Chemical / Environmental Resistance

Chemical / Environmental Resistance

The chemical and environmental resistance of Makrolon® depends on the unique combination of factors and variables it encounters in its application.

Outlined below is an overview of its primary outside influencers, and common types of potential damage. A summary of laboratory tests designed to meet its practical requirements, as well as its resistance to a wide range of chemicals and substances, is also provided.

Your Covestro Representative, with the support of our Technical Service Group, is available to work with you to evaluate your specific application.

Influencing parameters

Makrolon properties are influenced chiefly by:

- The composition of chemical ingredients
- Temperature
- Duration of exposure
- The level of internal or applied stress and strain

Types of damage

Makrolon can sustain several distinct types of damage, including swelling, dissolution, stress cracking and molecular degradation. Circumstances under which these potential types of damage can occur are detailed below. Different chemicals may act simultaneously on Makrolon sheet causing one or more types of damage.

Swelling or dissolution

When low-molecular, aromatic, halogenated and polar components migrate into the polycarbonate, the damage can range from a tacky surface, to swelling, to complete dissolution.

Stress cracking

Even in small quantities, a number of chemicals can penetrate the surface of Makrolon. This may result in stress cracks that affect the formed or fabricated part's appearance or mechanical properties.

With transparent grades of Makrolon, stress cracks are generally easy to detect. In opaque grades, it may be difficult to detect them. Stress cracks can act like a notch, leading to significant deterioration in several mechanical properties, particularly impact, flexural and tensile performance. Laboratory tests such as impact or flexural strength can be used as indicators for mechanical property degradation.

Temperature and the duration of exposure are key influencers in the potential cracking of Makrolon. As temperature rises, the time that elapses before damage occurs shortens. The exposure time required for initial damage ranges from a few seconds to more than 1000 hours due to the chemical involved, temperature, and stress level. For example, when formed or fabricated parts with pronounced stresses are immersed in aggressive solvents, stress cracks will occur in less than one minute.

It is possible for a component within a solid to migrate to polycarbonate through long-term contact and cause damage. One example is the contact between polycarbonate and plasticized PVC. Plasticizers within PVC, such as phthalates can trigger stress cracking and result in damage to the polycarbonate.

Molecular degradation

Many of Makrolon properties are determined by the size of its molecules. If an incompatible chemical causes a reduction in molecular weight, mechanical property degradation can occur. The molecular weight has virtually no influence on electrical properties and only a slight influence on thermal properties.

Solutions with a high pH (bases) can act to lower the molecular weight of polycarbonate. Low pH (acids) solutions typically do not degrade the molecular weight. Ammonia and amines are aggressive towards polycarbonate.

Covestro laboratories have tested a series of chemicals and commercial products to determine their compatibility with polycarbonate. The results of Makrolon resistance to substances are included in the following table (pages 10-13).

Laboratory tests supply information on the formulation tested. The composition of many commercial products can change over time.

Oxidative damage

Makrolon is relatively stable toward oxidizing agents such as oxygen, nitric acid, and hydrogen peroxide.

Resistance

Makrolon's resistance to chemicals, common industrial cleaners, pharmaceuticals, household and cosmetic substances, is dependent on the ingredients in the product, as well as the temperature and duration of exposure. The following section provides a general overview of resistance to these commonly used materials. If you require additional information, please contact your Covestro representative.

- **Resistance to sealing compounds, adhesives and plastics**

Makrolon's resistance to sealants, adhesives and plastics is largely dependent on the presence of aggressive components, such as plasticizers (e.g., phthalates) or solvents, which can migrate into polycarbonate.

- **Resistance to paints**

Solvents in paints may cause stress cracking or swelling depending upon the solvent and the flash-off and drying conditions. It is possible to formulate paints with solvents that do not cause damage. In some applications, painting can increase the chemical resistance of the finished part.

Two component paints are resistant if the individual components do not cause damage to Makrolon in the short period between the application and curing. The SDS can be used to identify the chemical composition of the paint.

