Hydrophobic Oligomers

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DYMAX®

Hydrophobic Oligomers, What Are They?

By definition, hydrophobic means resistant to or avoiding wetting. Hydrophobic oligomers are commonly used by formulators in coating and ink applications where it's desirable to have a water-repellent surface. Surfaces formulated with these oligomers exhibit high contact-angle values and promote beading of water on the surface. The tendency of these materials to absorb small quantities of moisture facilitates water resistance and reduced permeability to moisture vapor.

Features & Benefits:

- Low water absorption
- Enhanced flexibility even after exposure to elevated temperatures
- Chemical resistance
- Water resistance with reduced permeability to moisture vapor
- Weatherability
- Non-yellowing
- Optical clarity
- Light stability
- Glossy appearance

Hydrophobic Oligomers in Moisture-Barrier Coatings and Inks

Hydrophobic oligomers often include molecular structures like -CH2- chains and hydrocarbon rings. These segments of the oligomer tend to lack the ability to hydrogen bond and their surface energy is relatively low. Research has shown that these properties are desirable in functional and smart coating applications where anti-fogging and frost-resistant properties are desirable. Because the water droplets stay beaded up, these materials are useful in easy-to-clean coating applications as well. In these applications, when the water droplet comes in contact with the hydrophobic coating, the water is repelled forming the droplet.

Figure 1. Inks and coatings formulated with hydrophobic oligomers repel water

While there are many advantages to using hydrophobic oligomers, they are most often selected for their water-resistant properties. Coatings and inks formulated with hydrophobic oligomers show a reduction in permeability to moisture vapor making them an ideal choice when formulating moisture-barrier coatings and inks for electronics, optical goods, and a variety of consumer goods.

Figure 2. Hydrophobic oligomers are ideal for use in a variety of applications including moisture-barrier, anti-fogging, frost-resistant, and easy-to-clean coatings.

Water Absorption

When comparing the water absorption of the Bomar™ hydrophobic oligomers given in Table 1, it was discovered that water absorption correlates with the molecular weight and oxygen content of the oligomers' chemistries. BR-543, a polyether urethane acrylate with a relatively high molecular weight and high oxygen content, is the least hydrophobic oligomer in this study. As the oxygen content decreases for these formulas, so does the percent of water absorption, except for BRC-841. BRC-841 has relatively high oxygen content but, due to its low molecular weight, a highly crosslinked coating results upon curing. This allows for less water absorption. Polybutadiene urethane acrylates like BR-641D, BR-643, and BR-640D exhibit the lowest water absorption and therefore the highest hydrophobicity due to their very low oxygen content.

Table 1. Water Absorption vs. Molecular Weight and Oxygen Content

Bomar™ Oligomer	BR-543	BRC-843	BRC-841	BRC-443	BR-641D	BR-643	BR-640D
Molecular Weight Ratio	4.0	4.0	1.0	4.0	6.0	6.0	4.0
Oxygen/Carbon Ratio	4.8	4.0	5.5	2.8	1.1	1.0	1.5
% Water Absorption (24h)							
Formula A: 70% oligomer, 30% IBOA & 2 phr Irgacure 184	0.67	0.38	0.27	0.25	0.06	0.04	0.01
Formula B: 50% oligomer, 50% IBOA & 2 phr Irgacure 184	0.320	0.280	0.224	0.163	0.055	0.029	0.037

The data collected in Table 1 shows there is little impact on the oligomers' properties when IBOA is used as the monomer at an addition level of between 30 to 50%. Therefore, the remainder of this paper will focus on oligomer chemistries with 50% IBOA levels. Curing for these tests was completed with a Dymax UVCS Conveyor outfitted with a Fusion F300 lamp using the D bulb (Metal Halide). Fusion F300 lamps are microwave-powered curing lamps which provide high intensity over a 1" x 6" curing area. One or two of the lamps can be mounted on Dymax UVCS Series systems for convenient conveyor curing. One lamp was used to cure the oligomers in this study. All

UVCS conveyor configurations have adjustable belt speeds of 1 to 32 fpm, and adjustable lamp-to-belt distance to address a variety of application requirements. The data collected in this study was completed at a speed of 20 ft/min for 2 passes. Curing conditions were recorded with an ACCU-CAL™ 150 radiometer. The total measured energy was 1,900 mJ/cm^2 with an intensity of 2,300 mW/cm^2

Figure 3. UVCS Conveyor with Fusion F300 lamp

Figure 4. ACCU-CAL™ 150 Radiometer

Chemical Resistance

The chemical resistance of the Bomar™ hydrophobic oligomers was also evaluated and the results can been seen in Figures 5-12 on the following page. Each chemical was in contact with the coating for 24 hours, with responses noted as follows:

