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APPLICATION KNOWLEDGE

Plastics

Properties and chemical resistance

Introduction

Besides glass, plastics play a very important role in laboratories. Resistance to breakage and low weight are important advantages of plastics.
The application determines which plastic to select. A variety of parameters should be considered: exposure time and concentration of chemicals, thermal stress (e.g., autoclaving), exertion of force, exposure to UV radiation, and aging, which may be caused by the action of detergents, or other environmental factors.

In general, plastics can be divided into the three groups:

+ Elastomers
Polymers with loosely cross-linked molecules, exhibiting rubber-like elasticity at room temperature. Heating causes irreversible curing (vulcanization).
The most popular elastomers are natural rubber and silicone rubber.

+ Thermosets
Polymers with tightly cross-linked molecules are very hard and brittle at room temperature; heating causes irreversible curing. These plastics are rarely used for plastic labware. The best known thermosets are the melamine resins. Melamine resin is produced by polycondensation of melamine with formaldehyde.

+ Thermoplastics
Polymers with a linear molecular structure with or without side branches are transformed into objects during molding operations without changing their thermoplastic properties. Thermoplastics are the materials commonly used in plastic labware production. Hence we provide here a brief description of some individual plastics explaining their structural, mechanical, chemical and physical properties.
The most popular thermoplastics are polyolefins like polyethylene and polypropylene.

Thermoplastics

PS – Polystyrene
Polystyrene is glass-clear, hard, brittle, and dimensionally stable due to its amorphous structure. PS has good chemical resistance to aqueous solutions but limited resistance to solvents. Disadvantages include low thermal stability and its tendency to suffer from stress-cracks.

SAN – Styrene-acrylonitrile copolymer
This is a glass-clear material with good resistance to stress-cracking. It has slightly better chemical resistance than PS.

PMMA – Polymethyl methacrylate
Rigid, glass-clear ("organic glass"). Resistant to atmospheric agents. Replaces glass in many applications where temperatures are below 90 °C and low chemical resistance is required. PMMA has excellent UV radiation stability.

PC – Polycarbonate
These are thermoplastic linear carboxylic acid polyesters combining many of the properties of metals, glass and plastics. The materials are transparent and have good thermal properties between -130 to +130 °C. Note: PC may be weakened by autoclaving or exposure to alkaline detergents.

PA – Polyamide
Polyamides are linear polymers with repeating amide chain linkages. With their favorable strength characteristics and high durability, polyamides can often be used as structural materials and for surface coating metals. They have good chemical resistance against organic solvents, but are easily attacked by acids and oxidizing agents.

PVC – Vinyl chloride polymers
The vinyl chloride polymers are mainly amorphous thermoplastics with very good chemical resistance.
Their combination with plasticizers opens up many useful applications, ranging from artificial leather to injection molding components. PVC has good chemical resistance, especially with oils.

POM – Polyoxymethylene
POM has superior properties with regard to hardness, rigidity, strength, durability, chemical resistance and favorable slip and abrasion characteristics. It can replace metals in many applications. POM can withstand temperatures up to 130 °C.

PUR – Polyurethane
Polyurethane is a very versatile plastic, and is therefore used in a wide variety of applications.The molecules are formed by a polyaddition reaction of dialcohols with polyisocyanate.
As a material for the coating of
BLAUBRAND® graduated flasks, a high-quality, scratch-resistant, transparent PUR type with a high modulus of elasticity is used. The working temperature can range from -30 to +80 °C. Brief exposure to higher temperatures of up to
135 °C are permissible, but over time this will lead to a reduction in elasticity.

PE-LD – Low Density Polyethylene
The polymerization of ethylene under high-pressure results in a certain number of branches in the chain. The result is a less compact molecular structure than PE-HD, with very good flexibility and good chemical resistance, but less chemical resistance to organic solvents than PE-HD. Use is limited to temperatures below 80 °C.

PE-HD – High Density Polyethylene
If the polymerization of ethylene is controlled by a catalytic process, a very small number of branches in the chain are obtained. The result is a more rigid and compact structure with enhanced chemical resistance and usability up to 105 °C.

PP – Polypropylene
PP has a similar structure to Polyethylene, but with methyl groups at every second carbon atom of the chain. The major advantage, compared with PE, is its higher temperature resistance. It can be repeatedly autoclaved at 121 °C. Like the above mentioned polyolefins, PP has good mechanical properties and good chemical resistance but is sligthly more susceptible to be attacked by strong oxidizing agents than PE-HD.

PMP – Polymethylpentene

PMP is similar to PP but has isobutyl groups instead of the methyl groups. Chemical resistance is comparable to PP but tends to suffer from tension cracks when exposed to ketones or chlorinated solvents. The most important qualities of PMP are its excellent transparency and good mechanical properties at temperatures up to 150 °C.

ETFE – Ethylene-Tetrafluoroethylene copolymer

ETFE is a copolymer of ethylene with chlorotrifluoroethylene and/or with tetrafluoroethylene. This plastic is remarkable for its excellent chemical resistance, but its temperature stability is lower in comparison with PTFE (at most 150 °C).

