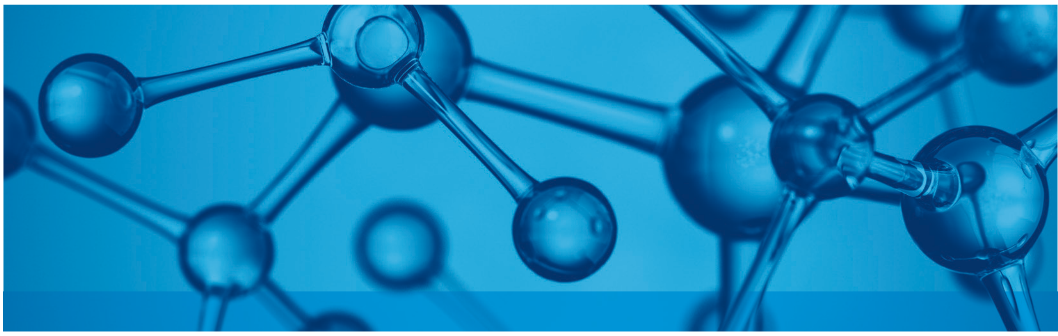

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Resistance of High-Performance Plastics to Chloroamines at Elevated Temperatures

Chlorinated water remains one of the most significant advancements in public health. This practice dramatically improves our quality of life by giving us the assurance that we get clean, safe drinking water when we turn on the tap in public places, at work and in our homes.

For that reason, over 98 % of all water treatment facilities in the U.S. disinfect water with chlorine and chlorine-amine based products. This type of disinfectant offers numerous advantages over other systems, including high germicidal potency, economy and efficiency.

Chlorine has a lasting, residual effect throughout the entire water distribution system and this must be taken into consideration when selecting materials to construct water delivery systems. Residual chlorine in water systems combined with elevated temperatures can produce an oxidizing environment. Since many metals and plastics are susceptible to oxidation and oxidizing agents, this condition can dramatically shorten the service life of components made from these materials.

This bulletin focuses on the effects of chloroamines on a variety of different plastics in a hot water environment. Additional bulletins are available from Solvay that compare the performance of sulfone polymers, CPC and polyacetals in chlorinated environments: *Effects of Chlorinated Water on Plastic-Based Water Delivery Systems* and *Effects of Chlorinated Water on Engineering Thermoplastics at Elevated Temperatures.*

Materials and Sample Preparation

The following materials were evaluated in this study:

- PVDF (Solef® 1010)
- ECTFE (Halar® 350 LC)
- PPSU (Radel® R-5000)
- PSU (Udel® P-1700)
- PA12

Test specimens for PVDF, ECTFE, and PA12 were cut according to ASTM D638 (type V shape) from 1.5-mm thick compression molded plane sheets. PSU and PPSU test specimens were injection molded with 3.5-mm thicknesses.

Test Setup

Test specimens were aged at 70 °C (160 °F) for 8 weeks (1,344 hours) in a 50-ppm monochloramine (NH_2Cl) solution prepared according to ASTM D6284a. The solution was replaced every 2 to 4 days to ensure that enough reactive chloramine was present throughout the study. Residual chlorine was measured using an iodometric titration.

Changes in weight were monitored throughout the study. Tensile properties after ageing were measured according to ASTM D638.

Potential structural and chemical changes were followed using DSC and FT-IR. Test specimens were routinely inspected visually.

Table 1: Mechanical properties before and after ageing

	PVDF	ECTFE	PPSU	PSU	PA12
Initial Properties					
E-Modulus [Mpa]	2,027 (56)[1]	1,645 (55)	2,000 (100)	2,200 (100)	1,035 (27)
Tensile strength [Mpa]	56.9 (0.4)	31.9 (0.7)	78.8 (0.7)	79.6 (1.5)	38.1 (0.2)
Elongation at yield [%]	7.0 (0.2)	6.5 (0.5)	6.5 (0.5)	6.0 (0.5)	6.2 (0.1)
Change in Properties After Ageing					
E-Modulus [%]	−6	−4	0	0	−33
Tensile strength [%]	4	8	−2	0	−9
Elongation at yield [%]	11	4	−3	−16	96

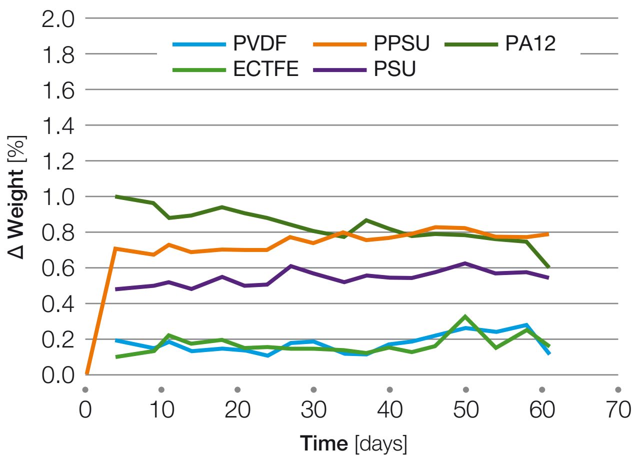
(1) Values in parentheses note the standard deviation.

