THE CHEMICAL RESISTANCE OF PVC

Introduction

The excellent chemical resistance of polyvinyl chloride (PVC) makes it particularly suitable for a wide range of applications in which this property is of primary importance.

Most of the data on the chemical resistance of PVC has been obtained from short term immersion tests carried out in the laboratory. These tests involve qualitative assessment of the effect on a reagent of the surface of a specimen and it is difficult to use these results to predict the performance of fabricated forms in service. Attack of the surface of specimens in laboratory tests is recorded because it will probably be observed in practice, e.g. as a change of surface appearance, but it does not necessarily mean the PVC is unsuitable for use in contact with the reagent. Even when chemicals actually dissolve or degrade the PVC, or cause marked swelling, other factors such as concentration of the reagent and the conditions of service have their effect. Only by trials on the fabricated article under actual or simulated service conditions can the suitability of PVC in a specific application be ascertained.

Resistance of Plasticised PVC

Plasticisers are incorporated in PVC compounds so as to confer flexibility and softness. Plasticised compounds can cover a very wide range of flexibility and softness and will also differ in other respects e.g. tensile strength and resilience, according to the type and/or amount of plasticiser(s) used. For example, the type of plasticiser used will effect the chemical resistance, but in these notes it has been assumed that a commonly used, fairly resistant plasticiser dioctyl phthalate (DOP) would be present.

The amount of plasticiser incorporated will also effect the chemical resistance. An increase in plasticiser content will lead to a deterioration in chemical resistance, because the plasticiser is less resistant to attack than the PVC.

Acid & Alkalis

Diluted acids and alkalis have little effect at room temperature, but at elevated temperatures some hydrolysis and extraction of plasticiser may occur. Concentrated acids and alkalis hydrolyse plasticiser slowly in the cold and more rapidly when heated.

Organic Liquids

The main effect of organic liquids on plasticised PVC is to extract the plasticiser and this results in some hardening, particularly when the PVC is removed from contact with the liquid the compound may become rigid and less tough.

Most organic solvents will extract plasticiser and give rise to these effects, but with aromatic and chlorinated hydrocarbons, aliphatic and aromatic nitro compounds, ketones, aliphatic and cyclic ethers, this plasticiser extraction is accompanied by a softening of the PVC and the overall effect is difficult to predict.

With certain solvents too, the plasticiser extracted is replaced by the solvents so that the compound remains flexible, provided it remains in contact with the liquid. On allowing the solvent to evaporate the material will stiffen and will not soften on re-immersion.

Disclaimer

Information in this publication and otherwise supplied to users is based on our general experience and is given in good faith, but because of the many particular factors which are outside our knowledge and control and affect the use of products, no warranty is given or is to be implied with respect to such information.

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The relative resistances are listed in the following groups:

Vinyl products
- Chemical substances: 3 - 7
- Foodstuffs: 7
- Technical goods & drugs: 8 - 9
- Pharmaceuticals & Cosmetics: 9

Foam products
- Chemical substances:10

Legend:

1	Resistant
2	Particularly resistant
3	Limited resistant
4	Poorly resistant
5	Not resistant
aq	Aqueous

Chemical Substance	Concentration (% by weight)	Resistance 20°C (68°F)	Resistance 60°C (140°F)
Acetic acid	100	5	5
Acetic acid aq	50	3	5
(see also vinegar)	10	1	3
Acetic anhydride	100	5	5
Acetone*	100	5	5
Aluminium salts aq	Any	1	1
Alums aq	Any	1	1
Ammonia, gaseous	100	1	1
Ammonia aq	Concentrated	1	4
	10	1	3
Ammonium acetate aq	Any	1	1
Ammonium carbonate aq	Any	1	
Ammonium chloride aq	Any	1	1
Ammonium nitrate aq	Any	1	1
Ammonium phosphate aq	Any	1	
Ammonium sulphate aq	Any	1	1
Amyl alcohol, pure		4	5
Aniline	100	5	5
Animony Chloride		1	1
Arsonic Acid	Concentrated	1	2
Barium Salts aq		1	1
Benzaldehyde	100	5	5
Benzaldehyde aq	Saturated	5	5
	(0.3)		

* Boiling point 56.3°C

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Chemical Substance	Concentration (% by weight)	Resistance 20°C (68°F)	Resistance 60°C (140°F)
Benzene	100	5	5
Benzoic acid	100	1	
Benzoic acid aq	Saturated	1	
Bismuth Carbonate		1	1
Boric acid	100	1	
Boric acid aq	Saturated	1	1
	(4.9)		
	Low	5	
Bromine water	Saturated		
Butane, gaseous	100		
Butane, liquid	100	5	
Bulyl acetate	100	5	5
n-Butyl alcohol	100	5	5
Butyric Acid	20	1	
Calcium chloride aq	Saturated	1	1
Calcium nitrate aq	Saturated	1	1
Carbon bisulphide **	100	5	
Carbon dioxide		1	1
Carbon tetrachloride	100	5	5
Caustic potash solution	50	3	5
Caustic soda solution	10	1	2
	25	2	3
	50	5	5
Chlorine, gas, dry	100	5	5
Chlorine, gas, humid	10	5	5
Chlorine, liquid	100	5	
Chlorine water	Saturated	3	
Chlorobenzene	100	5	5
Chloroform	100	5	5
Chlorosulphonic acid	100	5	5
Chromium salts (bi-and trivalent) aq	Saturated	1	1