PTFE – Polytetrafluoroethylene

PTFE is a fluorinated hydrocarbon with a macromolecular, partly crystalline structure. PTFE is resistant to virtually all chemicals. It offers the widest working temperature range, from -200 to +260 °C. Its surface is adhesion resistant. The slip properties and electrical insulation capacity of the material are better than those of FEP and PFA. The only disadvantage is that it can only be molded by sintering processes. PTFE is opaque. It is suitable for use in microwave ovens.

FEP – Tetrafluorethylene-perfluorpropylene copolymer

A fluorinated hydrocarbon with a macromolecular, partly crystalline structure. The surface is non-adhesive. The mechanical and chemical properties are comparable with PTFE, but the working temperature is limited to the range from -100 to +205 °C. Water absorption is extremely low. FEP is translucent.

PFA – Perfluoroalkoxy copolymer

Fluorinated hydrocarbon with a high-molecular, partly crystalline structure. Its surface is adhesion-resistant. Mechanical properties and chemical inertness are comparable with those of PTFE. The working temperature can range from -200 to +260 °C. The water absorption of PFA is extremely low. PFA is translucent. PFA is manufactured without the addition of catalysts or plasticizers, and can be molded to produce an extremely smooth, readily cleanable surface, and is therefore particularly well suited for trace analysis.

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General Properties

The recommendations listed below are based on technical literature and information provided by the manufacturers of raw materials. They were prepared carefully and are intended as general guidance. However, they cannot replace suitability testing perfomed by the user under actual working conditions.

Physical properties

	Max. operating temperature (°C)	Brittle temperature (°C)	Micro wave suitability*	Density (g/cm³)	Elasticity	Transparency
PS	70	-20	no	1.05	rigid	transparent
SAN	70	-40	no	1.03	rigid	transparent
PMMA	65 to 95	-50	no	1.18	rigid	transparent
PC	125	-130	yes	1.20	rigid	transparent
PVC	80	-20	no	1.35	rigid	transparent
POM	130	-40	no	1.42	good	opaque
PE-LD	80	-50	yes	0.92	very good	translucent
PE-HD	105	-50	yes	0.95	good	translucent
PP	125	0	yes	0.90	moderate	translucent
PMP	150	0	yes	0.83	moderate	transparent
ETFE	150	-100	yes	1.70	moderate	translucent
PTFE	260	-200	yes	2.17	very good	opaque
FEP	205	-100	yes	2.15	moderate	translucent
PFA	260	-200	yes	2.17	moderate	translucent
PUR	80	-30	yes	1.20	very good	transparent
FKM	220	-30	–	–	very good	–
EPDM	130	-40	–	–	very good	–
NR	80	-40	no	1.20	very good	opaque
SI	180	-60	no	1.10	very good	translucent

* Observe chemical and temperature resistance

Sterilization

	Autoclaving* at 121 °C (2 bar), acc. DIN EN 285	β/γ-radiation 25 kGy	Gas (ethylene oxide)	Chemical (formalin, ethanol)
PS	no	yes	no	yes
SAN	no	no	yes	yes
PMMA	no	yes	no	yes
PC	yes[1)]	yes	yes	yes
PVC	no[2)]	no	yes	yes
POM	yes[1)]	yes (restricted)	yes	yes
PE-LD	no	yes	yes	yes
PE-HD	no	yes	yes	yes
PP	yes	yes (restricted)	yes	yes
PMP	yes	yes	yes	yes
ETFE	yes	no	yes	yes
PTFE	yes	no	yes	yes
FEP/PFA	yes	no	yes	yes
PUR	yes[3)]	–	yes	yes
FKM	yes	–	yes	yes
EPDM	yes	–	yes	yes
NR	no	no	yes	yes
SI	yes	no	yes	yes

* Before autoclaving, labware must be carefully cleaned and rinsed with distilled water. Always remove covers from containers!
1) Frequent autoclaving reduces mechanical stability.
2) With the exception of PVC tubing, which is autoclavable up to 121 °C.
3) Frequent autoclaving reduces elasticity.

Biological Properties

The following plastics are generally non-toxic to cell cultures:
PS, PC, PE-LD, PE-HD, PP, PMP, PTFE, FEP, PFA.

Chemical Properties

With regard to chemical resistance, plastics are classified as follows:

+ = Excellent chemical resistance

Continuous exposure to the substance does not cause damage within 30 days. The plastic may remain resistant for years.

o = Good to limited chemical resistance

Continuous exposure to the substance causes minor damage, some of which is reversible, within 7-30 days (e.g., swelling, softening, decrease of mechanical strength, discoloration).

– = Poor chemical resistance

Not suitable for continuous exposure to the substance. Immediate(!) damage may occur (loss of mechanical strength, deformation, discoloration, cracking, dissolution).

Abbreviations of the described plastics (to DIN 7728)

PS	Polystyrene
SAN	Styrene-acrylonitrile copolymer
PMMA	Polymethyl methacrylate
PC	Polycarbonate
PVC	Polyvinyl chloride
POM	Polyoxymethylene
PE-LD	Low-density polyethylene
PE-HD	High-density polyethylene
PP	Polypropylene
PMP	Polymethylpentene
ETFE	Ethylene-tetrafluoroethylene copolymer
PTFE	Polytetrafluoroethylene
FEP	Perfluoroethylene-propylene copolymer
PFA	Perfluoroalkoxy copolymer
PUR	Polyurethane
FKM	Fluoro elastomer
EPDM	Ethylene-propylene-diene-rubber
NR	Natural rubber
SI	Silicone rubber

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Chemical Resistance

The data for the chemical resistance of salts also apply to their aqueous solutions.

