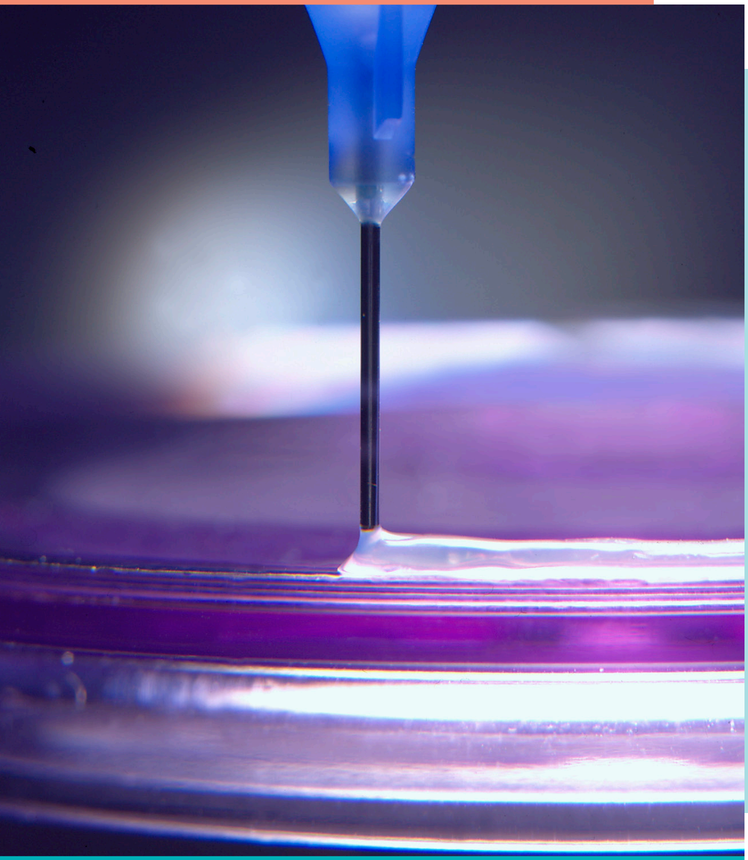

BOMAR® OLIGOMERS STUDY

Adhesion Performance of Modified Urethane Acrylates

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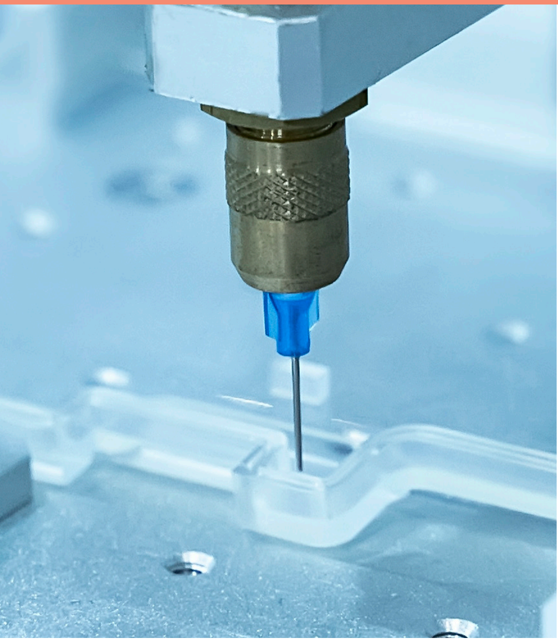
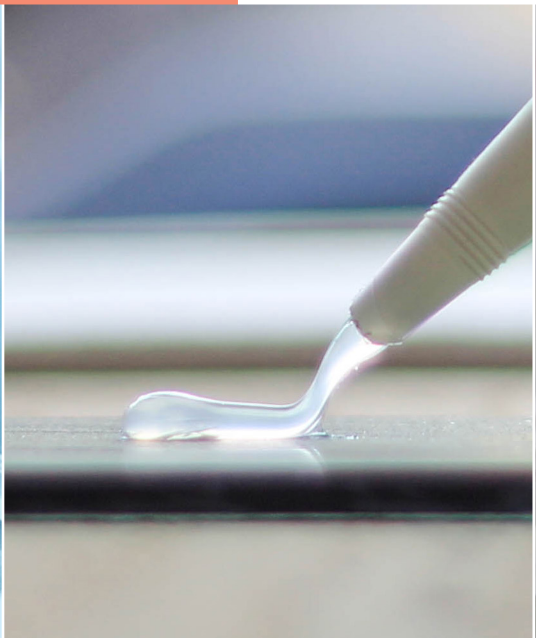
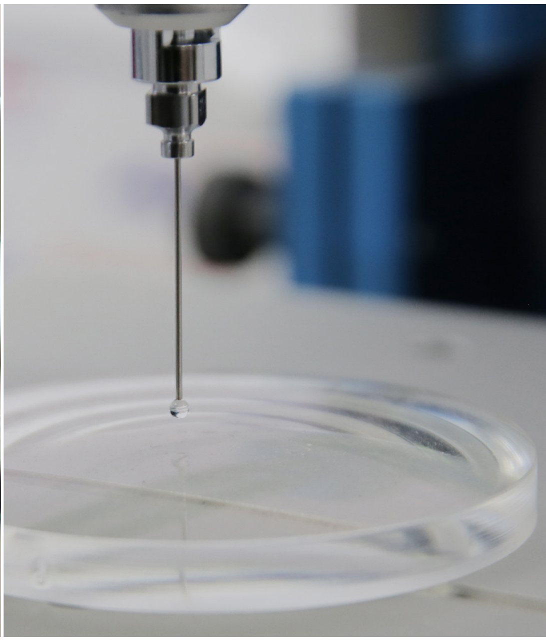




