact strength
- Excellent dimensional stability and low mold shrinkage
- Stretch forming increases bi-axial toughness

**DISADVANTAGES AND LIMITATIONS**

- Poor solvent resistance; attacked especially by ketones, esters, chlorocarbons and aromatic hydrocarbons, freons.
- Subject to stress cracking
- Combustible
- Continuous service temperature limited to about 200°F
- Flexible grades unavailable

**Typical Applications:** Transparent items such as lenses, automotive trim, household items, light fixtures and decorator items, conformed coatings for printed wiring boards.

**Alkyd**

Alkyds are formed by the reaction of polyhydroxy compounds with dibasic acids. Many structural variations are possible.

Perhaps one of the most important variations is brought about by the use of an unsaturated acid such as maleic acid. The resulting unsaturation in the polymer backbone can be utilized to crosslink the polymer and form a thermoset resin. Systems which are produced by reaction of saturated alcohols and acids are thermoplastic and are usually used in solution typically for coatings.

**ADVANTAGES**

- One of the most inexpensive resin types available.
- Wide structural variations possible.
- May be thermosetting.
- Sometimes modified with styrene or acrylic monomers.
- Very suitable for fiberglass composites.

**DISADVANTAGES**

- Chemical resistance is marginal.

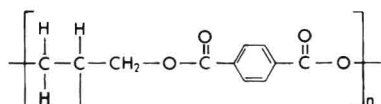
### Alkyd (Cont.)

Shrinkage during cure is high (unsaturated types).

Solvent resistance of thermoplastic types is poor.

**Typical Applications:** Boat hulls and other fiber reinforced items, sheet molding compounds, coatings and filled molding compounds.

### Allylic Esters or Allyls



These materials are commonly supplied as "B" staged prepolymers, such as diallyl phthalate (DAP) or diallyl isophthalate and are cured by peroxides to yield thermoset resins. Other variations include trifunctional diallyl maleate (DAM), triallylcyanurate (TAC) and transparent allyl carbonate.

#### ADVANTAGES

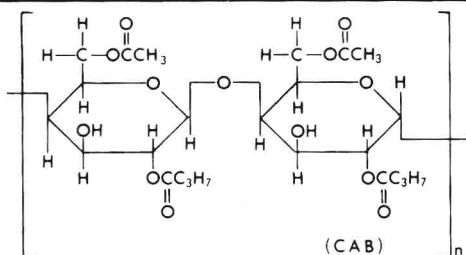
- Excellent moisture resistance
- Low burning and self-extinguishing grades are available
- Service temperatures as high as 400-450°F
- Good chemical resistance

#### DISADVANTAGES AND LIMITATIONS

- More expensive than alkyds
- High shrinkage during curing
- Not recommended for use in contact with phenols and oxidizing acids

**Typical Applications:** Electronic connectors, appliance handles, automotive distributor caps — frequently molded by transfer or simple compression molding, transformer cases.

### Cellulosic Esters



Cellulose nitrate, over one hundred years old, is man's first successful effort in modifying a natural polymer to improve processability. Celluloid and pyroxylin were two forms of this resin used in many moldings and coated articles. Also known as gun cotton, it is rarely used today in plastic articles because of its high flammability. It has been largely displaced in thermoplastic applications by organic acid esters of cellulose such as acetates, propionates and butyrates.

#### ADVANTAGES

- Forms glossy moldings by conventional thermoplastic methods

**Tough materials even at low temperatures**

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Non-petrochemical base

Wide processing characteristics available

Resists stress cracking

Has good "feel" due to low specific heat and low conductivity

#### DISADVANTAGES AND LIMITATIONS

Poor solvent resistance

Poor resistance to alkaline materials and fungus

High moisture pick-up and high permeability

Compressive strength tends to be low

Flammable

**Typical Applications:** Telephone and appliance cases, automotive steering wheels, pens and pencils.

### Chlorinated Polyalkylene Ether

These chloro-polymers have a unique characteristic among chlorine-containing polymers in that there is no hydrogen on the carbon atom adjacent to the halogen. As a result the polymer is more thermally stable than other chlorine-containing structures because of the reduced tendency to lose hydrogen chloride.