	PS		SAN		PMMA		PC		PVC		POM		PE-LD		PE-HD	
	20 °C	50 °C	20 °C	50 °C	20 °C	50 °C	20 °C	50 °C	20 °C	50 °C	20 °C	50 °C	20 °C	50 °C	20 °C	50 °C
Acetaldehyde	–	–	–	–	–	–	o	–	–	–	+	+	+	–	+	o
Acetic acid (glacial) 100%	–	–					–	–			–	–	+	o	+	+
Acetic acid 50%	o	o	+	o	–	–	+	o	+	o	o	–	+	+	+	+
Acetic anhydride	–	–					–	–	–	–	–	–	–	–	o	o
Acetone	–	–	–	–	–	–	–	–	–	–	+	+	+	o	+	+
Acetonitrile	–	–	–	–	–	–	–	–	–	–	+		+	o	+	o
Acetophenone	–	–	–	–	–	–	–	–	–	–	+		–	–	o	o
Acetyl chloride	–	–	–	–	–	–	–	–	–	–			+		+	
Acetylacetone	–	–	–	–	–	–	–	–	–	–	+		+		+	
Acrylic acid	–	–	–	–	–	–	–	–	–	–	–	–	+		+	
Acrylonitrile	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+
Adipic acid	+	+	+	+	+	+	+	+	+	o	+	+	+	+	+	+
Allyl alcohol (2-Propene-1-ol)	o	o	o	–	–	–	o	o	o	–	+	+	+	+	+	+
Aluminium chloride	+	+	+	+	+	+	–	–	+	o	+	o	+	+	+	+
Aluminium hydroxide	o	o	o	o	o	o	o	–	+	+	+	+	+	+	+	+
Amino acids	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Ammonium chloride	+	+	+	+	o	o	o	o	+	o	+	+	+	+	+	+
Ammonium fluoride	+	+	+	+	o	o	o	o	+	o	+	+	+	+	+	+
Ammonium hydroxide 30% (Ammonia)	o	–	+	o	+	+	–	–	+	o	o	o	+	+	+	+
Ammonium sulfate	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
n-Amyl acetate	–	–	–	–	+	+	–	–	–	–	+	+	o	–	+	o
n-Amyl alcohol (Pentanol)	o	o	+	+			+	+	o	o	+	+	+	+	+	+
Amyl chloride (Chloropentane)	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–
Aniline	–	–	–	–	–	–	o	–	–	–	o	o	+	o	+	+
Aqua regia	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Barium chloride	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Benzaldehyde	–	–	–	–	–	–	o	–	–	–	+	+	+	+	+	+
Benzene	–	–	–	–	–	–	–	–	–	–	+	o	o	–	+	+
Benzine (gasoline)	–	–	–	–	+		o	–	o	–	+	+	o	–	+	+
Benzoyl chloride	–	–	–	–	–	–	–	–	–	–	+	o	o	–	+	+
Benzyl alcohol	–	–	–	–	–	–	o	o	o	o	+	+	o	–	o	–
Benzylamine	–	–	–	–	–	–	–	–	–	–	+		o	–	o	
Benzylchloride	–	–									+					
Boric acid, 10%	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Bromine	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bromobenzene	–	–	–	–	–	–	–	–	–	–			–	–	–	–
Bromoform	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bromonaphthalene	–	–	–	–												
Butanediol	–	–	–	–							+	+	+	+	+	+
1-Butanol (Butyl alcohol)	o	–	+	o	o	–	o	o	o	o	+	+	+	+	+	+
n-Butyl acetate	–	–	–	–	–	–	–	–	–	–	+	o	o	o	+	+
Butyl methyl ether	–	–	–	–	–	–	–	–	–	–	+	+	o	–	o	–
Butylamine	–	–	–	–							+	+				
Butyric acid	–	–	–	–			o	–					–	–	o	–
Calcium carbonate	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Calcium chloride	+	+	+	+	+	+	+	+	o	–	+	+	+	+	+	+
Calcium hydroxide	+	o	+	o	+	+	–	–	+	+	+	+	+	+	+	+
Calcium hypochlorite	+	+	+	+	o	o	o	–	o	–	+	+	+	+	+	+
Carbon disulfide	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–
Carbon tetrachloride	–	–	–	–	o	–	–	–	–	–	o	o	o	–	o	–
Chloro naphthalene											–	–				
Chloroacetaldehyde	–	–	–	–	–	–										
Chloroacetic acid	o	–	–	–	o	–	o	–	+	o	–	–	+	+	+	+
Chloroacetone	–	–	–	–	–	–										
Chlorobenzene	–	–	–	–	–	–	–	–	–	–			–	–	–	–
Chlorobutane	–	–	–	–	–	–					–	–	o	–	o	–
Chloroform	–	–	–	–	–	–	–	–	–	–	–	–	o	–	o	–
Chlorosulfonic acid											–	–				
Chromic acid 10%	–	–	–	–	o	–	+	o	+	o	o	o	+	+	+	+
Chromic acid 50%	–	–	o	o	–	–	o	–	+	–	–	–	+	o	+	o
Chromosulfuric acid	o	o	o	o	–	–	–	–	+	o	–	–	–	–	–	–
Copper sulfate	+	+	+	o	+	+	+	+	+	o	+	+	+	+	+	+
Cresol	–	–					–	–	–	–			–	–	o	–
Cumene (Isopropyl benzene)	–	–	–	–	–	–	–	–	–	–	+	–	o	–	+	o
Cyclohexane	–	–					–	–	–	–	+	+	o	–	o	–
Cyclohexanone	–	–					–	–	–	–			–	–	o	–
Cyclopentane	–	–					–	–	–	–			–	–	o	–
Decane							o		o		+				o	–
Decanol	o		o				o		+		+				+	
Dibenzyl ether	–	–	–	–	–	–					+				+	
Dibromoethane																
Dibutyl phthalate	–	–	–	–	–	–	–	–	–	–	+	+	o	–	o	–
Dichlorbenzene	–	–	–	–	–	–	–	–	–	–	–	–	o	–	o	–
Dichlormethane (Methylene chloride)	–	–					–	–	–	–			o	–	o	–
Dichloroacetic acid	o	–					o	–	o	–			o	–	o	o
Dichloroethane											–	–	o	–	o	–
Diesel oil (Heating oil)	–	–	–	–	o	–	–	–	o		+	+	o	–	+	o
Diethanolamine	–	–	–	–	–	–	–	–							o	
Diethyl ether	–	–	–	–	–	–	–	–	–	–	+	+	–	–	o	–
Diethylamine	o	o					–	–	–	–			–	–	o	–
Diethylbenzene	–	–					o	–	–	–			–	–	o	–
Diethylene glycol	o	–	+	+	–	–	o	o	–	–	+	o	+	+	+	+
Dimethyl sulfoxide (DMSO)	–	–	–	–	–	–	–	–	–	–			+	+	+	+
Dimethylaniline	–	–	–	–	–	–	–	–								
Dimethylformamide (DMF)	–	–	–	–	–	–	–	–	o	–	+	+	+	+	+	+
1.4 Dioxane	–	–	–	–	–	–	o	o	–	–	o	o	+	o	+	+
Diphenyl ether	–	–	–	–	–	–					o					
Ethanol (Ethyl alcohol)	o	–	o	–	–	–	+	o	+	o	+	+	+	+	+	+
Ethanolamine																
Ethyl acetate	–	–					–	–	–	–			+	+	+	+
Ethyl methyl ketone	–	–	–	–	–	–	–	–	–	–	–	–	o	–	o	–
Ethylbenzene	–	–	–	–	–	–	–	–	–	–			–	–	–	–
Ethylene chloride	–	–	–	–	–	–	–	–	–	–	o	–	–	–	–	–

