HYDROPHOBIC OLIGOMERS

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What are Hydrophobic Oligomers?

Hydrophobic oligomers can be used by formulators in coating and ink applications where a water-repellent surface or interface is desired. 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 only small quantities of moisture facilitates water resistance and reduced permeability to moisture vapor. Hydrophobic urethane acrylates also excel in applications where both heat and humidity resistance are desired.

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.

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.

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

Water Absorption

When comparing the water absorption of the Bomar hydrophobic oligomers given in Table 1, it was noted 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.

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.

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

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

	Molecular Weight Ratio	Oxygen/Carbon Ratio	% Water Absorption (24h)	
			Formula A: 70% oligomer, 30% IBOA & 2 phr Irgacure 184	Formula B: 50% oligomer, 50% IBOA & 2 phr Irgacure 184
BR-543 (control)	4.0	5.4	0.67	0.32
BR-640D	4.0	1.8	0.01	0.0437
BR-641D	6.0	1.0	0.06	0.0655
BR-641E	6.0	3.1	0.02	0.03
BR-643	6.0	1.1	0.04	0.0329
BRC-441D	1.4	5.7	0.18	0.14
BRC-4421	2.0	6.0	0.17	0.13
BRC-443	4.0	7.6	0.25	0.163
BRC-841	1.0	6.6	0.27	0.224
BRC-843	4.0	6.3	0.38	0.28
BRC-8430E	4.0	6.1	0.44	0.32
BRC-843S	4.0	6.2	0.40	0.284

Chemical Resistance

The chemical resistance of the Bomar hydrophobic oligomers was also evaluated and the results can been seen in Figure 1. Each chemical was in contact with the coating for 24 hours, with responses noted to the right:

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)

Figure 1. Chemical Resistance Testing

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.

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 2. High Temperature Impact on Elongation (%)

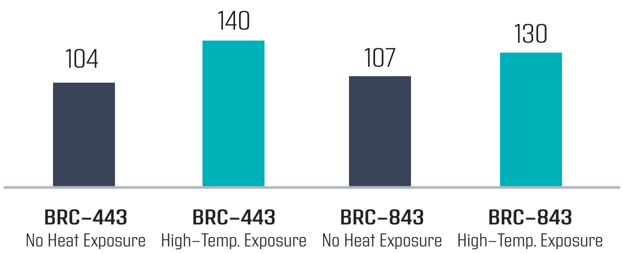


Figure 3. High Temperature Impact on Tensile Strength (psi)

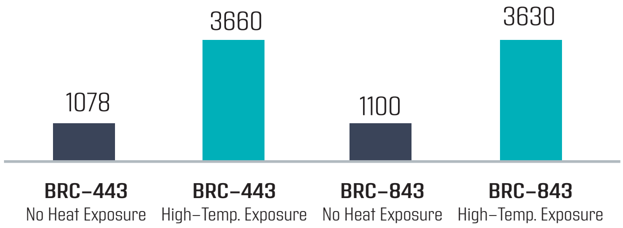
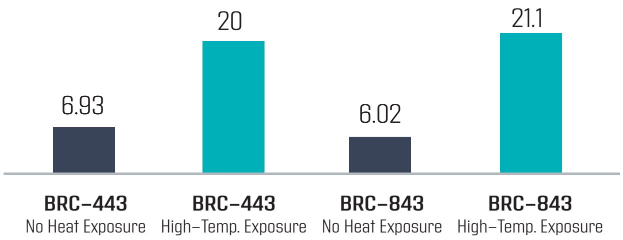


Figure 4. High Temperature Impact on Modulus (ksi)



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 2. Mechanical Properties of Bomar Hydrophobic Oligomers

		50:50 Oligomer & IBOA with 2 phr Omnirad™ 481 Cured Mechanical Properties					Uncured Properties
	Functionality	Water Absorption, %	Tensile Strength, psi	Elongation, %	Elastic Modulus, ksi	Durometer Hardness	Viscosity, cP
BR-543 (control)	2	0.55	1,300	130	9.7	74A	2,500
BR-640D	2	0.04	840	190	0.65	45D	1,500
BR-641D	2	0.06	2400	410	0.50	43D	2,900
BR-641E	1.3	0.03	350	400	0.23	60A	2,600
BR-643	2	0.03	2,700	65	80	58D	2,000
BRC-441D	2	0.14	4,400	11.3	250	82D	850
BRC-4421	2	0.13	3,300	30	210	81D	1,100
BRC-443	2	0.16	1,100	100	6.9	63D	3,200
BRC-841	2	0.25	9,500	3.9	360	85D	1,900
BRC-843	2	0.28	1,100	110	3.0	62D	1,600
BRC-8430E	1.6	0.32	1,600	170	25	45D	4,000
BRC-843S	2	0.28	4,700	390	1.5	60D	3,000

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 noted 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 3. Adhesion Properties of Bomar Hydrophobic Oligomers

	Plastic Substrates								Other Substrates			
	ABS	Acrylic	HDPE	PC	Nylon	PVC	PP	PS	Aluminum	C.R. Steel	Glass	SS
BR-543	■	■		■	■	■	■	■	■	■	■	■
BRC-843	■			■		■		■	■	■	■	■
BRC-841	■	■		■						■	■	■
BRC-843S	■	■		■	■		■	■	■	■		
BRC-8430E	■	■		■	■							
BRC-441D	■	■		■	■							
BRC-4421	■	■		■	■							
BRC-443		■		■	■	■		■	■	■	■	■
BR-641E												
BR-641D	■	■	■	■	■	■	■	■	■	■	■	■
BR-640D	■	■		■	■	■	■	■	■	■	■	■
BR-643			■	■						■	■	■

Global Headquarters: 51 Greenwoods Road | Torrington, CT 06790 | USA | +1 860–626–7006 www.bomar–chem.com

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