INTRODUCTION

For today's adhesive and coating formulators, enhanced adhesion is more than just a performance metric—it's essential to product integrity, durability, and long-term value. Whether developing bonding materials or functional coatings, achieving reliable adhesion across a range of substrates is fundamental to ensuring a formulation performs as intended in real-world applications. From structural strength to resistance against environmental stressors, strong and stable adhesion is at the core of successful material design.

This study evaluates three Bomar urethane acrylate oligomers formulated to address the growing demand for materials that deliver both high adhesion and formulation flexibility. Tailored to meet modern adhesion performance challenges, these oligomers were assessed through a structured, three-phase process:

- **Physical Properties** – screening of the neat oligomers for their physical properties. The viscosity and fatigue properties were measured for each oligomer.
- **Adhesion Performance** – focused on bonding to industrial substrates including glass, steel, aluminum, BOPP, and PET.
- **Cure Optimization** – to identify the ideal exposure time and temperature conditions needed to achieve peak adhesion performance.

While additional testing on surface tension, weatherability, and thermal properties will follow, the initial findings highlight clear adhesion benefits with each oligomer offering a unique profile that can be leveraged in next-generation adhesive and coating systems.

TESTING & RESULTS

Table 1 lists the urethane acrylate oligomers evaluated in this study. At the time of testing, the specific chemical compositions of the materials were not disclosed to the formulators.

Table 1. Screened Oligomers

Modified Urethane Acrylate Oligomers	Unmodified Urethane Acrylate Analogs
BR-374SL	BR-374
BR-572SL	XREW-67-117
BRC-843SL	BRC-843SD1

Thirteen formulations were prepared for adhesion testing, as shown in Table 2, and an additional six formulations were prepared for tensile and elongation testing (Table 3).

The test methods used are outlined as follows:

Fatigue Properties: Tensile strips were prepared in accordance with internal work instruction WI 830-0230C. Tensile/Elongation measurements were made in accordance with ASTM D882 on an Instron model 3345 with a 500N load cell.

Viscosity Measurements: Viscosity measurements were made using a BYK CAP+2000 Viscometer.

Glass-to-Glass Compression: Sample preparation and compression testing was performed in accordance with Dymax internal specification – DSTM 250.

Metal Adhesion: Sample drawdowns were performed on cold rolled steel and aluminum panels (6" X 4") using oligomer blends at 2 mil/50-micron wet film thickness. Adhesion testing was conducted using a modified ASTM D3359 - Cross Hatch Adhesion test.

Laminate Adhesion: Laminates of Biaxial Oriented Polypropylene (BOPP) and Polyethylene Terephthalate (PET) were used in this testing. Peel testing was conducted on a Thwing - Albert peel tester at 180° for 300 mm/minute.