Continued list of "Chemical Resistance"

	PP		PMP		ETFE		PTFE		FEP/PFA		FKM	EPDM	NR	SI
	20 °C	50 °C	20 °C	50 °C	20 °C	50 °C	20 °C	50 °C	20 °C	50 °C	20 °C	20 °C	20 °C	20 °C
Acetaldehyde	+	–	o	–	+	o	+	+	+	+	–	o	–	–
Acetic acid (glacial) 100%	+	o	+	o	+	+	+	+	+	+	–	o	o	o
Acetic acid 50%	+	+	+	+	+	+	+	+	+	+	–	–	–	–
Acetic anhydride	o	o	+	o	+	+	+	+	+	+	–	o	o	o
Acetone	+	+	+	+	+	o	+	+	+	+	–	+	o	–
Acetonitrile	+	o	o	–	+	+	+	+	+	+	–	–	–	–
Acetophenone	o	o	o	–	+	+	+	+	+	+	–	+	–	–
Acetyl chloride	+				+	+	+	+	+	+	+	–	–	–
Acetylacetone	+		+		+	+	+	+	+	+	–	+	–	–
Acrylic acid	+		+		+	+	+	+	+	+	–	–	–	–
Acrylonitrile	o	–	–	–	+	+	+	+	+	+	–	–	–	–
Adipic acid	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Allyl alcohol (2-Propene-1-ol)	+	+	+	o	+	+	+	+	+	+	+	+	o	–
Aluminium chloride	+	+	+	+	+	+	+	+	+	+	+	+	o	o
Aluminium hydroxide	+	+	+	o	+	+	+	+	+	+	+	+	+	+
Amino acids	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Ammonium chloride	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Ammonium fluoride	+	+	+	+	+	+	+	+	+	+	o	+	–	+
Ammonium hydroxide 30% (Ammonia)	+	+	+	+	+	+	+	+	+	+	–	+	+	o
Ammonium sulfate	+	+	+	+			+	+			–	+	o	o
n-Amyl acetate	o	–	+	o	+	+	+	+	+	+	–	o	o	–
n-Amyl alcohol (Pentanol)	+	+	+	+	+	+	+	+	+	+	o	o	o	–
Amyl chloride (Chloropentane)	–	–	–	–	+	+	+	+	+	+	+	–	–	–
Aniline	+	+	+	o	+	o	+	+	+	+	–	–	–	–
Aqua regia	–	–	–	–	+	+	+	+	+	+	–	–	–	–
Barium chloride	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Benzaldehyde	+	+	+	+	+	o	+	+	+	o	–	o	–	–
Benzene	+	o	o	o	+	+	+	+	+	+	o	–	–	–
Benzine (gasoline)	o	o	o	o	+	+	+	+	+	+	+	–	–	–
Benzoyl chloride	+	o	o	o	+	+	+	+			+	–	–	–
Benzyl alcohol	o	–	o	–	+	+	+	+	+	+	+	o	–	o
Benzylamine	o		o		+	+	+	+	+	+	+	o	–	o
Benzylchloride					+	+	+	+			+	–	–	–
Boric acid, 10%	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Bromine	–	–	–	–	+	+	+	+	+	+	o	–	–	–
Bromobenzene	–	–	–	–	o	–	+	+	+	+	+	–	–	–
Bromoform	–	–	–	–	+	+	+	+	+	+			–	–
Bromonaphthalene					+	+	+	+	+	+				
Butanediol	+	+	+	+	+	+	+	+	+	+	–	+	o	–
1-Butanol (Butyl alcohol)	+	+	+	o	+	+	+	+	+	+	+	o	+	o
n-Butyl acetate	o	o	+	o	+	+	+	+	+	+	–	o	–	–
Butyl methyl ether	+	o	+	–	+	o	+	+	+	+	–	–	–	–
Butylamine					+	+	+	+			–	–	–	o
Butyric acid	–	–			+	+	+	+	+	+	o	–	–	–
