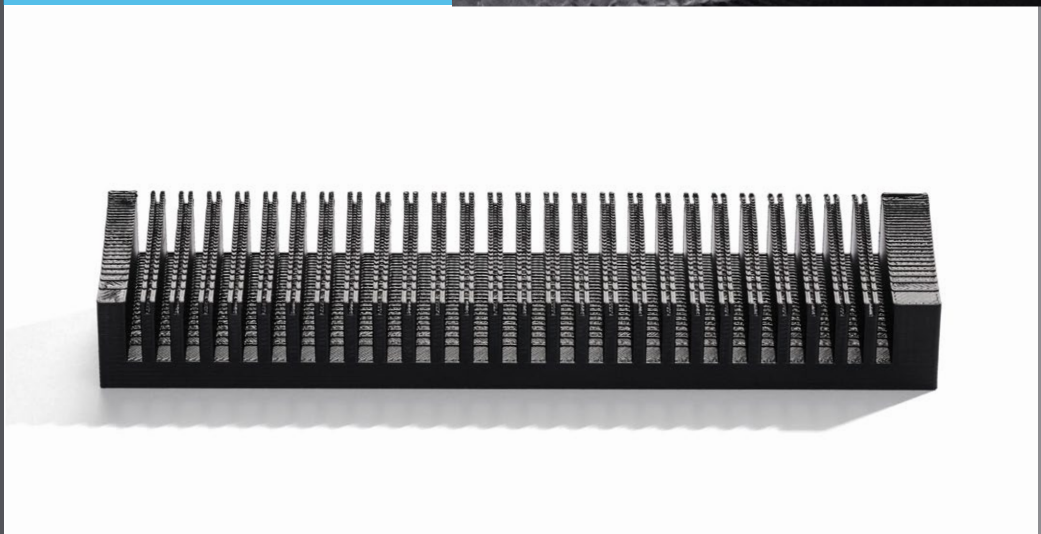
Chemical Resistance of Antero 840CN03



White Paper

Chemical Resistance of Antero 840CN03

Antero™ 840CN03, a Stratasys proprietary Polyetherketoneketone (PEKK) based material filled with carbon nanotubes, is a semi-crystalline high-performance thermoplastic resin known for its strength, high temperature tolerance, and excellent chemical resistance properties. This study was conducted to characterize the chemical resistance properties of the Antero 840CN03 material formulation when exposed to representative chemicals commonly found in the aviation industry.

Based on previous chemical resistance literature provided by PEKK manufacturers and the prevalence of certain chemicals in the aerospace industry, a characteristic group of chemicals that would exhibit the most deleterious effects toward Antero 840CN03 was chosen. The chemical reagents are:

- Methyl Ethyl Ketone (Butanone) – organic solvent
- Toluene – aromatic hydrocarbon solvent
- Dichloromethane (DCM) – geminal organic solvent
- Ethyl Acetate – organic solvent
- Skydrol 500B-4 – aviation hydraulic fluid
- Jet-A – aviation fuel
- 30% Nitric Acid (HNO3)
- 30% Sulfuric Acid (H2SO4)
- 60% Sodium Hydroxide (NaOH)
- Concentrated Ammonia (NH3)

The results indicated low chemical resistance to dichloromethane, and some plasticizing effects from sulfuric and nitric acids. However, Antero 840CN03 exhibited good to excellent chemical resistance for the remaining chemicals. By demonstrating the material's exemplary chemically resistive performance, Antero 840CN03 has shown a competitive advantage in the aerospace industry.

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Methods:

Specimens were generated via fused deposition modeling (FDM®) on a single Stratasys F900™ 3D printer using a T20D tip to achieve a 0.010” bead thickness. The test specimens were generated using identical parameters and software versions over a two-week period. Mechanical specimens were printed using four separate spools from the same lot of material and tracked throughout the experiment. Samples were printed with default parameters, single contour and solid +45/-45 rasters.