0 = no effect
1 = very minor discoloration
2 = minor discoloration
3 = discoloration
4 = very discolored
5 = coating failure (blistered, failure in spots, loss of adhesion)

Results

BR-543 and BRC-843 performed poorly and had the least chemical resistance when the coatings came in contact with iodine, mustard, white vinegar, and muriatic acid. BRC-443 and the polybutadiene urethane acrylates performed the best and had minor or no discoloration noted when the coating came in contact with iodine, mustard, white vinegar, and muriatic acid. This is attributed to the low oxygen content and relatively high bond strength of the oligomer backbone. All of the oligomers evaluated in this study held up well to the high pH chemical environments of Drano, bleach, and TSP, which is attributed to the bond strength of the oligomer backbone. All of the oligomers tested also held up well to motor oil.

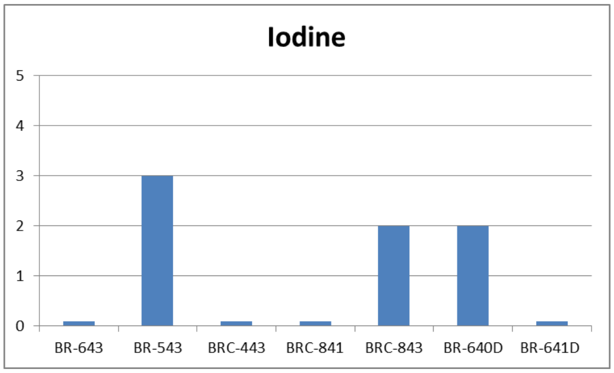

Figure 5. Chemical Resistance Against Iodine

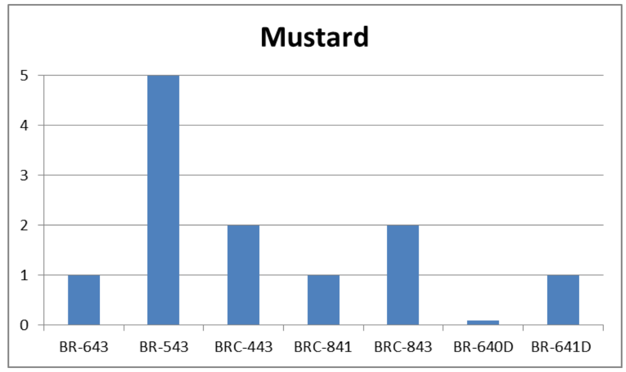

Figure 6. Chemical Resistance Against Mustard

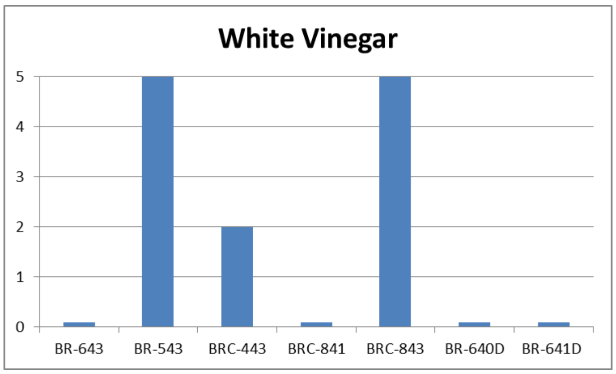

Figure 7. Chemical Resistance Against White Vinegar