Calcium carbonate	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Calcium chloride	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Calcium hydroxide	+	+	+	+	+	+	+	+	+	+	+	+	+	o
Calcium hypochlorite	+	+	+	o	+	+	+	+	+	+	+	+	–	o
Carbon disulfide	–	–	–	–	+	o	+	+	+	+	+	–	–	–
Carbon tetrachloride	–	–	–	–	+	+	+	+	+	+	+	–	–	–
Chloro naphthalene					+	+	+	+			+	–	–	–
Chloroacetaldehyde					+	+	+	+						
Chloroacetic acid	+	o	+	o	+	+	+	+	+	+	o	o	–	–
Chloroacetone					+	+	+	+			–	+	o	–
Chlorobenzene	–	–	–	–	+	o	+	+	+	+	o	–	–	–
Chlorobutane	o	–	o	–	+	+	+	+	+	+	o	–	–	–
Chloroform	–	–	o	–	+	o	+	+	+	o	o	–	–	–
Chlorosulfonic acid					o	–	+	+	+	+	–	–	–	–
Chromic acid 10%	+	+	+	+	+	+	+	+	+	+	+	–	–	o
Chromic acid 50%	o	o	o	o	+	+	+	+	+	+	+	–	–	–
Chromosulfuric acid	–	–	o	–	+	+	+	+	+	+	+	–	–	–
Copper sulfate	+	+	+	+	+	+	+	+	+	+	+	+	o	+
Cresol	o	o	–	–	+	o	+	+	+	+	+	–	–	–
Cumene (Isopropyl benzene)	o	–	–	–	+	+	+	+	+	+	+	–	–	–
Cyclohexane	o	–	–	–	+	o	+	+	+	+	+	–	–	–
Cyclohexanone	o	–	o	o	+	+	+	+	+	+	–	–	–	–
Cyclopentane	o	–	o	–	+	+	+	+	+	+	+	–	–	–
Decane	o		o		+	+	+	+	+	+	+	–	–	o
Decanol	+		+		+	+	+	+	+	+	+	+	o	o
Dibenzyl ether	+		o		+	+	+	+	+	+	–	o	–	–
Dibromoethane					o		+	+	+					
Dibutyl phthalate	+	o	+	o	+	+	+	+	+	+	o	o	–	o
Dichlorbenzene	o	–	–	–	+	o	+	+	+	+	+	–	–	–
Dichlormethane (Methylene chloride)	o	–	o	–	o	o	+	+	+	+	o	–	–	–
Dichloroacetic acid	o	–	+	+	+	o	+	+	+	+	–	–	–	–
Dichloroethane	o	–	o	–	+	+	+	+	+	+	o	–	–	–
Diesel oil (Heating oil)	+	o	o	–	+	+	+	+	+	+	+	–	–	–
Diethanolamine	o						+	+				o		
Diethyl ether	o	–	–	–	+	+	+	+	+	+	–	–	–	–
Diethylamine	o	–	o	o	+	o	+	+	+	+	–	o	o	
Diethylbenzene	–	–	–	–	+	o	+	+	+	+	+	–	–	–
Diethylene glycol	+	+	+	+	+	+	+	+	+	+	+	+	+	o
Dimethyl sulfoxide (DMSO)	+	+	+	+	+	+	+	+	+	+				+
Dimethylaniline					+	+	+	+	+	+	o	o	–	o
Dimethylformamide (DMF)	+	+	+	+	+	+	+	+	+	+	–	o	o	o
1.4 Dioxane	+	o	o	o	+	o	+	+	+	+	–	o	–	–
Diphenyl ether							+	+			o	–	–	–
Ethanol (Ethyl alcohol)	+	+	+	o	+	+	+	+	+	+	o	+	o	o
Ethanolamine	+				+	+	+	+	+	+	–	+	–	–
Ethyl acetate	+	o	o	–	+	+	+	+	+	+	–	o	–	
Ethyl methyl ketone	+	o	–	–	o	o	+	+	+	+	–	o	–	
Ethylbenzene	–	–	–	–	o	o	+	+	+	+	o	–	–	–
Ethylene chloride	o	–	–	–	+	+	+	+	+	+	o	–	–	–

