5. Environmental Resistance

5.1 Chemical Resistance

The part design engineer will appreciate the need to consider the chemical environment to which the part will be exposed during its service life. Celcon® acetal copolymers have excellent resistance to many chemicals and solvents when molded parts are exposed in an unstressed state. In some cases, slight discoloration is observed with little change in the mechanical properties measured. Table 5.1 summarizes the performance of Celcon acetal copolymer after exposure to a variety of chemicals over a range of temperature and exposure times.

In general, Celcon acetal copolymer is minimally affected by a wide variety of solvents and chemicals, except by strong mineral acids (sulfuric, nitric, hydrochloric, etc.) and strong oxidizing agents such as aqueous solutions containing high concentrations of hypochlorite or permanganate ions. A summary of the performance of test specimens of Celcon acetal copolymer in various environments is given below:

Fuels: Celcon acetal copolymer shows small changes in dimensions, weight and strength when exposed to oxygenated and non-oxygenated fuels at 65°C.1

Oils: Almost no effect is seen following exposure to various hydrocarbon and ester oils such as mineral oil, motor oil and brake fluids, even at elevated temperatures.

Organic Reagents: Most of the organic reagents tested did not affect Celcon acetal copolymer. Only a slight change was seen for common degreasing solvents such as carbon tetrachloride, trichloroethylene and acetone at room temperature. Prolonged exposure at elevated temperature to more aggressive solvents such as ethylene dichloride, phenolic solutions and aniline should be avoided, unless the application is designed around the potential change in properties.

Aqueous Bases (Alkalies): Celcon acetal copolymer is especially resistant to strong bases (alkalies) showing superior resistance in this medium when compared to acetal homopolymer. Molded Celcon acetal copolymer specimens immersed in almost boiling 60% sodium hydroxide solution and other strong bases for several months, showed little change.

Aqueous Acids: Celcon acetal copolymer is not recommended for use in the presence of mineral acids or strong Lewis acids such as zinc chloride or boron trifluoride. Celcon acetal copolymer should only be exposed to aqueous solutions that have a pH above 4.0.

Detergents: Immersion for up to six months at 82°C (180°F) in several commercial dishwashing detergent solutions produced virtually no change in the tensile strength of molded parts of Celcon acetal copolymer.

Potable Water: Prolonged or continuous exposure of Celcon acetal copolymer in aqueous solutions containing hypochlorite ions should be limited to hypochlorite concentrations typically found in U.S. domestic potable water supplies.

Table 5.1 summarizes the exposure tests of three unfilled Celcon acetal copolymer grades to a wide spectrum of inorganic and organic chemicals, as well as commercial products including automotive fluids and detergents. The results illustrate the resistance shown by Celcon acetal copolymer to most common solvents and chemicals.

[1] Reference "Plastics and Aggressive Auto Fuels – a 5,000 Hour Study of Seven Plastics and Nine Fuel Blends," 01-300, March, 2001.

Fig 5.1 · Chemical resistance of Celcon® acetal copolymer standard unfilled grades

Chemical	Exposure Time (Months)	Temp. °C	Yield Strength % Change	Tensile Modulus % Change	Length* % Change	Weight % Change	Visible Effect**
Control (Air)	2	23	0	0	0	0.22	N.C.
Inorganic Chemicals							
10% Aluminum Hydroxide	6	23	0	0	0.3	0.88	Disc.
	12	23	0.7	-16	0.3	1.03	Disc.
	6	82	-0.3	-12	0.4	0.74	Disc.
3% Hydrogen Peroxide	6	23	2	-15	0.3	0.97	N.C.
	12	23	3	-12	0.3	0.88	N.C.
10% Hydrochloric Acid	6	23	x	x	x	x	x
10% Nitric Acid	6	23	x	x	x	x	x
10% Sodium Chloride	6	23	2	-12	0.2	0.59	N.C.
	12	23	3	-15	0.2	0.71	SL.Disc.
	6	82	4	-10	0.2	0.77	SL.Disc.
2% Sodium Carbonate	6	23	0	-9	0.2	0.77	N.C.
	12	23	6	-9	0.2	0.78	N.C.
	6	82	3	-2	0.4	0.96	N.C.
20% Sodium Carbonate	6	82	3	-2	0.2	0.61	N.C.
1% Sodium Hydroxide	6	23	1	2	0.2	0.80	N.C.
	12	23	2	2	0.2	0.84	N.C.
10% Sodium Hydroxide	6	23	1	-8	0.2	0.49	N.C.
	12	23	-2	-6	0.2	0.73	N.C.
	6	82	-3	-8	0.2	0.83	SL.Disc.
60% Sodium Hydroxide	6	82	-3	-6	-0.1	-0.18	SL.Disc.
4-6% Sodium Hypochlorite	6	23	x	x	x	x	x
26% Sodium Thiosulfate	6	82	3	-12	0.2	0.61	N.C.
3% Sulfuric Acid	6	23	0	-8	0.4	0.81	N.C.
	12	23	2	-14	0.2	0.82	N.C.
30% Sulfuric Acid	6	23	x	x	x	x	x
Buffer, pH 7.0	6	82	2	-15	0.3	0.94	SL.Disc.
Buffer, pH 10.0	6	82	4	-12	0.3	0.89	SL.Disc.
Buffer, pH 4.0	4	82	x	x	x	x	x
Water (Distilled)	6	23	0	-12	0.2	0.83	N.C.
	12	23	4	-12	0.2	0.84	N.C.
	12	82	0	-18	-0.1	-3.32	Disc.
Organic Chemicals							
5% Acetic Acid	12	23	0.6	-16	0.2	1.13	N.C.
Acetone	6	23	-4	-20	0.7	3.60	N.C.
	12	23	-17	-48	1.6	3.68	N.C.
Aniline	6	82	-26	-73	4.8	12.10	Reddish Tint
Benzene	6	49	-17	-43	1.8	3.93	N.C.
Carbon Tetrachloride	6	23	-1	-4	0.2	0.86	N.C.
	12	23	2	-6	0.1	1.39	N.C.
	6	49	-11	-32	1.2	5.23	N.C.
10% Citric Acid	6	23	0	-12	0.3	0.74	N.C.
	12	23	3	-10	0.2	1.93	N.C.
Dimethyl Ether	6	23	-15	-26	1.1	2.09	N.C.
Dimethyl Formamide	6	82	-19	-63	3.1	7.70	N.C.
Ethyl Acetate	6	23	-5	-20	0.6	3.62	N.C.
	12	23	-17	-46	1.6	4.25	N.C.
	6	49	-22	-50	2.1	5.23	N.C.
Ethylene Dichloride	6	49	-23	-68	3.2	10.05	N.C.
50% Ethylene Glycol	6	82	x	x	x	x	x
95% Ethanol	6	23	-4	-19	0.6	1.43	N.C.
	12	23	-6	-35	0.7	2.19	N.C.
	6	49	-17	-31	1.3	2.54	N.C.