Cure Conditions: All samples were cured at a dosage of 491 mJ/in^2 using a D-bulb on a Dymax UVCS conveyor at a speed of 10 ft/minute.

Table 2. Prepared Formulations, Adhesion Testing

Components	1	2	3	4	5	6	7	8	9	10	11	12	13
BR-374SL		55.0	27.5	18.5									
BR-374			27.5	36.5	55.0								
BR-572SL						55.0	27.5	18.5					
XREW-67-117							27.5	36.5	55.0				
BRC-843SL										55.0	27.5	18.5	
BRC-843SD1											27.5	36.5	55.0
IBOA	40.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
TPGDA	55.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
Irgacure 184	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Darocur 1173	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Total (wt%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 3. Prepared Formulations, Tensile & Elongation Testing

Components	1	2	3	4	5	6
BR-374SL	70					
BR-374		70				
BR-572SL			70			
XREW-67-117				70		
BRC-843SL					70	
BRC-843SD1						70
IBOA	28	28	28	28	28	28
Irgacure 184	2	2	2	2	2	2
Total Wt%	100	100	100	100	100	100

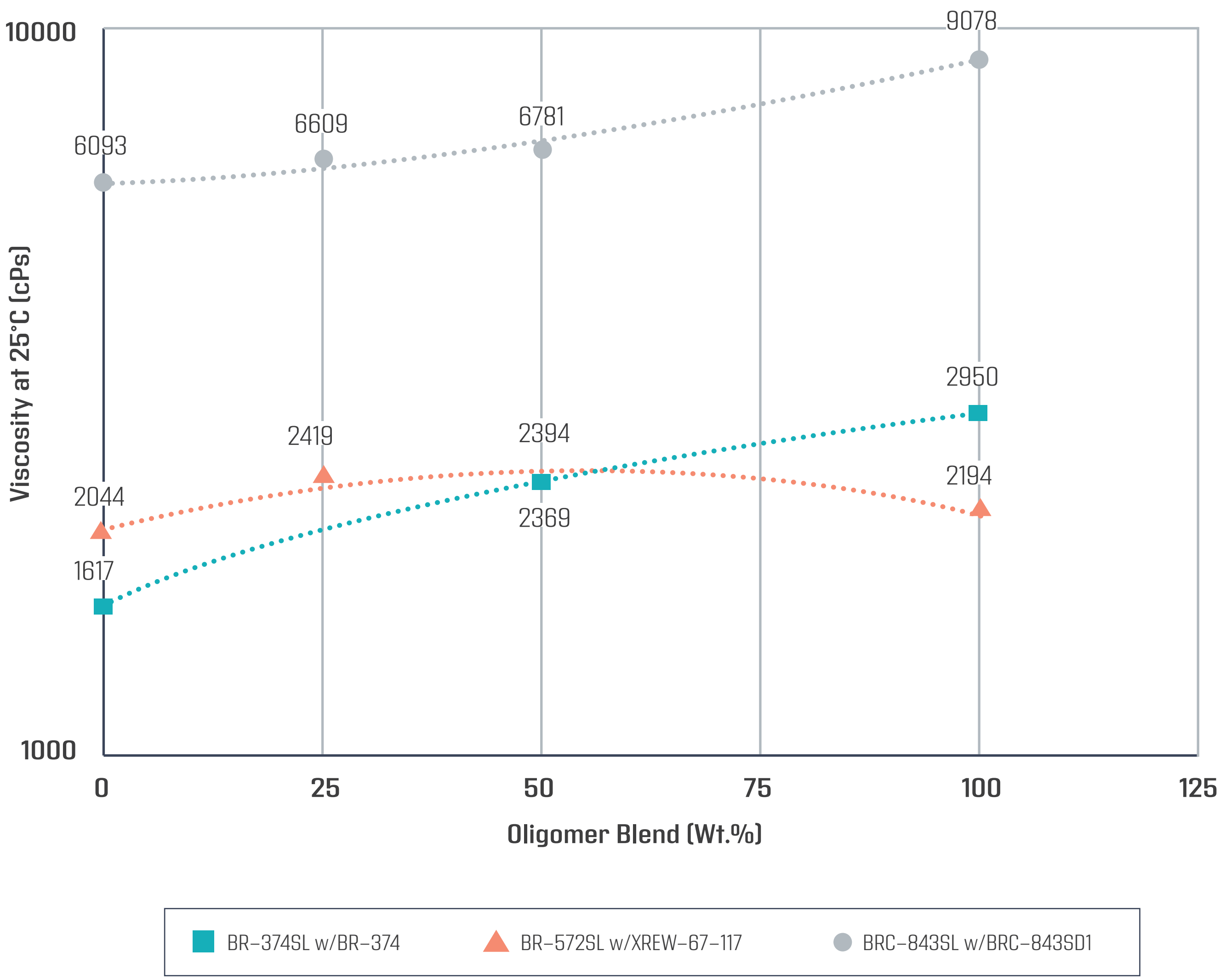
RESULTS

Physical Property Testing

Viscosity Measurements

Figure 1 shows the measured viscosities for each oligomer blend evaluated in this study. It should be noted that the oligomer blend weight percentages throughout this report are represented by the ratio of urethane acrylate to urethane acrylate analog. Among the samples tested, the blend of BRC–843SL with BRC–843SD1 exhibited the highest viscosity.

