Surlyn®

resin

Chemical Resistance

Surlyn® resins have outstanding resistance to both physical and chemical attack. They are also highly resistant to permeation by liquids. However, some aromatic, cyclic, and higher aliphatic hydrocarbon solvents cause swelling and permeate through the resin; therefore, they should be used with caution. The permeation rate of any liquid will vary depending upon the particular grade of resin and wall thickness, as well as the molecular weight and polarity of the liquid.

Note: This report applies to industrial applications for *Surlyn®* resins and not for flexible packaging applications. Generally, industrial applications involve material thicknesses greater than 20 mil. Flexible packaging applications, by comparison, typically involve thin films and/or thin coatings or laminations to other substrates. The chemical resistance performance of *Surlyn®* for these thin, flexible packaging applications may be different than indicated in this report.

Chemical environmental effects on *Surlyn®* resins may be divided into three categories: oxidation, stress cracking, and plasticization. Only oxidation is a chemical degradation; the other two involve the physical properties of the polymer.

Oxidizers

Oxidizers are capable of chemically degrading *Surlyn®*. The chemical effects of even a strong oxidizer may be gradual and may not be measurable over the short term. However, they may be significant over the long term and should be evaluated if continuous exposure is expected. The following materials are examples of strong oxidizers that are unsuitable for long-term exposure to *Surlyn®* resin:

- Nitric acid, fuming
- Sulfuric acid, fuming (oleum)
- Aqua regia
- Chlorine (wet gas)
- Bromine (liquid)

Stress Crack Agents

Certain surface-active materials, although they have no chemical effect, can accelerate the cracking of *Surlyn®* resins when under stress. This accelerated form of stress failure is called environmental stress cracking (ESC). Although all resins are subject to stress cracking, some are more susceptible to it than others. Certain *Surlyn®* grades are specially designed to be more resistant to this type of failure.

ESC failure depends on the amount of stress in the resin and, therefore, thermal history and design factors are very important. When designing for known or possible stress crack agents, *Surlyn®* grade selection and optimum fabrication techniques (i.e., for minimum internal stress) must be considered. The following materials are examples of stress crack agents that are unsuitable for long term exposure to *Surlyn®* resin:

- Methyl alcohol
- Ethyl alcohol
- n-Propyl alcohol
- Isopropyl alcohol
- Ethylene glycol

Plasticizers

Certain types of nonaqueous chemicals are absorbed to varying degrees by *Surlyn®* resins causing swelling, weight gain, softening, and some loss of yield strength. These plasticizing materials cause no actual chemical degradation of the resin. Some organic solvents such as aliphatic hydrocarbons, chlorinated hydrocarbons, aromatics, and heterocyclic compounds have a strong plasticizing action (10--20% solubility in the polymer). However, most of these solvents are sufficiently volatile, so that if they are removed from contact with the resin, the part will "dry out" and return to its original condition with

no impairment of properties. Sodium-type resins absorb less of these solvents than zinc types. Conversely, aqueous solutions will plasticize sodium-type resins more than zinc types. If the end product is unsupported, absorption of either aqueous or nonaqueous product will reduce the product stiffness and may change color and increase internal haze.

Testing Is Important

It cannot be expected that one chemical resistance data chart will include the effects of all chemicals. Furthermore, the suitability of *Surlyn®* depends not only on the nature of the chemical environment, but also on the expected service temperature and stress, the duration of exposure, and whether it is intermittent or continuous.

Because so many variables are involved, it must be recognized that standard laboratory tests can give only a general guide as to whether a resin may resist exposure to a specific environment. Therefore, the feasibility of any chemical environment must be determined by extensive laboratory tests carried out under conditions that approximate as closely as possible those expected in service.