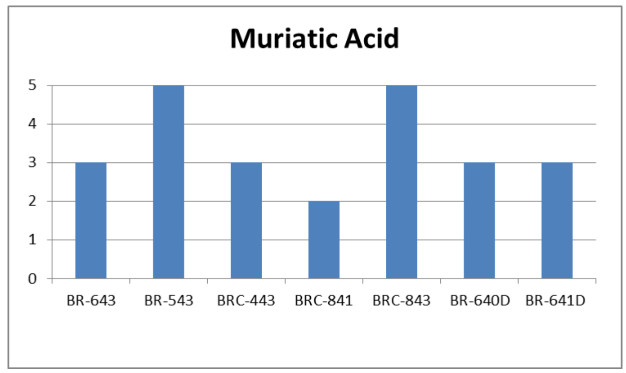

Figure 8. Chemical Resistance Against Muriatic Acid

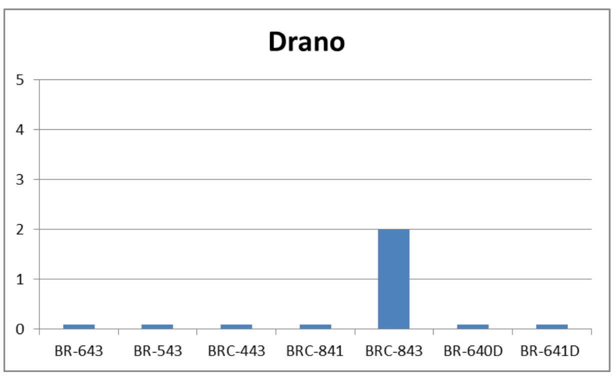

Figure 9. Chemical Resistance Against Drano

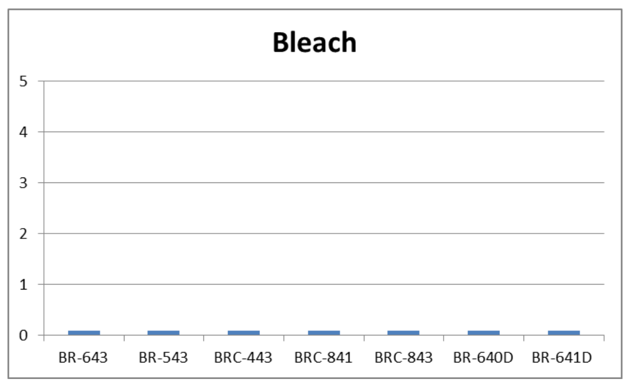

Figure 10. Chemical Resistance Against Bleach

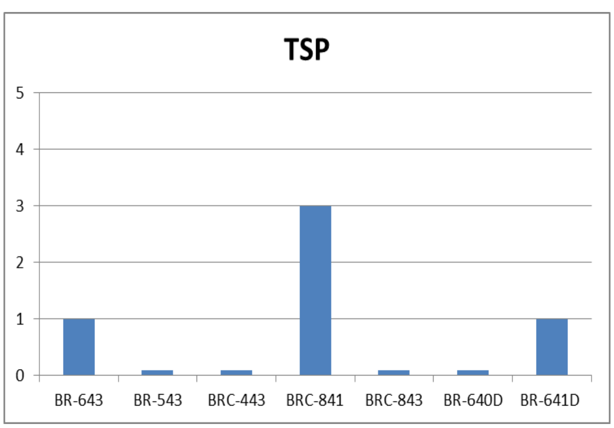

Figure 11. Chemical Resistance Against TSP

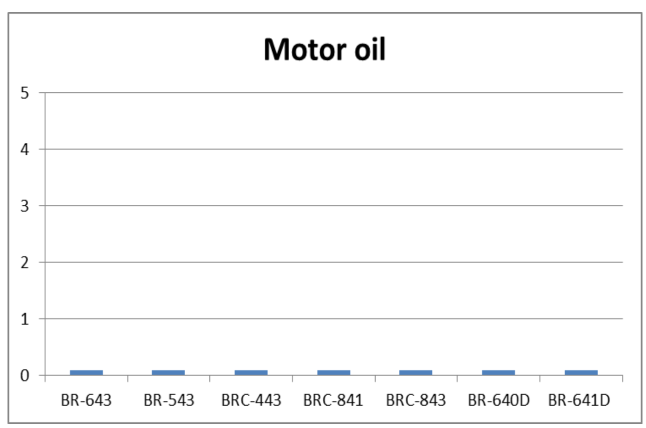

Figure 12. Chemical Resistance Against Motor Oil

High-Temperature-Resistance Impact on Mechanical Properties

BRC-843 and BRC-443 were both evaluated for their retention of mechanical properties after exposure to high temperatures. As can be seen in the charts below, both coatings in this study showed improvement in the percentage of elongation, tensile strength, and modulus when exposed to 200°C for 30 minutes. For most coatings exposed to these temperatures, the mechanical properties are reduced due to weak oligomer backbone structure and residual catalysts which catalyse degradation of the polymer backbone. The increase in mechanical properties after prolonged heat exposure is attributed to the oligomers' good bond strength, minimization of residual catalysts, and further reaction of acrylates.