Test Results

Figure 1 shows that all materials except PA12 reached a saturation level and remained constant. The weight loss evident in PA12 may be an indication of oxidation.

Only PA12 showed a significant variation in mechanical properties after ageing (Table 1). In part, this can be attributed to some water absorption but this does not tell the full story. DSC and FT-IR show changes in the structure from the material. PPSU and PSU have also absorbed water.

Figure 1: Weight change after ageing 8 weeks at 70 °C (160 °F)

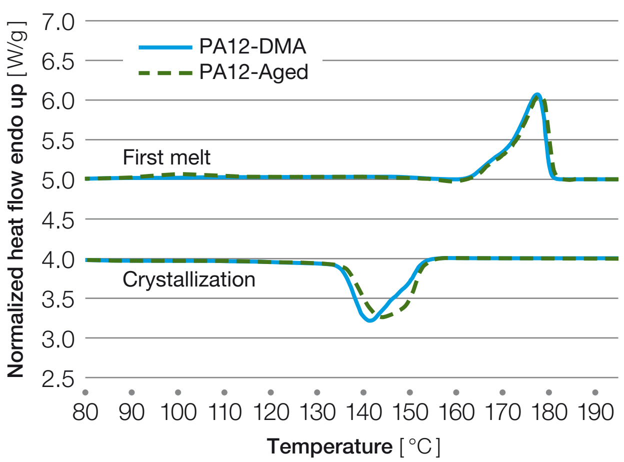


Structural and Chemical Changes

DSC (Differential Scanning Calorimetrie)

DSC is typically used as a quick screening tool to check any structural changes in the material when heating up the sample. For semi-crystalline materials, this is used to measure the amount of energy needed to crystallize. No changes are seen for the materials except for PA12 (Figure 2) whereas a slight shift in crystallization temperature is seen after ageing. This is an indication that the crystalline structure from the material is somewhat changed.

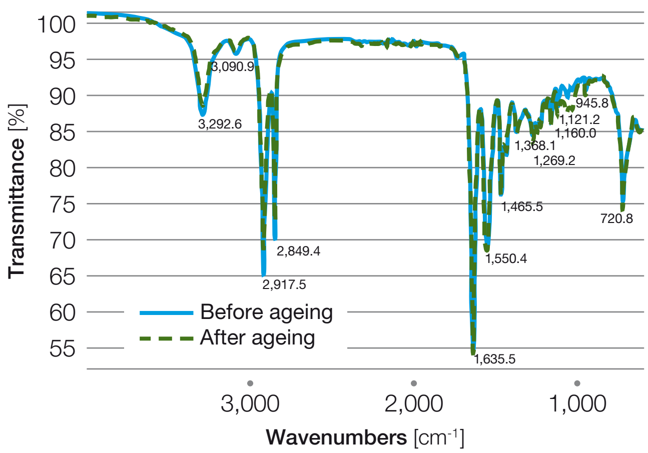
Figure 2: DSC on PA12 before and after ageing



FT-IR (Fourier Transform Infrared)

FT-IR is used to evaluate potential chemical organic changes in a material. The right section of the graph is used as a fingerprint area from a material and can be used to identify a material. There are some minor changes visible for PA12 around 1,120 cm^{-1} which is an indication of oxidation. No changes are seen for the other materials.

Figure 3: FT-IR spectrum from PA12 before and after ageing



Conclusions

Solvay's high-performance plastics are suitable for use in chloroamine environments and have been used in this type of environment for over 20 years. PA12 shows some early signs of degradation already after 1,300 hours, so some precaution has to be taken when using this material in the conditions like those described above. It would be interesting to test for longer times or higher temperatures at lower concentrations to understand if PA12 would react the same.

Since each plumbing application has unique performance requirements and design criteria, it is important that specialized testing be conducted by the design engineer to evaluate the resin under conditions that simulate the environment and function of the component in service. The test results reported here are not a substitute for such testing.

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