The following procedure is recommended to determine the suitability of *Surlyn®* to resist a specific chemical exposure:

1. Immerse a sample of the *Surlyn®* resin in the chemical under study. The sample should be preweighed and immersed at the expected service temperature for a reasonable time.
   Note: Many of the chemicals under study may be toxic, corrosive, flammable, and/or irritants. In addition, many of the chemicals under study should not be inhaled, ingested, or come in contact with human skin. Therefore, accepted industrial standards should be used when involved with these chemicals.
2. At the end of the test period, the sample should be reweighed to determine if there is a weight gain or loss. In addition, any change in surface hardness should be noted.
3. Check for chemical degradation of the resin by observing any surface crazing, cracking, or discoloration.
4. Tensile properties should be checked by measuring ultimate tensile strength and elongation. Tensile properties will change with percent plasticization. If chemical attack has occurred, a remarkable decrease in ultimate tensile strength should be evident.
5. Environmental stress cracking characteristics of the chemical under study can be determined using ASTM test procedure D1693 by substituting the chemical of interest for the test liquid specified in this procedure.

Guide to Chemical Resistance

The chemical resistance data presented in the following table originated in part from tests conducted at DuPont laboratories and, in part, from reliable published sources. *This table is intended only as a preliminary, general guide to the resistance of* Surlyn® *to various chemicals. It should not be used by the industry as the basis for final decisions because the specific end-use application, design, and/or conditions of use may have added effects on performance in a particular chemical environment. It is recommended that laboratory testing of the specific end-use application be conducted under expected service conditions.*

Resistance Code	Caution Code
R Resistant; no indication that serviceability would be impaired.	O Oxidizer P Plasticizer
V Variable resistance, depending on conditions of use.[a] U Not resistant. Not recommended for service applications under any conditions	A Known stress crack agent [b] B Possible stress crack agent [b]

[a] The classification "variable resistance" is very broad. Depending on the nature of the chemical, its concentration, the service temperature and pressure, and the time of exposure, *Surlyn®* resin can be either very resistant or very susceptible to attack. Therefore, where *Surlyn®* is said to have variable resistance to a chemical, it is critical that extensive pretesting be conducted.

[b] A system using *Surlyn®* in exposure to a chemical to which it is designated resistant, but which carries a stress crack identifier (A or B), may be serviceable over a useful lifetime providing the following precautions are observed:

- A stress crack resistant grade of *Surlyn®* resin should be used.
- Stresses in the fabricated *Surlyn®* must be minimized by design and processing.
- Conditions and limitations of the application should be carefully observed (avoidance of high temperature, etc.).

Chemical Resistance Data – *Surlyn*® Resin

Caution Code	Chemical	Chemical Resistance Code 21°C (70°F)	Chemical Resistance Code 60°C (140°F)
B	Acetaldehyde (100%)	V	U
	Acetic Acid(10%)	R	R
B	Acetic Acid (60%)	R	V
	Acetic Anhydride	R	R
	Acetone	R	*
	Acrylic Emulsions	R	R
	Adipic Acid	R	R
	Air	R	R
B,P	Allyl Chloride	U	U
	Aluminum Chloride	R	R
	Aluminum Fluoride	R	R
	Aluminum Hydroxide	R	R
	Aluminum Nitrate	R	R
	Aluminum Oxychloride	R	R
	Aluminum Sulfate	R	R
	Alums (all types)	R	R
	Ammonia (100% dry gas)	R	R
	Ammonia, Liquid	R	R
	Ammonium Acetate	R	R
	Ammonium Carbonate	R	R
	Ammonium Chloride	R	R
	Ammonium Fluoride	R	R
	Ammonium Hydroxide (10–28%)	R	R
	Ammonium Metaphosphate	R	R
	Ammonium Nitrate	R	R
	Ammonium Persulfate	R	R
	Ammonium Phosphate, Ammoniacal and Neutral	R	R
	Ammonium Sulfide	R	R
	Ammonium Sulfate	R	R
	Ammonium Thiocyanate	R	R
B,P	Amyl Acetate (100%)	U	U
A,P	Amyl Alcohol (100%)	V	V
P	Amyl Chloride (100%)	U	U
P	Aniline (100%)	R	U
P	Aniline Hydrochloride	U	U
	Anthraquinone	R	R
	Anthraquinone Sulfonic Acid	R	R
	Antimony Trichloride	R	R
O	Aqua Regia	U	U
P	Aromatic Hydrocarbons	R	V
	Arsenic Acid	R	R
	Ascorbic Acid (10%)	R	R
	Barium Carbonate	R	R
	Barium Chloride	R	R
	Barium Hydroxide	R	R
	Barium Sulfate	R	R
	Barium Sulfide	R	R

