ITW TEXWIPE

TechNote CRW-7

Yellowing of Polyurethane Foam

Introduction

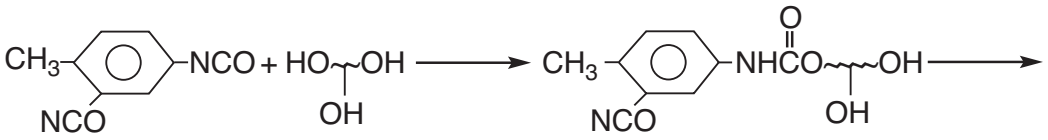
Polyurethane foams yellow as they age. The yellowing results from an oxidation reaction in the backbone of the polymer. Since it is the polymer itself that is being oxidized, the yellow color cannot be extracted. Yellow foam has similar properties to white foam.

The Chemistry

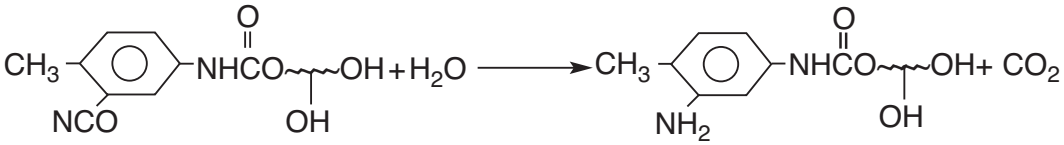
Polyurethane foams are made by reacting a diisocyanate with polyols and water. The isocyanate, typically toluene diisocyanate (TDI) or methylenediisocyanate (MDI), reacts with the polyol to form the urethane polymer. It also reacts with the water to release carbon dioxide. The carbon dioxide acts as the blowing agent to form the cellular structure. The other product of the water/isocyanate reaction is an amine. This resulting aromatic amine will oxidize when exposed to UV light and oxygen to form a quinone. Quinones are yellow. They impart an increasing yellow hue to the foam as oxidation proceeds over time. Since the quinone is a component of the urethane backbone, the yellow color cannot be extracted from the foam.

This slight color change does not represent significant foam degradation. Common practice to slow the color change is to keep the package sealed until use and to store the package away from UV light.

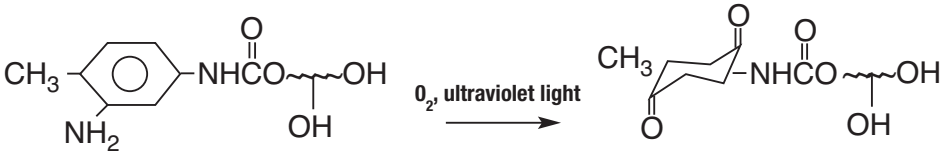
Polyurethane



2,4 toluene diisocyanate **polyol** **urethane linkage**



urethane **aromatic amine** **urethane** **carbon dioxide gas**



aromatic amine **urethane** **yellow colored quinone** **urethane**

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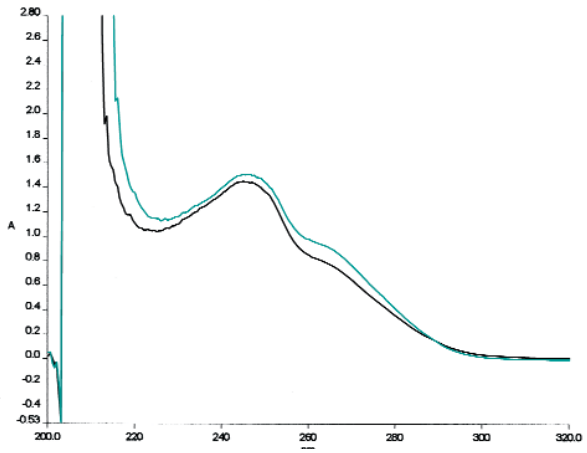
Performance Characteristics

It is important to note that the reaction that produces the yellowing of foam is a minor side reaction and will not affect the performance of polyurethane foam over its useful life. Measurements of extracted material and strength characteristics confirm this.

Extractable Results

Extractable levels in isopropyl alcohol of un-aged (white) and aged (yellowed) foams were compared. Accelerated aging was accomplished by heating the polyurethane foam in an oven set at 150°F for 6 weeks. No appreciable difference was found. However, both foam samples, when soaked for 24 hours prior to spectral analysis, exhibited significant increases in the absorption at approximately 240 nanometers. The white foam had an IPA extractable level of 0.043g/g, while the yellowed foam had an IPA extractable value of 0.046g/g. Figures 1 and 2 depict these results.

Figure 1:
Extraction results after 2-hour soak in 99% isopropyl alcohol



White foam (2-hour soaking time)
Aged yellow foam (2-hour soaking time)

Strength Characteristics

Polyurethane foam retains its strength characteristics, as measured by tensile strength and breaking load, even when aged. Again, no appreciable difference was found between the un-aged (white) and aged (yellowed) polyurethane foam samples. Test results are depicted in Figure 3.

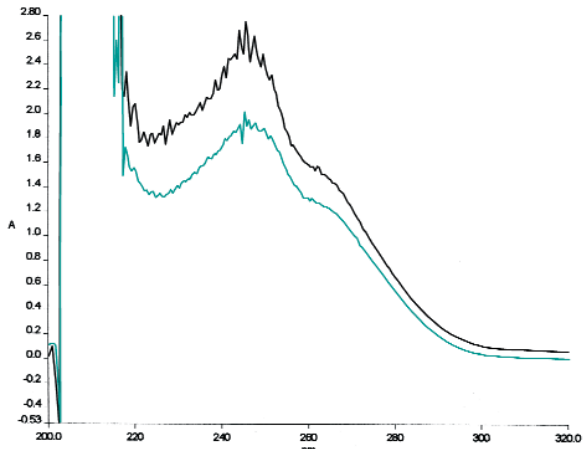
Table 1: Strength Characteristics

Sample	Elongation	Breaking Load
White foam	1.4 inches	2.5 pounds
Aged yellow foam	1.3 inches	2.6 pounds
% change	–7%	4%

Conclusion

The yellowing of polyurethane foam is caused by a side reaction to a quinone urethane. Since this side reaction is dependent upon oxygen and ultraviolet light, keeping the foam covered with minimal exposure to air will slow the yellowing. However, in the event that the foam does turn yellow, performance characteristics will not be compromised.

Figure 2:
Extraction results after 24-hour soak in 99% isopropyl alcohol



White foam (24-hour soaking time)
Aged yellow foam (24-hour soaking time)

For additional information, please contact ITW Texwipe Customer Support at one of the numbers listed below:

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