#### ADVANTAGES

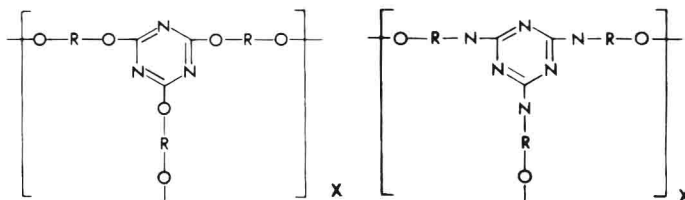
- Good chemical resistance
- Servicable up to 140°C
- Greater thermal stability than other chlorinated resins

#### DISADVANTAGES AND LIMITATIONS

- Extremely limited availability
- Comparatively high cost
- Low impact strength

**Typical Applications:** Pipe and chemical-processing equipment.

### Cyanate/Cyanamide



Introduced in the early 1970's, these resins represent a future alternative to epoxy resins. The monomers essentially trimerize to form thermosetting modified triazine structures with capability up to 450°F. They are addition polymers and consequently hold promise as adhesive and composite matrix resins.

#### ADVANTAGES

- No volatiles evolved during cure (epoxy alternative)
- Temp. capability to 450°F
- Excellent adhesion

#### DISADVANTAGES AND LIMITATIONS

- High shrinkage during cure

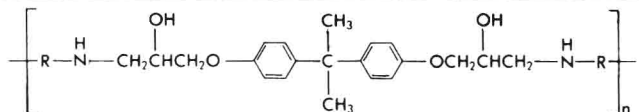
**Cyanate/Cyanamide (Cont.)**

Very small data base and considered still developmental

Limited availability

Comparatively high cost

**Typical Applications:** Adhesives and composites including printed circuit boards.

**Epoxy**

Epoxy resins are available in a wide variety of thermosetting structures and curing-agent variations. Physical properties can thus be varied over a wide range of rigidity and flexibility. Since their introduction in the late 40's and early 50's, the market has expanded to over 100 million pounds per year. This group of resins form the foundation for the structural adhesives industry, as well as being used extensively in fiber reinforced composites.

A number of epoxy resins are now available which are nonflammable due to introduction of bromine in aromatic ring substitution. Also, a few hybrids have been introduced such as epoxy urethanes and epoxyimides.

In addition to older glycidyl ether types, newer cycloaliphatic types have been produced which are synthesized by the epoxidation of the corresponding olefin, usually by peracetic acid. They differ from glycidyl ether types in that amine cures are usually not suitable and they are polymerized by anhydride cures.

**ADVANTAGES**

Convenient range of cure conditions from RT to 350°F

No volatiles formed during cure

Excellent adhesion

Suitable for all thermosetting processing methods

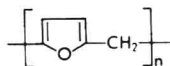
**DISADVANTAGES AND LIMITATIONS**

Poor oxidative stability and some moisture sensitivity

Thermal stability limited to 350°-450°F

Specialty grades are comparatively expensive

**Typical Applications:** Adhesives, electronics encapsulation, composites and printed circuit boards, coatings, solder maskants.

**Furans**

By acid catalysis, furfural or furfuryl alcohol will condense to form thermosetting resins with very good chemical, solvent and temperature resistance. Resins crosslink through unsaturation in the furan ring.

**ADVANTAGES**

Produced from non-petrochemical sources.

Excellent chemical resistance

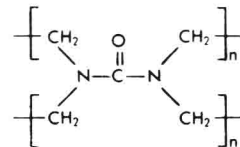
**DISADVANTAGES AND LIMITATIONS**

Difficult to process, limited to fiber-reinforced plastics

Attacked by halogens

A-4

**Typical Applications:** Chemical processing towers, tanks and pipe for use in corrosive environments.

**Melamine-Formaldehyde, Urea-Formaldehyde, Casein-Formaldehyde**

These similar comparatively inexpensive thermosetting resins are frequently referred to as aminos or amino plastics. They are formed by condensation of melamine, urea or casein with formaldehyde, resulting in a highly crosslinked resin which is similar to a phenolic in utility.

**ADVANTAGES**

Good Hardness and Scratch resistance

Comparatively low cost

Wide range of colors possible

Self extinguishing

Solvent resistant, including hot water

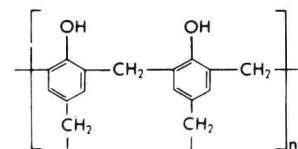
**DISADVANTAGES OR LIMITATIONS**

Must be filled for successful molding

Long-term oxidation resistance is poor

Attacked by strong acids and bases

**Typical Applications:** Electrical insulators, tableware, buttons

**Phenolic**

Phenolics, discovered in 1904 by George Backeland, is one of the oldest types of thermosetting resins. Phenolics now are considered the work-horse of the plastics industry. Usually, the resin is extended by combining with a filler. The resin is highly crosslinked.

**ADVANTAGES**

Comparatively low cost

Thermoset resin suitable for use as high as 400°F

Excellent solvent resistance

High modulus (rigid)

Good compressive strength

High resistivity

Self-extinguishing

**DISADVANTAGES AND LIMITATIONS**

Requires fillers for moldings

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