Caution Code	Chemical	Chemical Resistance Code 21°C (70°F)	Chemical Resistance Code 60°C (140°F)
	Beer	R	R
B	Beet Sugar Liquors	R	R
B	Benzaldehyde	V	U
P	Benzene	R	V
P	Benzene Sulfonic Acid (10%)	R	R
	Benzoic Acid	R	R
	Bismuth Carbonate	R	R
	Black Liquor	R	R
	Bleach Lye (10%)	R	R
	Borax	R	R
	Boric Acid	R	R
	Brine	R	R
	Bromic Acid	R	V
O	Bromine, Liquid	U	U
O	Bromine, Vapor (25%)	U	U
O	Bromine, Water	U	U
P	Butadiene	V	*
P	Butane	R	*
A	Butanediol	R	V
	Butter	R	R
P	n-Butyl Acetate (100%)	R	V
A	n-Butyl Alcohol (100%)	V	U
	Butyric Acid	U	U
	Cadmium Cyanide	R	R
	Calcium Bisulfite	R	R
	Calcium Bisulfide	R	R
	Calcium Carbonate	R	R
	Calcium Chlorate	R	R
	Calcium Chloride	R	R
	Calcium Hydroxide	R	R
B	Calcium Hydroxide (bleach solution)	V	V
	Calcium Nitrate (50%)	R	R
	Calcium Oxide	R	R
	Calcium Sulfate	R	R
B,P	Camphor Oil	U	U
	Carbon (slurry)	R	R
	Carbon Dioxide	R	R
	Carbon Disulfide	U	U
	Carbon Monoxide	R	R
P	Carbon Tetrachloride	U	U
	Carbonic Acid	R	R
	Castor Oil	R	R
	Caustic Potash	R	R
	Caustic Soda	R	R
P	Cellosolve	R	U
P	Chloralhydrate	U	U
O	Chlorine (100% dry gas)	U	U
O	Chlorine (wet gas)	U	U
O	Chlorine Liquid	U	U

V -- Variable resistance
U -- Not resistant
* -- Insufficient data
Refer to text for explanation of Resistance and Caution Codes.

Chemical Resistance Data – *Surlyn*® Resin

Caution Code	Chemical	Chemical Resistance Code 21°C (70°F)	Chemical Resistance Code 60°C (140°F)
B	Chlorine Water (2%)	R	V
P	Chlorobenzene	U	U
P	Chloroform	U	U
	Chlorosulfonic Acid (100%)	U	U
	Chromic Acid (10%)	R	*
O	Chromic Acid (30--50%)	R	*
	Cider	R	R
	Citric Acid	R	R
A	Coconut Oil Alcohols	R	V
	Coffee	R	R
	Cola Concentrates	R	R
	Copper Carbonate	R	R
	Copper Chloride	R	R
	Copper Cyanide	R	R
	Copper Fluoride (2%)	R	R
	Copper Nitrate	R	R
	Copper Sulfate	R	R
	Corn Oil	R	R
	Corn Syrup	R	R
P	Cottonseed Oil	R	R
P	Cresol	U	U
	Crude Oil	R	R
	Cupric Fluoride	R	R
	Cupric Sulfate	R	R
	Cuprous Chloride	R	R
B	Cyclohexanol	R	V
P	Cyclohexanone	R	U
B	Detergents, Synthetic	R	R
	Developers, Photographic	R	R
	Dextrin	R	R
	Dextrose	R	R
	Diazo Salts	R	R
	Dibutylphthalate	R	V
B,P	Dichlorobenzene (o & p)	U	U
B	Diethyl Ketone	V	U
A	Diethylene Glycol	R	V
A	Diglycolic Acid	R	R
	Dimethylamine	U	U
P	Dioctylphthalate	R	U
	Disodium Phosphate	R	R
	Distilled Water	R	R
P	Esters	R	V
P	Ethers	R	V
P	Ethyl Acetate (100%)	R	U
P	Ethyl Acrylate	R	V
A	Ethyl Alcohol	V	U
B,P	Ethyl Benzene	U	U
P	Ethyl Chloride	U	U
P	Ethyl Ether	U	U
B,P	Ethylene Bromide	U	U
B,P	Ethylene Chloride	U	U
B,P	Ethylene Chlorohydrin	U	U
B,P	Ethylene Dichloride	U	U
A	Ethylene Glycol	V	U
	Ethylene Oxide	R	V