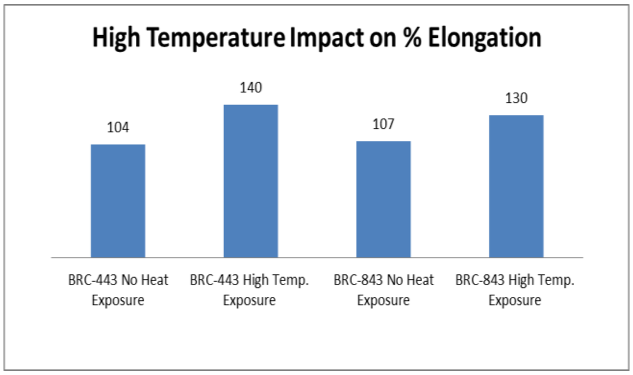

Figure 13. High Temperature Impact on Elongation (%)

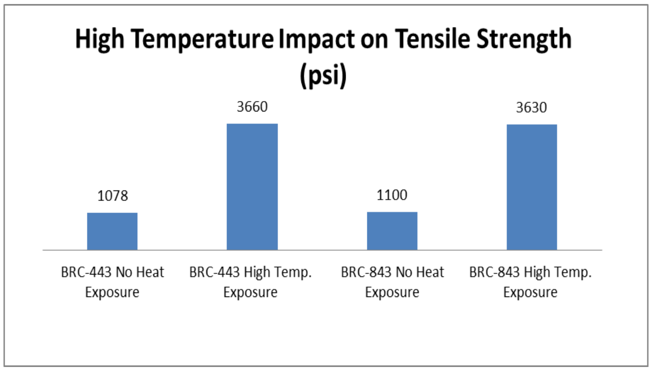

Figure 14. High Temperature Impact on Tensile Strength (psi)

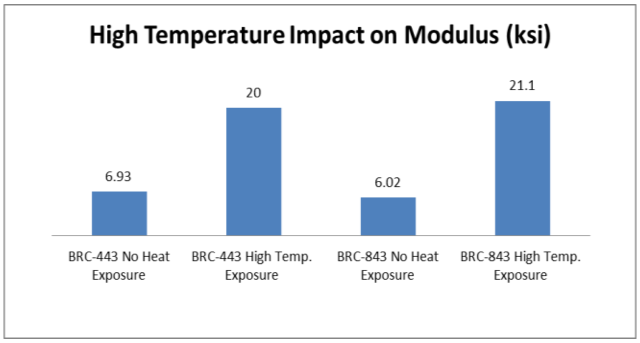

Figure 15. High Temperature Impact on Modulus (ksi)

Oligomer Properties

Table 2 displays various uncured and cured properties of the Bomar™ hydrophobic oligomers line including viscosity, tensile strength, durometer, elastic modulus, elongation, and functionality. Table 3 displays the adhesion properties of these oligomers. The adhesion properties of all oligomers in this study were evaluated when cured onto the following substrates: acrylonitrile-butadiene-styrene (ABS), acrylic, high-density polyethylene (HDPE), polycarbonate (PC), nylon-6, poly(vinyl chloride) (PVC), polypropylene (PP), polystyrene (PS), aluminum, cold rolled steel, glass, and stainless steel (SS). Curing was done using a Dymax UVCS Conveyor outfitted with one Fusion F300 lamp with a D bulb in a single pass at a speed of 20 ft/min. From the testing, it was discovered that BR-543, the least hydrophobic oligomer, had the greatest adhesion to the hydrophobic plastic substrates. None of the chemistries adhered well to HDPE, and all of the chemistries adhered well to polycarbonate (PC).

Table 2. Mechanical Properties of Bomar™ Hydrophobic Oligomers

Bomar™ Oligomer	Functionality	Water Absorption, %	Uncured Properties	50:50 oligomer & IBOA with 2 phr Omnirad™ 481			
				Cured Mechanical Properties			
			Viscosity (cP)	Tensile Strength	Elongation	Elastic Modulus	Durometer Hardness
BR-543	2	0.320	2,516	1,300	250	0.41	82A
BRC-843	2	0.280	1,650	1,100	110	3.02	62D
BRC-841	2	0.224	2,200	9,990	5	248	87D
BRC-443	2	0.163	3,234	1,100	100	6.93	63D
BR-643	2	0.029	2,050	2,670	65	80	58D
BR-640D	2	0.037	1,513	840	185	0.65	45D
BR-641D	2	0.055	2,937	2400	410	0.5	43D

Table 3. Adhesion Properties of Bomar™ Hydrophobic Oligomers

Bomar™ Oligomer	Plastic Substrates								Adheres to These Other Substrates (metals, glass)			
	ABS	Acrylic	HDPE	PC	Nylon	PVC	PP	PS	Aluminum	C.R. Steel	Glass	SS
BR-543	•	•		•	•	•	•	•	•	•		•
BRC-843	•			•		•		•	•	•	•	•
BRC-841	•	•		•						•	•	•
BRC-443		•		•	•	•		•	•	•	•	•
BR-641D	•	•		•	•	•	•	•	•	•	•	•
BR-640D	•	•		•	•	•		•	•	•	•	•
BR-643										•	•	•

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