- **Resistance to cleaning and washing agents**

Makrolon is resistant to most household soaps but not those containing amines, ammonia and sodium hydroxide.

- **Resistance to disinfectants, drugs and cosmetics**

Makrolon may be damaged by disinfectants, drugs and cosmetics, which contain solvents or active ingredients that are incompatible with polycarbonate. For example, nail polish and nail polish remover will cause damage to the material.

If the product ingredients are known, it is possible to estimate the compatibility with Makrolon. However, it is recommended to put the finished part through a practical test if no data is available. Refer to the compatibility table (pages10-13) for resistance levels.

Chemical / Environmental Resistance

Testing to meet practical requirements

The compatibility information presented in this section should be used as a starting point for determining the integrity and durability of your application. Testing is essential if finished Makrolon components are likely to encounter aggressive chemicals during use. The internal and applied stress in a formed or fabricated part, as well as duration of chemical exposure, can lead to very different results.

Compatibility assessment methods

The data shown in the compatibility table (pages10-13) was generated using DIN 53449-3. This method uses test pieces of 80 x 10 x 4 mm Makrolon sheet clamped to a curved fixture. The fixture applies a graduated strain ranging from 0 to 2%.

Assessment criteria

The information in the compatibility table is based on exposure to chemicals at 23°C and a range from 0-2% strain. Components that lead to damage with a strain of $\varepsilon < 1.0$ % are classified as incompatible.

The results shown in the following tables are based on a one-time test. Change in the composition by the producers of these substances can change the results.

Please contact your Covestro representative or the Technical Service Group at 800.628.5084 with any questions, or if you require additional information.

Chemical / Environmental Resistance

Legend

Explanation of the symbols:

- **+** Resistant
- **O** Partially resistant
- **-** Not Resistant

Chemicals

Acetaldehyde	-
Acetic acid, up to 10% solution	+
Acetone	-
Acetylene	+
Acrylonitrile	-
Allylalcohol	O
Alum	+
Aluminum chloride, saturated aqueous solution	+
Aluminum oxalate	+
Aluminum sulphate, saturated aqueous solution	+
Ammonia	-
Ammoniacal liquor	-
Ammonium chloride, saturated aqueous solution	+
Ammonium nitrate, saturated aqueous solution	+
Ammonium sulphate,saturated aqueous solution	+
Ammonium sulphide, saturated aqueous solution	-
Amylo acetate	-
Aniline	-
Antimony chloride, saturated aqueous solution	+
Arsenic acid, 20% solution	+
Benzaldehyde	-
Benzene	-
Benzoic acid	-
Benzyl alcohol	-
Borax, saturated aqueous solution	+
Boric acid	+
Bromic benzene	-
Bromine	-
Butane (liquid or gaseous)	+
Butyl acetate	-
Butanol	+
Butylene glycol	+
Butyric acid	-
Calcium chloride, saturated aqueous solution	+
Calcium hypochloride	+
Calcium nitrate, saturated aqueous solution	+
Calcium-soap, fat/pure	+
Carbon acid, wet	+
Carbon monoxide	+
Chlorine benzene	-
Chlorine gas, dry	O
Chlorine gas, wet	-
Chlorine lime slurry	+
Chlorine lime, 2% in water	+
Chloroform	-
Chrom alum, saturated aqueous solution	+
Chromic acid, 20% in water	+
Citric acid	+
Copper sulphate, saturated aqueous solution	+
Cresol	-
Cupric chloride, saturated aqueous solution	+
Cuprous chloride, saturated aqueous solution	+
Cyclo hexane	-
Cyclo hexanol	O
Cyclo hexanone	-
Dekaline	+
Diamyl phthalate	-
Dibutyl phthalate (plasticizer)	-
Diethylene glykol	+
Diethylether	-
Diglycolic acid, saturated aqueous solution	+
Dimethyl formamide	-
Dinonyl phthalate (plasticizer)	O
Dioctyl phthalate (plasticizer)	O
Dioxane	-
Diphyl 5, 3	O
Ether	-
Ethyl alcohol, 96% pure	+
Ethyl amine	-
Ethyl bromide	-
Ethylene chlorohydrine	-
Ethylene chloride	-
Ethylene glykol	+
Ferritrichloride, saturated aqueous solution	+
Ferro bisulphate	+
Formaline, 10%ig	+
Formic acid, 30%	O
Gasoline	+
Glycerine	O
Glycol	+
Heptane	+
Hexane	+
Hydrochloric acid, 20%	+
Hydrochloric acid, conc.	-
Hydrofluoric acid, 5%	+
Hydrofluoric acid, conc.	-
Hydrofluorosilicic acid, 30%	+
Hydrogen peroxide, 30%	+
Iodine	-
Isoamyl alcohol	O
Isopropyl alcohol	+
Lactic acid, 10% in water	+
Lead tetraethylene, 10% in gasoline	O
Lighting gas	+