V -- Variable resistance
U -- Not resistant

Caution Code	Chemical	Chemical Resistance Code 21°C (70°F)	Chemical Resistance Code 60°C (140°F)
	Ferric Chloride	R	R
	Ferric Hydroxide	R	R
	Ferric Nitrate	R	R
	Ferric Sulfate	R	R
	Ferrous Chloride	R	R
	Ferrous Sulfate	R	R
	Fish Solubles	R	R
	Fluoboric Acid	R	R
O	Fluorine, Gas, Wet	U	U
	Fluosilicic Acid (conc.)	R	V
	Fluosilicic Acid (32%)	R	R
B	Formaldehyde	R	V
	Formic Acid	R	R
	Fructose	R	R
B	Fruit Pulp	R	R
P	Furfural (100%)	U	U
B,P	Furfuryl Alcohol	U	U
B	Gallic Acid	R	R
P	Gas, Natural, Dry and Wet	R	*
P	Gasoline	R	V
P	Gasoline, High Octane	R	V
P	Genetron 11, 12 & 22	R	*
	Glucose R	R	R
B	Glycerine	R	R
A	Glycol	V	U
A	Glycolic Acid (30%)	R	R
	Grape Sugar (sat. aq.)	R	R
P	n-Heptane	R	V
	Hexachlorobenzene	R	R
P	Hexane	R	V
B	Hexanol, Tertiary	R	R
*	Hydrobromic Acid (50%)	R	R
	Hydrochloric Acid	R	R
	Hydrocyanic Acid	R	R
*	Hydrofluoric Acid (40--60%)	R	R
	Hydrogen (100%)	R	R
	Hydrogen Chloride (dry gas)	R	R
	Hydrogen Peroxide (3%)	R	V
	Hydrogen Sulfide	R	R
	Hydroquinone	R	R
	Hydroxylamine Sulfate	R	R
	Hypochlorous Acid	R	R
B	Inks	R	R
O	Iodine (in Kl solution)	U	U
A	Isopropyl Alcohol	V	U
P	Jet Fuels, JP4 and JP5	V	U
P	Kerosene	V	U
	Kraft Liquors	R	R
	Lactic Acid (25%)	R	R
	Lard Oil	R	R
	Latex	R	R
	Lauric Acid	R	V
P	Lauryl Chloride	V	*

* -- Insufficient data
Refer to text for explanation of Resistance & Caution Codes.

Chemical Resistance Data – *Surlyn*® Resin

Caution Code	Chemical	Chemical Resistance Code 21°C (70°F)	Chemical Resistance Code 60°C (140°F)
	Lead Acetate	R	R
	Lead Chloride	R	R
	Lead Nitrate	R	R
	Lead Sulfate	R	R
P	Linseed Oil	V	U
	Lithium Bromide	R	R
P	Lubricating Oil, ASTM #1, #2, #3	R	V
P	Machine Oil	R	V
	Magnesium Carbonate	R	R
	Magnesium Chloride	R	R
	Magnesium Citrate	R	R
	Magnesium Hydroxide	R	R
	Magnesium Nitrate	R	R
	Magnesium Sulfate‘	R	R
	Maleic Acid	R	R
	Mercuric Chloride	R	R
	Mercuric Cyanide	R	R
	Mercurous Nitrate	R	R
	Mercury	R	R
P	Methane	R	*
A	Methyl Alcohol	V	U
P	Methyl Chloride	U	U
P	Methyl Ethyl Ketone	R	V
P	Methyl Isobutyl Ketone	R	V
	Methyl Sulfate	R	R
	Methyl Sulfuric Acid	R	R
B,P	Methylene Chloride (100%)	U	U
	Milk	R	R
	Mineral Oils	R	V
	Molasses	R	R
P	Naptha	V	U
P	Napthalene	U	U
	Nickel Chloride	R	R
	Nickel Nitrate	R	R
	Nickel Sulfate	R	R
B	Nicotine (dilute)	R	R
	Nitric Acid (0--10%)	R	V
O	Nitric Acid (10--98%)	U	U
O	Nitric Acid, fuming	U	U
P	Nitrobenzene (100%)	U	U
P	Nitrous Oxide	R	*
P	n-Octane	R	R
P	Oleic Acid	U	U
	Oxalic Acid	R	R
O	Oxygen	R	V
O	Ozone	R	*
O	Perchloric Acid (10--70%)	U	U
P	Perchloroethylene	R	U
P	Phenol	U	U
P	Phenylhydrazine	U	U
P	Phenylhydrazine Hydrochloride	U	U