(See notes page 37 bottom)

Fig 5.1 · Chemical resistance of Celcon® acetal copolymer standard unfilled grades

Chemical	Exposure Time (Months)	Temp. °C	Yield Strength % Change	Tensile Modulus % Change	Length* % Change	Weight % Change	Visible Effect**
Organic Materials Continued							
50% Ethanol	6	23	-4	-24	0.6	1.62	N.C.
	12	23	-5	-32	0.7	1.98	N.C.
	6	49	-13	-34	1.0	2.27	N.C.
Heptane	12	23	3	4	-0.07	0.09	N.C.
	6	82	-6	-9	0.02	0.35	N.C.
Oleic Acid	12	23	3	31	-0.04	1.26	N.C.
	6	82	0	-9	0.5	1.04	N.C.
5% Phenol	6	23	-15	-45	2.1	9.34	N.C.
	12	23	-10	-46	1.4	4.70	Disc.
Toluene	6	23	-7	-17	0.4	1.12	N.C.
	12	23	-7	-19	0.7	1.87	N.C.
	6	82	-14	-43	1.6	3.80	N.C.
Other Materials							
Automatic Transmission Fluid	6	82	5	5	-0.07	-0.15	N.C.
Anti-Freeze (Telar®)	6	82	x	x	x	x	x
Brake Fluid, "Super 9®"	6	23	0	-12	0.3	0.34	N.C.
	12	23	3	-1	0.2	0.53	N.C.
Brake Fluid, "Lockheed 21®"	7	23	-3	-13	0.3	0.70	N.C.
	12	23	0.5	-9	0.2	1.05	N.C.
	6	82	-11	-41	1.4	3.60	N.C.
Brake Fluid, "Delco 222®"	6	82	-5	-33	1.3	3.18	N.C.
Detergents							
"Acclaim®"	6	82	2	-11	0.2	0.85	SL.Disc.
"Calgonite®"	6	82	3	-15	0.3	1.00	SL.Disc.
"Electro-Sol®"	6	82	3	-10	0.3	1.04	N.C.
50% Igepal®	6	23	18	-14	0.4	0.75	N.C.
	12	23	3	-15	0.4	0.84	N.C.
	6	82	0	-18	0.7	1.64	N.C.
Detergent Solution***	6	82	-3	-20	0.4	1.04	SL.Disc.
1% Soap Solution	6	82	-2	-15	0.5	1.32	N.C.
Fuels							
Mobil® Reg. (93.5 Octane)	6	49	-11	-12	0.7	1.30	N.C.
Mobil® "Hi-Test" (99.0 Octane)	6	49	-12	-12	0.7	1.50	N.C.
Sunoco® "280" (103 Octane)	6	49	-6	-10	0.7	1.43	N.C.
Gasohol	8	23	-8	—	0.6	1.42	N.C.
10% Ethanol/90% Gasoline	8	40	-6	—	0.5	1.26	N.C.
Kerosene	6	82	0	-7	0.3	0.34	N.C.
Linseed Oil	6	82	8	11	0.2	-0.13	N.C.
Lubricating Grease	6	82	4	3	0.2	-0.03	N.C.
Mineral Oil ("Nujol®")	12	23	3	-1	-0.06	0.05	N.C.
	6	82	8	7	0.0	-0.18	N.C.
Motor Oil (10W30)	12	23	5	7	-0.06	-0.14	N.C.
	6	82	5	0	-0.06	-0.14	N.C.
Diesel Fuel C	6	71	-8	-32	0.99	2.44	N.C.
	12	71	-10	-33	1.04	2.39	N.C.

*** Type 1 Tensile bars used in these tests measure 21.3 x 12.6 x 3.2 mm; initial yield strength is 61 MPa; tensile modulus 2800 MPa; weight 13 grams.
*** x = Not recommended; N.C. = No Change; Disc. = Discoloration; SL.Disc. = Slight Discoloration.
*** Consists of 0.5 grams of an alkyl sulfonate + 0.20 grams of trisodium phosphate per liter of water.