After building test specimens in both on-edge (XZ) and upright (ZX) orientations, the specimens were immersed for 168 hours in the previously mentioned chemicals. Test specimens we placed in sealed non-reactive containers under standard controlled laboratory conditions for the established time. The specimens were kept separated from each other, and lightly agitated every 24 hours per ASTM D543. The specimens were not subjected to strain during chemical exposure.

After the 168 hour immersion in the solvent bath, the samples were removed and dried under the hood for up to two minutes, depending on the solvent, before mechanical testing. Tensile testing was conducted per ASTM D638. Laboratory conditions were kept constant throughout testing.

Note that the Skydrol specimens were first cleaned with a cloth before the subsequent drying to remove as much of the hydraulic fluid as possible from the surface prior to testing.

Results:

Overall, Antero 840CN03 exhibited very good chemical resistance to the host of chemicals, with the exception of dichloromethane (DCM). Visually, the material’s reaction to DCM was especially significant, resulting in an immediate color change. The other chemicals did not visually affect the samples. See figures 1 through 11.

Figure 1. Printed samples before exposure to chemicals.

Figure 2. Samples after exposure to Skydrol.

Figure 3. Samples after exposure to MEK.

Figure 4. Samples after exposure to DCM.

Figure 5. Samples after exposure to ethyl acetate.

Figure 6. Samples after exposure to toluene.

Figure 7. Samples after exposure to Jet A.

Figure 8. Samples after exposure to 30% nitric acid.

Figure 9. Samples after exposure to 30% sulfuric acid.

Figure 10. Samples after exposure to 60% sodium hydroxide.

Figure 11. Samples after exposure to concentrated ammonium hydroxide.

DCM, being halogenated, also has an immediate and severe effect on the mechanical properties. Antero 840CN03 exhibited excellent chemical resistance to the other chemicals tested, and the only other significant effect was a higher elongation at break after exposure to nitric and sulfuric acids. Except for the reagent DCM, the tensile strength and modulus remained the same throughout testing, regardless of chemical (see Table 1).

Table 1. Change in Mechanical Properties, Antero 840CN03 - 168 hour Chemical Exposure (ASTM D543)

	Reagent	XZ orientation	ZX orientation
Tensile Strength	Dichloromethane	-88%	-74.8%
	Ethyl Acetate	-2.9%	-2.3%
	Jet A	-2.1%	7.3%
	Methyl Ethyl Ketone	-0.7%	-2.1%
	Skydrol	-2.1%	6.3%
	Toluene	-5.0%	1.4%
	30% HNO3	-5.7%	5.7%
	30% H2SO4	-9.3%	-10.1%
	60% NaOH	-1.4%	1.9%
% Elongation @ break	Dichloromethane	714.8%	1598.4%
	Ethyl Acetate	4.2%	16.2%
	Jet A	-0.4%	7.0%
	Methyl Ethyl Ketone	-4.4%	11.9%
	Skydrol	32.3%	9.7%
	Toluene	17.2%	32.4%
	30% HNO3	61.4%	52.4%
	30% H2SO4	47.2%	-5.4%
	60% NaOH	5.2%	-1.6%
	NH3	11.1%	10.8%
Tensile Modulus	Dichloromethane	-90.7%	-85.3%
	Ethyl Acetate	1.8%	6.4%
	Jet A	1.4%	5.3%
	Methyl Ethyl Ketone	3.1%	4.3%
	Skydrol	0.6%	6.7%
	Toluene	-0.4%	6.2%
	30% HNO3	-0.8%	-6.2%
	30% H2SO4	-7.6%	-5.0%
	60% NaOH	0.2%	3.3%
	NH3	-0.4%	5.0%

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Conclusion:

Though each application is unique in the environment and conditions in which the material will be exposed, the data shows that Antero 840CN03 exhibits exceptional chemical resistance to most chemicals typically used in the aerospace, oil & gas, and automotive industries and will withstand exposure to those chemicals while maintaining properties.

References:

ASTM D543: Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents

ASTM D638: Standard Test Methods for Tensile Properties of Plastics

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