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U -- Not resistant
* -- Insufficient data
Refer to text for explanation of Resistance & Caution Codes.

Caution Code	Chemical	Chemical Resistance Code 21°C (70°F)	Chemical Resistance Code 60°C (140°F)
	Phosphoric Acid	R	R
	Photographic Solutions	R	R
O	Picric Acid	U	U
	Plating Solutions		
	Brass	R	R
	Cadmium	R	R
	Copper	R	R
	Gold	R	R
	Lead	R	R
	Nickel	R	R
	Silver	R	R
	Tin	R	R
	Zinc	R	R
	Potassium Bicarbonate	R	R
	Potassium Bichromate	R	R
	Potassium Borate	R	R
	Potassium Bromate	R	R
	Potassium Bromide	R	R
	Potassium Carbonate	R	R
	Potassium Chlorate	R	R
	Potassium Chloride	R	R
	Potassium Chromate (40%)	R	R
	Potassium Cyanide	R	R
	Potassium Dichromate (40%)	R	R
	Potassium Ferri/ Ferro Cyanide	R	R
	Potassium Fluoride	R	R
	Potassium Hydroxide	R	R
	Potassium Nitrate	R	R
	Potassium Perborate	R	R
	Potassium Perchlorate (10%)	R	R
	Potassium Permanganate (20%)	R	R
	Potassium Persulfate	R	R
	Potassium Sulfate	R	R
	Potassium Sulfide	R	R
	Potassium Sulfite	R	R
P	Propane	U	U
A	Propargyl Alcohol	R	V
A	n-Propyl Alcohol	V	U
P	Propylene Dichloride (100%)	U	U
A	Propylene Glycol	R	V
	Pyridine	R	U
	Resorcinol	R	R
	Salicylic Acid	R	R
	Sea Water	R	R
	Selenic Acid	R	R
	Sewage	R	R
	Shortening	R	R
	Silicic Acid	R	R
	Silver Cyanide	R	R
	Silver Nitrate Solution	R	R
	Silver Sulfate	R	R
	Soap Solution	R	R
	Sodium Acetate	R	R
	Sodium Benzoate (35%)	R	R
	Sodium Bicarbonate	R	R
	Sodium Bisulfate	R	R
	Sodium Bisulfite	R	R