** Boiling point 46.2°C

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Chemical Substance	Concentration	Resistance	
	(% by weight)	20°C (68°F)	60°C (140°F)
Citric acid aq	Saturated	1	
Copper salts aq	Saturated	1	
Cresols	100	5	5
Cresols aq	Saturated	4	5
Cupric Chloride		1	1
Cyclohexane	100	5	5
Cyclohexanol	100	5	5
Cyclohexanone	100	5	5
Decahydronaphthalene	100	5	5
Dimethylformamide	100	5	5
1,4-Dioxane	100	5	5
Disodium Phosphate		1	1
Ether	100	5	
Ethyl acetate	100	5	5
Ethyl alcohol, not denatured	100	5	5
Ethyl alcohol, aq, not denatured	96	3	5
	50	3	3
	10	1	3
Ethyl benzene	100	5	5
Ethyl chloride**	100	5	
Ethylene chloride	100	5	5
Ethylene glycol		1	
2-Ethyl hexanol	100	5	5
Ferric Sulphate		1	1
Formaldehyde aq	40	3	
Formic acid	98	5	5
	90	4	3
	50	3	5
	30	3	
	10	1	3
Fructose		1	1

** Boiling point 13.1°C

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Chemical Substance	Concentration	Resistance	
	(% by weight)	20°C (68°F)	60°C (140°F)
Glycerine	100	2	
Glycerine aq	High	1	3
	Low	1	1
Glycol	100	2	3
Glycol aq	High	1	1
	Low	1	
Heptane	100	5	5
Hexandecanol	100	1	1
Hydrochloric acid	Concentrated	2	3
	10	1	2
Hydrogen chloride gaseous	High	1	
Hydrogen peroxide aq	10	1	3
	3	1	2
Hydrogen sulphide*	Low	1	
Iron salts aq	Saturated	1	1
Isooctane	100	5	5
Isopropyl alcohol	100	5	5
Lactic acid aq	90	3	5
	50	3	5
	10	1	3
Lead acetate		1	1
Magnesium salts aq	Saturated	1	1
Mercuric salts aq	Saturated	1	
Mercury	100	1	
Methyl alcohol	100	5	5
Methyl alcohol aq	50	3	3
Methylene chloride**	100	5	
Methyl ethyl ketone	100	5	5
Naphthalene	100	5	5
Nickel salts aq	Saturated	1	1

* Discolouration with lead stabilisers

** Boiling point 41.6°C

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Chemical Substance	Concentration	Resistance	
	(% by weight)	20°C (68°F)	60°C (140°F)
Nitric acid	50	4	5
	10	2	
	5	1	1
Nitrobenzene	100	5	5
	25	3	4
	10	2	3
Oleic acid	100	3	5
Oxalic acid aq	Saturated	1	3
Ozone	Saturated	1	
Phenol (aqueous phase)	Saturated	5	5
Phenol (phenolic phase)	Saturated	5	5
Phosphoric acid	Saturated	1	3
	50	1	1
	10	1	1
Phosphorous pentoxide	100	2	
Phthalic anhydride		2	2
Potassium carbonate aq	Saturated	1	
Potassium chlorate aq	Saturated	1	3
Potassium chloride aq	Saturated	1	1
Potassium dichromate aq	Saturated	1	3
Potassium iodide aq	Saturated	1	
Potassium nitrate aq	Saturated	1	
Potassium	Saturated	2	
Potassium persulphate aq	Saturated	1	3
Potassium sulphate aq	Saturated	1	1
Propane, liquid	100	5	
Pyridine	100	5	5
Sodium bicarbonate aq	Saturated	1	
Sodium bisulphite aq	Saturated	1	
Sodium carbonate aq	Saturated	2	3
Sodium chlorate aq	25	1	
Sodium chloride aq	Saturated	1	1
Sodium chlorite aq	5	1	

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Chemical Substance	Concentration	Resistance	
	(% by weight)	20°C (68°F)	60°C (140°F)
Sodium hypochlorite aq (Bleach)	5	1***	
Sodium nitrate aq	Saturated	1	
Sodium perborate aq	Saturated	1	
Sodium phosphates aq	Saturated	1	
Sodium sulphate aq	Saturated	1	
Sodium sulphide aq	Saturated	1	
Sodium sulphite aq	Saturated	1	
Sodium thiosulphate aq	Saturated	1	
Stannous chloride	Saturated	1	
Succinic acid aq	Saturated	1	
Sulphur	100	1	
Sulphur dioxide	Low	1	
Sulphuric acid	96	5	5
	50	2	
	25	1	3
	10	1	1
Stearic acid	100	1	3
Tartaric acids aq	Saturated	1	
Tetrachlorethane	100	5	5
Tricholorethylene	100	5	5
Tetrahydrofurane	100	5	5
Tetrahydronaphthalene	100	5	5
Thiophen	100	5	5
Toluene	100	5	5
Trichlorehtylene	100	5	5
Urea aq	Saturated	1	3
Water	100	1	1
Xylene	100	5	5
Zinc salts aq	Saturated	1	1