Continued list of "Chemical Resistance"

	PS		SAN		PMMA		PC		PVC		POM		PE–LD		PE–HD	
	20 °C	50 °C	20 °C	50 °C	20 °C	50 °C	20 °C	50 °C	20 °C	50 °C	20 °C	50 °C	20 °C	50 °C	20 °C	50 °C
Ethylene glycol (Glycol)	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Ethylene oxide	–	–	–	–	–	–	o	–	o	–	+	+	o	o	o	o
Fluoroacetic acid	–	–	–	–	–	–	–	–	–	–	–	–				
Formaldehyde 40%	–	–	+	+	–	–	+	o	o	–	+	+	+	+	+	+
Formamide											–	–	+	+	+	+
Formic acid 98-100%	+	o	o	o	–	–	+	o	–	–	–	–	+	+	+	+
Glycerol	+	+	+	+	+	+	+	+	+	+	o	o	+	+	+	+
Glycolic acid 70%													+	+	+	+
Heating oil (Diesel oil)	–	–	–	–	o	–	–	–	o	–	+	+	o	–	+	o
Heptane	–	–			o	–	+	o	–	–			o	–	o	o
Hexane	–	–	+	+	o	o	–	–	o	–	+	+	o	–	+	o
Hexanoic acid					+											
Hexanol					+								+	+	+	+
Hydriodic acid													+	+	+	+
Hydrobromic acid	o	–					+	+			–	–	+	+	+	+
Hydrochloric acid 10%	+	+	o	–	o	–	–	–	+		–	–	+	+	+	+
Hydrochloric acid 20%	+	+	o	–	o	–	o	o	o		–	–	+	+	+	+
Hydrochloric acid 37%	o	o	o	–	o	–	–	–	o	–	–	–	+	+	+	+
Hydrofluoric acid 40%	+	+	+	o	–	–	–	–	o	–	–	–	+	+	+	+
Hydrofluoric acid 70%	–	–	–	–	–	–	–	–	–	–	–	–	+	–	+	o
Hydrogen peroxide 35%	+	+	+	+	–	–	+	+	+	o	+	–	+	+	+	+
Iodine-potassium iodide solution	o	–	o	–	–	–	o	–	–	–	o	o	–	–	–	–
Isoamyl alcohol											+	+	+	+	+	+
Isobutanol (Isobutyl alcohol)	o	o	o	–	o	–	+	+	+	o	+	+	+	+	+	+
Isooctane	o	–	o	–			o									
Isopropanol (2-Propanol)	o	o	+	–	o	–	+	+	+	o	+	+	+	+	+	+
Isopropyl ether	–	–					–	–	–	–			–	–	–	–
Lactic acid	+	+	+	+	o	–	+	+	o	o	+	–	+	+	+	+
Mercury	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Mercury chloride	+	o	+	+	+	+	+	+	–	–	o	o	+	+	+	+
Methanol	o	–	o	–	–	–	+	o	+	o	+	+	+	o	+	+
Methoxybenzene	–	–	–	–	–	–	–	–			o					
Methyl butyl ether	–	–	–	–	–	–	–	–	–	–	o		–	–	o	–
Methyl formate (Methyl methanoate)	–	–	–	–	–	–	–	–			+					
Methyl propyl ketone	–	–	–	–	–	–	–	–	–	–	+	+	+	o	+	+
Methylene chloride (Dichloro methane)	–	–	–	–	–	–	–	–	–	–	–	–	o	–	o	–
Mineral oil (Engine oil)	+		+		+	+	+		+	+	+	+	+	o	+	+
Nitric acid 10%	–	–	+	o	+	o	+	o	+	o	–	–	+	+	+	+
Nitric acid 30%	–	–	o	–	o	o	+	o	o	–	–	–	o	o	o	–
Nitric acid 70%	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Nitrobenzene	–	–	–	–	–	–	–	–	–	–	o	–	–	–	o	–
Oleic acid	–	–	–	–	–	–										
Oxalic acid	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Ozone	o	o	o	o	+	o	–	–	+	o	–	–	o	–	o	–
