

Effects of Chlorinated Water on Thermoplastics

Oxidizing agents such as chlorine and chloramines are used to treat drinking water in the United States by preventing the growth of microorganisms. Many thermoplastics are susceptible to oxidation and oxidizing agents. Elevated temperatures greatly increase this effect. For this reason, it is essential to understand the effects of chlorine on thermoplastics in order to select an oxidatively stable material for long-term exposure to potable water.

Test Procedure

Three different thermoplastics were tested for chlorine resistance – polysulfone (UDEL® P-1700), acetal copolymer and 33% glass-filled nylon 6/6. ASTM test specimens (both tensile and flex with 1/8-inch wall thicknesses) were placed in chlorinated water baths for six months. Each week bars were removed, weighed, tested for mechanical properties, and measured for thickness.

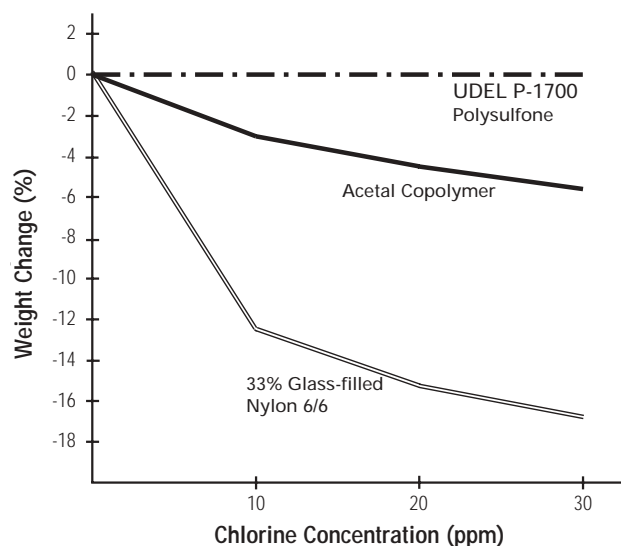
Three different levels of chlorine exposure were used in order to predict reaction rates at any chlorine level using regression analysis. The chlorine level of the baths was maintained by adding chlorine three times per week. A control sample with no chlorine added was used for each material to separate the effects of water absorption from the effects of chlorine.

All tests were conducted at 60°C (140°F) to simulate the temperature of typical residential hot water systems. Because the effect being measured is a chemical reaction, it is assumed that the rate of the reaction increases with increasing temperature based on the exponential law for chemical reactions.

It must be noted that this data is exclusive of other harmful chemicals or water chemistry. Inclusion of chemistry not found in this test setup will invalidate these findings.

Figure 1

Weight change of various polymers after exposure to chlorinated water at 60°C (140°F)



Results

The effects of chlorine over six months on the three materials is summarized in Figure 1. Chlorine had the most adverse affect on nylon 6/6, followed by acetal copolymer. Polysulfone showed no noticeable change.

The exposure to chlorine affected the physical and mechanical properties of acetal copolymer and 33% glass-filled nylon 6/6, resulting in the formation of a chalk-like scale on the acetal samples and the ablation of oxidized polymer from the surface of the nylon 6/6 parts. Since this oxidized surface is easily removed by running water, the sample properties were reduced by an equivalent change in size.

Conclusion

Each of the chlorine levels used for testing is in excess of the level used in drinking water. These levels were chosen not only to accelerate the testing, but also to provide a means for interpolation to practical chlorine levels in municipal water. The control sample

with no chlorine content, along with the three different chlorine levels, allows for the use of a quadratic regression analysis to predict the rate of material loss at any chlorine level. Table 1 shows the predicted weight loss for each of the materials over time with a chlorine level of 2 ppm, a level similar to that found in water delivery systems in the United States. From this data it is clear that the anticipated life of a molded thermoplastic part must be taken into account when material selection is made.

Table 1

Projected percent weight loss after exposure to 2 ppm chlorinated deionized water at 60°C (140°F)

	5 yrs	10 yrs	15 yrs	20 yrs
UDEL P-1700	0	0	0	0
Acetal Copolymer	4.8	9.6	14.3	19.1
33% Glass-Filled Nylon 6/6	42.2	84.4	100	100

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