Ligroin (hydrocarbon compound)	+
Lime milk, 30% in water	O
Magnesium chloride, saturated aqueous solution	+
Magnesium sulphate, saturated aqueous solution	+
Manganous sulphate, saturated aqueous solution	+
Mercuro chloride, saturated aqueous solution	+
Mercury	+
Methacrylic acid-methyester (MMA)	-
Methane	+
Methanol	-
Methyl amine	-
Methyl ethyl ketone (MEK)	-
Methylene chloride	-
Nitric acid, 10%	+
Nitric acid, 10-20%	O
Nitric acid, 20%	-
Nitric Gas, dry	-
Nitrobenzene	-
Oxalic acid, 10% in water	+
Oxygen	+
Ozone	+
Pentane	+
Perchloric acid, 10% in water	+
Perchloric acid, concentrated	O
Perchloro ethylene	-
Perhydrol, 30%	+
Petroleum	O
Petroleum ether	O
Petroleum spirit	+
Phenol	-
Phenyl ethyl alcohol	-
Phosphor trichloride	-
Phosphoric acid, conc.	+
Phosphoric oxichloride	-
Potassium aluminum sulpate, saturated aqueous solution	+
Potassium bichromate, saturated aqueous solution	+
Potassium bromide, saturated aqueous solution	+
Potassium carbonate, saturated aqueous solution	+
Potassium chloride, saturated aqueous solution	+
Potassium cyanide	-
Potassium hydroxide	-
Potassium metabisulphide, 4% in water	+
Potassium nitrate, saturated aqueous solution	+
Potassium perchlorate, 10% in water	+
Potassium permanganate, 10% in water	+
Potassium persulphate, 10% in water	+
Potassium rhodanide, saturated aqueous solution	+
Potassium sulphate, saturated aqueous solution	+
Propane gas	+
Propargyl alcohol	+
Propionic acid, 20%	+
Propionic acid, conc.	-
Propyl alcohol	+
Pyridine	-
Resorcin oil solution, 1%	+
Carbon disulphide	-
Hydrogen sulphide	+
Soda	+
Sodium bicarbonate, saturated aqueous solution	+
Sodium bisulphate, saturated aqueous solution	+
Sodium bisulphide, saturated aqueous solution	+
Sodium carbonate, saturated aqueous solution	+
Sodium chlorate, saturated aqueous solution	+
Sodium chloride, saturated aqueous solution	+
Sodium hydroxide	-
Sodium hypochloride, 5% in water	+
Sodium sulphate, saturated aqueous solution	+
Sodium sulphide, saturated aqueous solution	O
Styrene	-
Sublimate, saturated aqueous solution	+
Sulphur	+
Sulphur dioxide	O
Sulphuric acid, 50%	+
Sulphuric acid, 70%	O
Sulphuric acid, conc.	-
Sulphurous acid, 10%	-
Sulphuryl chloride	-
Tartaric acid, 10%	+
Tetrachlorocarbon	-
Tetrachloroethane	-
Tetrahydrofurane	-
Tetraline	-
Thiophene	-
Toluene	-
Trichloro acetic acid, 10%	O
Trichloroethyl amine	-
Trichloroethyl phosphate (plasticizer)	O
Trichloroethylene	-
Tricresyl phosphate (plasticizer)	-
Urea, saturated aqueous solution	+
Water	+
Xylene	-
Zinc chloride, saturated aqueous solution	+
Zinc oxide	+
Zinc sulphate, saturated aqueous solution	+