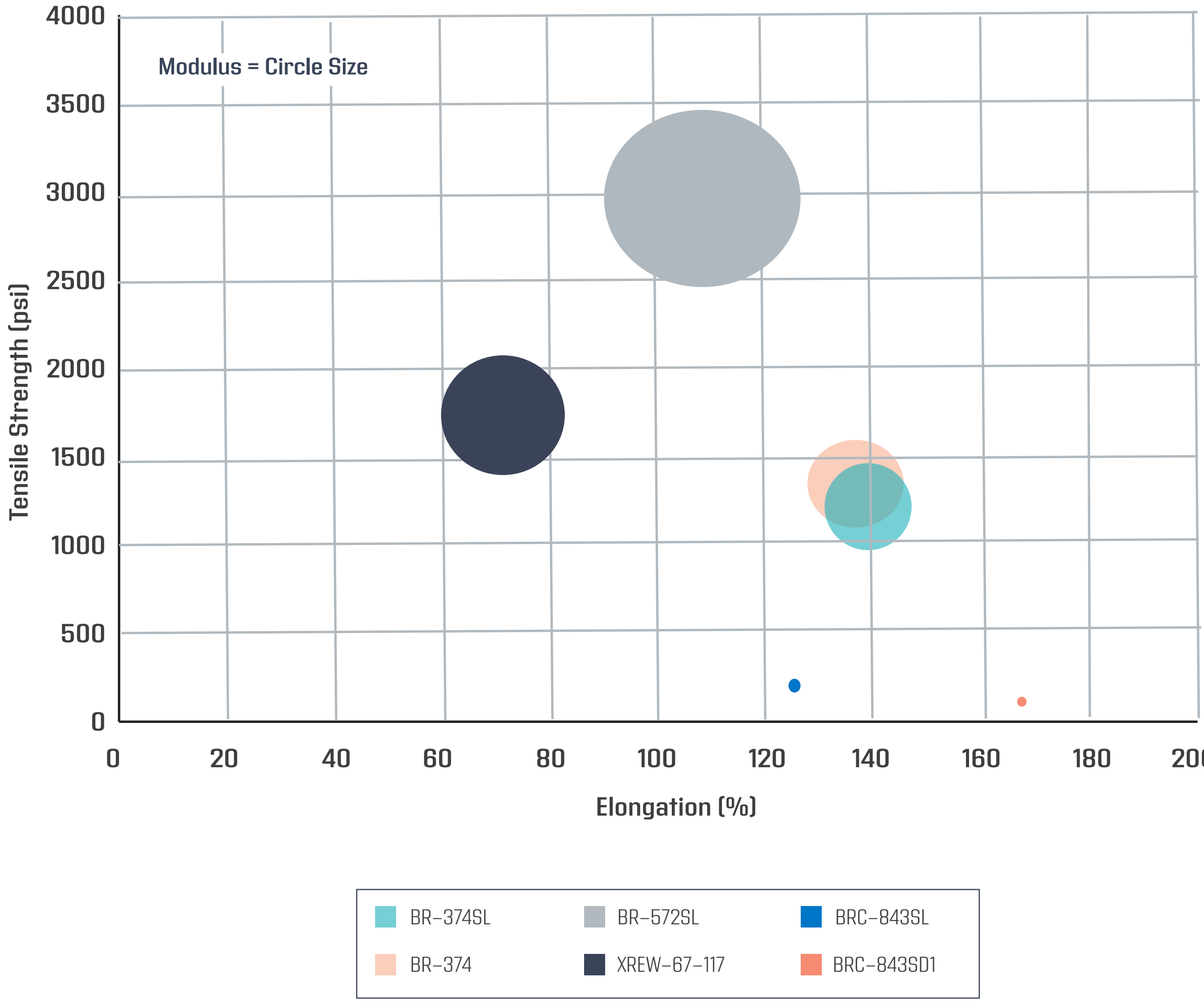
Figure 1. Oligomer Blend Viscosity



Tensile, Elongation, & Modulus

Figure 2 presents a new visual approach to comparing the tensile strength, elongation, and modulus of the neat oligomers evaluated in this study. This type of combined representation has not been used previously, but it offers a clear advantage: by incorporating modulus into the traditional tensile/elongation graph, we can better differentiate each oligomer based on its physical properties.