*** Mechanical properties of PVC unaffected, but colour will be affected by prolonged exposure to bleaching solutions.

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Foodstuffs	Concentration	Resistance	
	(% by weight)	20°C (68°F)	60°C (140°F)
Beef Suet		3	5
Common salt, dry		1	
Lard		3	5
Lemonades		1	
Lemon juice		1	
Mayonnaise		2	
Milk		1	
Pickled herring		1	
Salad oil, animal		3	5
Salad oil, vegetable		3	5
Salted water	Any	1	1
Soda water		1	
Soybean oil		3	5
Starch, starch solution aq	Any	1	
Sugar (dry)		1	
Sugar beet sirup		1	1
Sugar solution aq	Any	1	1
Tomato juice		1	
Vinegar		1	3
Vinegar essence		3	5
Wine, mulled claret		1	

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Technical Goods & Drugs	Concentration	Resistance	
	(% by weight)	20°C (68°F)	60°C (140°F)
Alum	Saturated	1	
Antifreeze agent (cars)*		1	3
Aqua regia		5	5
Asphalt*		3	4
Bleaching solution		1***	
Bone oil		3	5
Borax aq	Saturated	1	
Chloride of lime		3	
Chromic/sulphuric acid		5	5
Chromium plating		3	
Cresol solution		4	5
Detergents, synthetic**	High	1	3
	Ready for use	1	1
Dish-washing agents, liquid*		1	
Dixan solution		1	2
Fixing salt	100	1	1
Floor wax*		3	5
Formalin		3	
Fuel petrol, normal DIN 51 635		5	5
Petrol, regular		5	5
Petrol, super		5	5
Diesel oil*		4	5
Fuel oil*		4	5
Furniture polish*		5	5
Ink*		5	5
Lanolin		3	5
Linseed oil		3	5
Lysol		4	5
Mineral oil (without aromatic Hydrocarbons)*		3	5
Moth balls		5	
Motor oil (cars)*		3	5
Oil No 3 according to ASTM D 380-59	100	3	5

* Chemical resistance depends on the composition
** Without solvent, plastisers and other additives
*** Mechanical properties of PVC unaffected, but colour will be affected by prolonged exposure to bleaching solutions.

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Technical Goods & Drugs	Concentration	Resistance	
	(% by weight)	20°C (68°F)	60°C (140°F)
Oleum	Any	5	5
Paraffin	100	3	5
Paraffin oil	100	3	5
Pectin	Saturated	1	
Petroleum	100	5	5
Petroleum ether	100	5	5
Pine needle oil	100	5	
Storage battery acid		1	3
Photographic developers	Ready for use	2	
Sagrotan		4	5
Sea Water		1	1
Shoe polish		3	5
Tar*		3	4
Transformer oil*		3	
Turpentine oil		5	5
Two-stroke oil		3	5
Typewriter oil		3	
Water glass		1	
White spirit		5	5

* Chemical resistance depends on the composition

Pharmaceuticals & Cosmetics	Concentration	Resistance	
	(% by weight)	20°C (68°F)	60°C (140°F)
Hair shampoo*		1	
Nail polish*		5	5
Nail polish remover*		5	5
Perfume**		5	5
Soap, cake soap		1	
Soap solution		1	
Toothpastes		1	1
Vaseline		3	5

* Chemical resistance depends upon the composition
** The permeability for scents should be considered

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Chemicals	Products				
	Spark Safe	Tuff Spun	Zed Chex	Zed Land	Zed Tred
Acetic Acid	3	1	1	1	1
Acetone	2	4	4	4	4
Animal Fat	3	1	1	1	1
Brake Fluid	4	3	3	3	3
Butyl Alcohol	2	4	2	4	2
Chlorine (wet)	1	2	1	1	1
Cutting Oil	4	4	4	4	4
Formaldehyde	3	2	1	2	1
Gasoline	4	3	3	3	3
Hydraulic Fluid	2	2	2	2	2
Hydrochloric Acid	1	1	1	1	1
MEK	4	4	4	4	4
Mineral Oil	3	2	1	2	2
Motor Oil	2	2	1	2	2
Nitric Acid Dilute	3	2	1	2	1
Butyl Acetate	4	4	4	4	4
Sodium Hydroxide Dilute	1	2	1	1	1
Sulphuric Acid 25%	1	1	1	2	1
Transmission Fluid	2	2	1	2	2
Vegetable Oil	1	1	1	1	1
Xylene	4	4	4	4	4

Legend:

1	Almost no dimension and/or hardness change
2	Minor changes in dimension and/or hardness
3	Moderate change in dimension and/or hardness
4	Not recommended