Chemical / Environmental Resistance

Disinfectants

Accel TB	-
Baktol®, 5%	+
Carbolic acid	-
Chloroamine	+
Clorox® BROAD SPECTRUM Quaternary Disinfectant Cleaner	-
Clorox® Healthcare FUZION Cleaner Disinfectant	-
Clorox® Healthcare Bleach Germicidal Cleaner	-
Delegol ®, 5%	+
Dimamin T, 5%	O
Hydrogen peroxide	+
Iodine tincture	O
Lysoform, 2%	+
Lysol® Brand III Disinfectant Spray (original)	-
Maktol ®	+
Merfen ®, 2%	+
Oktozon ®, 1%	+
PDI® Super Sani-Cloth® Disposable Wipes	-
Perhydrol	+
PeridoxRTU® Sporicidal Disinfectant	-
Resorcinol solutions, 1%	+
Safetec Surface Safe Wipes	-
Sagrotan ®, 5%	O
Spirit, pure	+
Steriplex® SD	-
Sublimate	+
TB-Lysoform	-
Trosilin G extra ®, 1, 5%	+
ZEP® 40 Non-Streaking Cleaner	-
ZEP® SPIRIT II	-
Zephirol ®	O

Pharmaceutics and cosmetics

Blood plasma	+
Delial-Sunmilk ®	+
Botanicare® Hydroplex	+
Iodine tincture	O
Klosterbalsam	+
Lanoline	+
Menthol, 90% in Alcohol	O
Nail polish	-
Nail polish remover	-
Odol-mouthwash ®	+
Periston blood substitute ®	+
Vaseline	+
Vicks® VapoRub®	+

Nutrition

Allspice	-
Apple juice	+
Beef sebum	+
Beer	+
Beets syrup	+
Brandy, 38%	+
Butter	+
Chocolate	+
Cinnamon	+
Clove	-
Cod-liver oil	+
Coffee	+
Common salt	+
Fish	+
Fruit juice	+
Fruit syrup (Raspberry)	+
Gherkins	+
Grape sugar	+
Grapefruit juice	+
Juniper berry	+
Lard	O
Linseed oil	+
Liquor	+
Margarine	+
Meat	+
Milk	+
Mineral water	+
Mustard	+
Nutmeg	-
Onion	+
Orange juice	+
Paprika	+
Pepper	+
Rum	+
Salad oil	+
Syrup	+
Sugar solution, saturated aqueous solution	+
Tea	+
Tobacco	+
Tomato juice	+
Tomato puree	+
Vanilla	+
Vegetable juice	+
Vegetable oils	+
Vinegar	+
Vodka	+
Water	+
Wine	+
Worcestershire sauce	+

Chemical / Environmental Resistance

Washing and cleaning agents

Household soap	+
Top Job	+
Joy®	+
Palmolive Liquid®	+

Technical oils and fats

Camphor oil	-
Castor oil	+
Cod-liver oil	+
Drilling oil	-
Fish oil	+
Fuel oil	O
Lubricant based on paraffin	+
Paraffin oil	+
Sodium soap fat	+

Miscellaneous

Battery acid	+
Blood	+
Castor oil	+
Cement	+
Freon ® 113	+
Gasoline	O
Natural rubber	+
Oleic acid, conc.	+
Polishing wax	+
Polyethylene	+
Polyvinylchloride, (containing plasticizer)	O
Sea water	+
Starch	+
Weak acid >4.7 pH	+
Weak base <9.5 pH	O
Tannic acid	-