n-Pentane																
Peracetic acid							–	–			–	–				
Perchloric acid	–	–	–	–	–	–	–	–	o	–	–	–	+	–	+	–
Perchloroethylene	–	–	o	o	o	–	–	–	–	–	+	o	–	–	–	–
Petroleum	–	–			+		o	o	+	–	+	+	o	–	o	–
Petroleum ether	–	–			+				o	–	+	+	o			
Phenol	–	–	–	–	–	–	–	–	–	–	–	–	+	o	+	+
Phenylethanol															o	
Phenylhydrazine															o	
Phosphoric acid 85%	+	o	+	+	–	–	+	+	+	o	+	–	+	+	+	+
Piperidine															+	
Potassium chloride	o	o	o	o	+	+	+	+	+	o	+	+	+	+	+	+
Potassium dichromate																
Potassium hydroxide	o	o	o	o	+	+	–	–	o	o	+	+	+	+	+	+
Potassium permanganate	+	+	+	o	+	+	+	+	+	+	o	o	+	+	+	+
Propanediol (Propylene glycol)	+	+	–	–	o	o	+	o	o	–	+	+	+	+	+	+
Propanol	o		+	+	o		o		+	+	+	+	+	+	+	+
Propionic acid	o	–					–	–	o	–	–	–	o	–	+	o
Pyridine	–	–	–	–	–	–	–	–	o	–	+	o	+	o	+	o
Salicylaldehyde	–	–	–	–			o	o	–	–			+	+	+	+
Salicylic acid	+	+	+	+					o	–	–	–	+	+	+	+
Silver acetate	o	o	o	o	o	o	+	+	o	o	o	o	+	+	+	+
Silver nitrate	o	o	+	+	+	+	+	+	o	o	o	o	+	+	+	+
Sodium acetate	+	+	+	+	–	–	+	+	o	o	+	o	+	+	+	+
Sodium chloride	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Sodium dichromate	+	o	+	o	+	o	+	–	+	+	+	+	+	+	+	+
Sodium fluoride	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Sodium hydroxide	+	+	+	+			–	–	+	+	+	+	+	+	+	+
Sulfuric acid 60%	–	–	+	o	–	–	o	o	o	–	–	–	+	+	+	+
Sulfuric acid 98%	–	–	–	–	–	–	–	–	–	–	–	–	o	–	o	–
Tartaric acid	+	+	+	+	o	o	+	+	+	+	+	+	+	+	+	+
Tetrachloroethylene																
Tetrahydrofuran (THF)	–	–	–	–	–	–	–	–	–	–	o	o	o	–	o	–
Tetramethylammonium hydroxide							–	–			–	–				
Toluene	–	–	–	–	–	–	–	–	–	–	+	+	o	–	o	o
Trichloroacetic acid	o	–					o	–	o	–			o	–	o	o
Trichlorobenzene	–	–					–	–	–	–			–	–	–	–
Trichloroethane	–	–	–	–	–	–	–	–	–	–	o	–	–	–	o	–
Trichloroethylene	–	–	–	–	–	–	–	–	–	–	–	–	–	–	o	–
Trichlorotrifluoro ethane	–	–	–	–												
Triethanolamine	–	–	–	–												
Triethylene glycol	+	+	+	+	o	o	+	o	o	–	+	o	+	+	+	+
Trifluoro ethane	–	–	–	–												
Trifluoroacetic acid (TFA)	–	–	–	–							–	–				
Tripropylene glycol	+	+	+	+	o	o	+	o	o	–	+	o	+	+	+	+
Turpentine	–	–	o	o	+	+	–	–	+	+	+	+	o	–	o	–
Urea	+	+	+	+	+	+	–	–	o	–	+	+	+	+	+	+
Xylene	–	–	–	–	–	–	–	–	–	–	+	+	o	–	o	–
Zinc chloride	+	+	+	+	–	–	+	+	+	o	+	o	+	+	+	+
Zinc sulfate	+	+	+	+	o	o	+	+	+	o	o	–	+	+	+	+

