LyondellBasell Technical Tip

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Chemical Resistance of Polypropylene

BACKGROUND

As a general class of materials, polyethylene (PE) and polypropylene (PP) are recognized for their excellent resistance to harsh chemical environments. This property has resulted in the successful utilization of polyolefins in applications such as chemical tanks, industrial piping, automotive batteries, lab ware, etc. The ability to measure and predict chemical resistance is extremely important. There are two basic types of chemical "attack"; solvation and chemical reaction.

Solvation occurs when a chemical either dissolves the polymer or is absorbed causing swelling and/or softening of the polymer to occur, often in conjunction with a measurable weight change. In this case, no chemical change occurs in the polymer and may even be reversible in very mild cases where swelling is minimal.

When a chemical reaction takes place, there is a change in the chemical structure of the polymer often causing a change in molecular weight and a loss in physical properties.

Another related mechanism is Environmental Stress Cracking (ESC). Although ESC is often described as a chemical attack, it is a very complex combination of plasticizing, migration, low level stress and mechanical failure initiated by exposure to specific classes of liquids, primarily surfactants (soaps). ESC is a failure mechanism frequently experienced with PE. Unlike PE, PP is not susceptible to ESC in its strictest definition. Exposure to certain fluids, such as bleach (hypochlorites), causes a failure in PP that resembles ESC and is often described accordingly. However, the failure is caused by the strong oxidizing effect of the bleach that causes the PP to degrade and fail.

The temperature of exposure is another key factor because of the increased mobility of many chemical molecules and the increased rate of reaction at elevated temperatures. The ability of solvents to diffuse into the polymer also increases with increased temperatures. In many cases, the level of stress applied to a part can accelerate the rate of chemical or solvent attack. Finally, as the concentration or strength of the chemicals increases, the resistance of the polymer generally decreases.

CHEMICAL RESISTANCE TESTING

There are many laboratory test procedures available to evaluate the potential effects of chemical exposure on PP containers of other molded parts including ASTM D 542,"Standard Test Method for Resistance of Plastics to Chemical Reagents" and ASTM D 5419, "Test Method for ESCR of Threaded Plastic Closures." In addition, many molders, fabricators and end-users have developed very specific procedures to determine suitability to exposure. Although laboratory testing can provide a relative indication of performance between materials or product grades, it is of limited value in predicting actual end-use performance unless extensive correlation studies have been conducted. If testing is conducted using laboratory specimens, the variables introduced by "real" part geometry such as material distribution and degree of molded-in stresses and their effects, are not taken into account. Another variable is the composition of the reagents used in the test since in most cases mixtures of various products are used rather than the pure chemicals used in a laboratory. It is not uncommon to experience various degrees of synergism in which the mixtures may behave more antagonistically than the individual components.

SPECIFIC PERFORMANCE OF POLYPROPYLENE

It is generally felt any exposure of polypropylene to environments containing strong oxidizing agents, halogenated and aromatic hydrocarbons and some ketones and ethers should be viewed with concern, Acids, bases, alcohols, detergents, lower ketones, aldehydec and water soluble salts are usually not regarded as antagonistic. Table 1 is a general guideline to resistance of polypropylene to various reagents. Performance is relative to the test method used and other variables found in practical applications such as temperature, applied loads, synergism of chemicals and molded-in stresses which need to be considered when evaluating product capability. Generally, the choice of a product with the highest, practical molecular weight (lowest

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Chemical Resistance of Polypropylene *(Continued)*

Table 1
GENERAL CHEMICAL RESISTANCE GUIDE FOR POLYPROPYLENE

REAGENT*	70°F (21°C)	120°F (49°C)
Acetic Acid (Glacial)	S	S
Acetic Acid (5%)	S	S
Acetone	S	S
Ammonium Hydroxide (concentrated)	S	NR
Ammonium Hydroxide (10%)	S	S
Aniline	S	S
Benzene	S	NR
Carbon Tetrachloride	NR	NR
Chromic Acid (40%)	S	NR
Citric Acid (1%)	S	S
Cottonseed Oil	S	S
Detergent Solution	S	S
Diethyl Ether	S	NR
Dimethyl Formamide	S	S
Distilled Water	S	S
Ethyl Acetate	S	NR
Ethyl Alcohol (95%)	S	S
Ethyl Alcohol (50%)	S	S
Ethylene Dichloride	S	NR
2-Ethylhexyl Sebacate	**	**
Heptane	NR	NR
Hydrochloric Acid (Concentrated)	S	S
Hydrochloric Acid (10%)	S	S
Hydrofluoric Acid (40%)	S	S
Hydrogen Peroxide Solution (28%)	S	S
Hydrogen Peroxide Solution (3%)	S	S

*Taken from ASTM D-543-87 Standard Reagents

REAGENT*	70°F (21°C)	120°F (49°C)
Isooctane	S	S
Kerosene	S	NR
Methyl Alcohol	S	S
Mineral Oil, White	NR	NR
Nitric Acid (Concentrated)	NR	NR
Nitric Acid (40%)	NR	NR
Nitric Acid (10%)	S	S
Oleic Acid	S	S
Olive Oil	S	S
Phenol Solution (5%)	S	S
Soap Solution (1%)	S	S
Sodium Carbonate Solution (20%)	S	S
Sodium Carbonate Solution (2%)	S	S
Sodium Chloride Solution (10%)	S	S
Sodium Hydroxide Solution (60%)	S	S
Sodium Hydroxide Solution (10%)	S	S
Sodium Hydroxide Solution (1%)	S	S
Sodium Hypochlorite Solution (4 to 6%)		
Sulfuric Acid (Concentrated)	NR	NR
Sulfuric Acid (30%)	S	S
Sulfuric Acid (3%)	S	S
Toluene	NR	NR
Transformer Oil	S	M
Turpentine	S	S

Key:
S = Satisfactory
M = Marginal
NR = Not Recommended
** No Data Available

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