Chemical Resistance Data – *Surlyn*® Resin

Caution Code	Chemical	Chemical Resistance Code 21°C (70°F)	Chemical Resistance Code 60°C (140°F)
	Sodium Borate	R	R
	Sodium Bromide (dilute)	R	R
	Sodium Carbonate	R	R
	Sodium Chlorate	R	R
	Sodium Chloride	R	R
	Sodium Cyanide	R	R
	Sodium Dichromate	R	R
	Sodium Ferri/Ferro Cyanide	R	R
	Sodium Fluoride	R	R
	Sodium Hydroxide	R	R
B	Sodium Hypochlorite	R	V
	Sodium Nitrate	R	R
	Sodium Nitrite	R	R
O	Sodium Peroxide	R	*
	Sodium Sulfate	R	R
	Sodium Sulfide	R	R
	Sodium Sulfite	R	R
P	Sour Crude Oil	R	V
	Stannic Chloride	R	R
	Stannous Chloride	R	R
	Starch Solution	R	R
	Stearic Acid (100%)	R	R
P	Stoddards Solvent	R	V
	Sulfur	R	R
	Sulfur Dioxide, Dry or Wet	R	V
	Sulfuric Acid (0--30%)	R	R
O	Sulfuric Acid (30--98%)	U	U
O	Sulfuric Acid, fuming (oleum)	U	U
	Sulfurous Acid	R	R
P	Tallow	R	V
	Tannic Acid	R	R
	Tanning Liquors	R	R
	Tartaric Acid	R	R
P	Tetrahydrofuran	U	U

Caution Code	Chemical	Chemical Resistance Code 21°C (70°F)	Chemical Resistance Code 60°C (140°F)
P	Thionyl Chloride	U	U
	Titanium Tetrachloride	U	U
P	Toluene	U	U
P	Tributylphosphate	V	V
P	Trichloroethylene	U	U
B	Triethylene Glycol	R	V
	Trisodium Phosphate	R	R
P	Turpentine	V	U
	Urea (0--30%)	R	R
	Urine	R	R
A	Vanilla Extract	R	V
	Vinegar	R	R
P	Vinyl Acetate	V	*
	Water	R	R
	Water, Acid Mine	R	R
	Water, Salt and Sea	R	R
	Wetting Agents	R	R
A	Whiskey	R	V
B	Wines	R	V
P	Xylene	R	V
	Yeast	R	R
	Zinc Bromide	R	R
	Zinc Carbonate	R	R
	Zinc Chloride	R	R
	Zinc Nitrate	R	R
	Zinc Oxide	R	R
	Zinc Stearate	R	R
	Zinc Sulfate	R	R

V -- Variable resistance
U -- Not resistant
* -- Insufficient data
Refer to text for explanation of Resistance & Caution Codes.

DuPont Worldwide

Toll-free (U.S.A.) **800 438-7225**

United States

DuPont Packaging and
Industrial Polymers
Barley Mill Plaza 26-2122
Lancaster Pike & Route 141
P.O. Box 80026
Wilmington, DE 19880-0026
Telephone (302) 992-5225
Fax (302) 992-3495

Canada

DuPont Canada Inc.
P.O. Box 2200, Streetsville
7070 Mississauga, Road
Mississauga, ONT L5M 2H3
Telephone (Canada Only):
(800) 268-3943)/(905) 821 5953
Fax (905) 821-5230

Brazil/South America

DuPont do Brasil, S.A.
Alameda Itapecuru, 506
06454-080 Barueri, SP Brasil
Telephone 55 (11) 7266 8542
Fax 55 (11) 7266 8720

Mexico/Central America

DuPont, S.A. de C.V.
Homero 206 Anexo Planta Alta
Col. Chapultepec Morales
11570, D.F. Mexico
Telephone (525) 722 1000
Fax (525) 722 1308

Europe

DuPont de Nemours Int'l. S.A.
2, Chemin du Pavillon Box 50
CH-1218 Le Grand Saconnex
Geneva, Switzerland
Telephone (022) 717 51 11
Fax (022) 717 55 00

Asia Pacific

DuPont Singapore PTE Ltd.
1 Maritime Square #07-01
World Trade Centre
Singapore 0409
Telephone (65) 273 2244
Fax (65) 272 7494

Japan

Mitsui-DuPont
Polychemicals Co., Ltd.
Kasumigaseki Bldg. 24F
3-2-5 Kasumigaseki
Chiyoda-ku, Tokyo 100, Japan
Telephone (813) 3580 5531
Fax (813) 3592 1540

Australia

DuPont (Australia) Ltd.
254 Canterbury Road
Bayswater, Victoria 3153
Australia
Telephone (3) 9721 5900
Fax (3) 9721 5650

Internet/World Wide Web:
http://www.dupont.com/industrial-polymers/surlyn

E-Mail:
industrial.polymers@dupont.com

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