Continued list of "Chemical Resistance"

	PP		PMP		ETFE		PTFE		FEP/PFA		FKM	EPDM	NR	SI
	20 °C	50 °C	20 °C	50 °C	20 °C	50 °C	20 °C	50 °C	20 °C	50 °C	20 °C	20 °C	20 °C	20 °C
Ethylene glycol (Glycol)	+	+	+	+	+	+	+	+	+	+	0	+	0	+
Ethylene oxide	o	–	o	–	+	+	+	+	+	+	–	–	–	–
Fluoroacetic acid							+				–	–	–	–
Formaldehyde 40%	+	+	+	+	+	+	+	+	+	+	o	+	o	o
Formamide	+	+	+	+	+	+	+	+	+	+	o	o	+	
Formic acid 98-100 %	+	+	+	o	+	+	+	+	+	+	–	o	o	–
Glycerol	+	+	+	+	+	+	+	+	+	+	o	+	o	+
Glycolic acid 70%	+	+	+	+	+	+	+	+	+	+	o	+	+	+
Heating oil (Diesel oil)	+	o	o	–	+	+	+	+	+	+	+	–	–	–
Heptane	o	o	o	o	+	+	+	+	+	+	+	–	–	o
Hexane	+	o	o	–	+	+	+	+	+	+	+	–	–	o
Hexanoic acid							+	+						
Hexanol	+	+	+	+	+	+	+	+	+	+	+	–	o	o
Hydriodic acid	+	+	+	+	+	+	+	+	+	+	+	+		
Hydrobromic acid	+	+	+	+	+	+	+	+	+	+	+	o	o	–
Hydrochloric acid 10%	+	+	+	+	+	+	+	+	+	+	+	+	o	o
Hydrochloric acid 20%	+	+	+	+	+	+	+	+	+	+	+	+	o	–
Hydrochloric acid 37%	+	+	+	+	+	+	+	+	+	+	o	+	o	–
Hydrofluoric acid 40%	+	+	+	+	+	+	+	+	+	+	o	o	–	–
Hydrofluoric acid 70%	+	o	+	o	+	+	+	o	+	+	–	–	–	–
Hydrogen peroxide 35%	+	+	+	+	+	+	+	+	+	+	+	o	–	o
Iodine-potassium iodide solution	+	+	+	o	+	+	+	+	+	+	+	+	+	–
Isoamyl alcohol	+	+	+	+	+	+	+	+	+	+	o	o	o	o
Isobutanol (Isobutyl alcohol)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Isooctane					+	+	+	+	+	+	+	–	–	–
Isopropanol (2-Propanol)	+	+	+	+	+	+	+	+	+	+	+	+	+	o
Isopropyl ether	–	–	–	–	+	o	+	+	+	+	–	–	–	–
Lactic acid	+	+	+	+	+	+	+	+	+	+	+	o	o	o
Mercury	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Mercury chloride	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Methanol	+	+	+	+	+	+	+	+	+	+	–	+	o	+
Methoxybenzene					+	+	+	+	+	+	–	–	–	–
Methyl butyl ether	+	+	+	o	+	o	+	+	+	+	–	–	–	–
Methyl formate (Methyl methanoate)					+	+	+	+	+	+		o	–	o
Methyl propyl ketone	+	o	o	o	+	+	+	+	+	+	–	o	–	–
Methylene chloride (Dichloro methane)	o	–	–	–	+	+	+	+	+	+	o	–	–	–
Mineral oil (Engine oil)	+	+	+	+	+	+	+	+	+	+	+	–	–	o
Nitric acid 10%	+	+	+	+	+	+	+	+	+	+	o	o	–	–
Nitric acid 30%	o	–	o	–	+	+	+	+	+	+	o	–	–	–
Nitric acid 70%	–	–	–	–	+	+	+	+	+	+	–	–	–	–
Nitrobenzene	–	–	–	–	+	+	+	+	+	+	–	–	–	–
Oleic acid					+	+	+	+	+	+	o	–	–	–
Oxalic acid	+	+	+	+	+	+	+	+	+	+	+	+	o	o
Ozone	o	–	+	+	+	+	+	+	+	+	+	+	–	+
n-Pentane					+	+	+	+	+	+	+	–	–	–
Peracetic acid					+	+	+	+	+	+				–
Perchloric acid	+	–	o	–	+	+	+	+	+	o	+	o	–	–
Perchloroethylene	–	–	–	–	+	+	+	+	+	+	o	–	–	–
Petroleum	o	–	o	o	+	+	+	+	+	+	+	–	–	o
Petroleum ether					+	+	+	+	+	+	+	–	–	–
Phenol	+	+	o	o	+	+	+	+	+	+	o	–	–	–
Phenylethanol	o				+	+	+	+	+	+				
Phenylhydrazine	o				+	+	+	+	+	+	o	–	o	–
Phosphoric acid 85%	+	+	+	+	+	+	+	+	+	+	+	o	–	–
Piperidine	+				+	+	+	+	+	+	–	–	–	–
Potassium chloride	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Potassium dichromate							+	+			o	+	o	o
Potassium hydroxide	+	+	+	+	+	+	+	+	+	+	–	+	o	–
Potassium permanganate	+	+	+	+	+	+	+	+	+	+	+	+	o	–
Propanediol (Propylene glycol)	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Propanol	+	+	+	+	+	+	+	+	+	+	+	+	+	o
Propionic acid	+	o	+	o	+	o	+	+	+	+	+	o	–	–
Pyridine	o	o	+	o	–	–	+	+	+	+	–	–	–	–
Salicylaldehyde	+	+	+	+	+	–	+	+	+	+				
Salicylic acid	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Silver acetate	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Silver nitrate	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Sodium acetate	+	+	+	+	+	+	+	+	+	+	–	+	+	o
Sodium chloride	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Sodium dichromate	+	+	+	+	+	+	+	+	+	+	+	+	+	o
Sodium fluoride	+	+	+	+	+	+	+	+	+	+	+	+	o	o
Sodium hydroxide	+	+	+	+	+	+	+	+	+	+	o	+	o	o
Sulfuric acid 60%	+	+	+	+	+	+	+	+	+	+	+	–	–	–
Sulfuric acid 98%	–	–	+	+	+	+	+	+	+	+	+	–	–	–
Tartaric acid	+	+	+	+	+	+	+	+	+	+	+	o	+	+
Tetrachloroethylene					o		+	+	+		o	–	–	–
Tetrahydrofuran (THF)	o	–	o	–	+	o	+	+	o	o	–	–	–	–
Tetramethylammonium hydroxide					+	+	+	+	+	+	–	+		
Toluene	o	–	o	–	+	+	+	+	+	+	o	–	–	–
Trichloroacetic acid	o	–	+	+	+	o	+	+	+	+	–	o	o	o
Trichlorobenzene	–	–	o	o	+	o	+	+	+	+				
Trichloroethane	–	–	–	–	+	+	+	+	+	+	+	–	–	–
Trichloroethylene	–	–	–	–	+	+	+	+	+	+	o	–	–	–
Trichlorotrifluoro ethane					o	–	+	+	+	+				
Triethanolamine							+	+	+	+	–	o	o	–
Triethylene glycol	+	+	+	+	+	+	+	+	+	+	+	+	o	+
Trifluoro ethane							+	+	+	o	+	–	–	–
Trifluoroacetic acid (TFA)							+	o	+	–	–			
Tripropylene glycol	+	+	+	+	+	+	+	+	+	+			+	+
Turpentine	–	–	o	o	+	+	+	+	+	+	+	–	–	–
Urea	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Xylene	–	–	o	–	+	+	+	+	+	+	o	–	–	–
Zinc chloride	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Zinc sulfate	+	+	+	+	+	+	+	+	+	+	+	+	o	+

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