Figure 2. Physical Properties of Oligomers in 30 wt.% IBOA



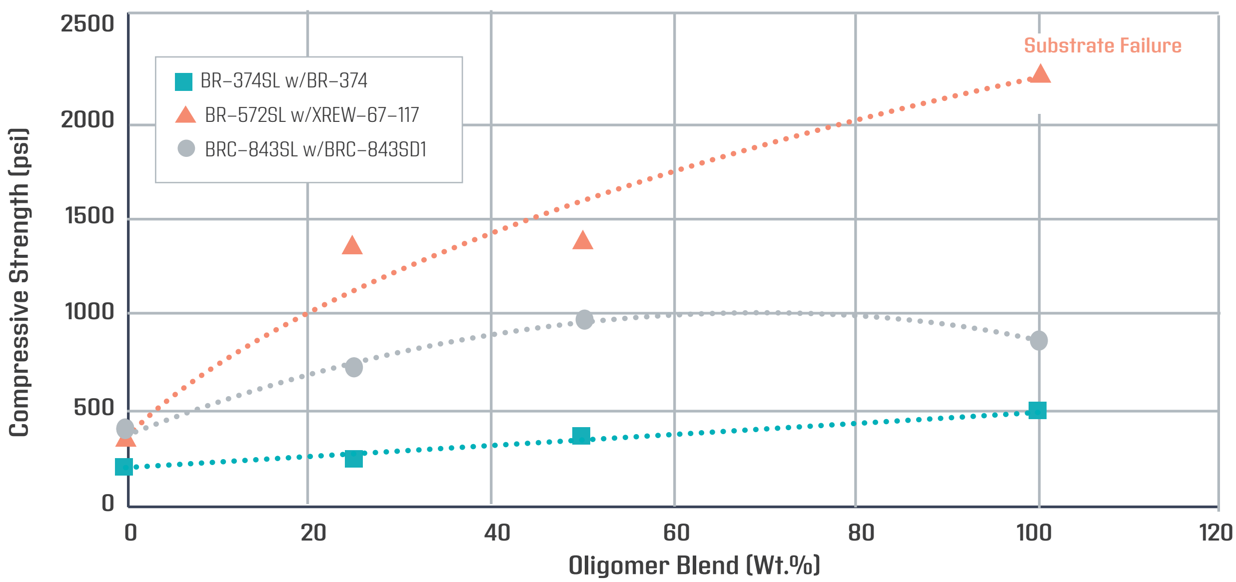
Adhesion Screening

Glass-to-Glass Adhesion

To evaluate glass-to-glass adhesion, two screening methods were used to simulate both standard and more demanding environmental conditions. In the first method, samples were UV-cured and tested for compressive strength without any exposure to elevated temperature or humidity. These baseline results, shown in Figure 3, indicate that blends containing BR-572SL demonstrated good adhesion between glass substrates.

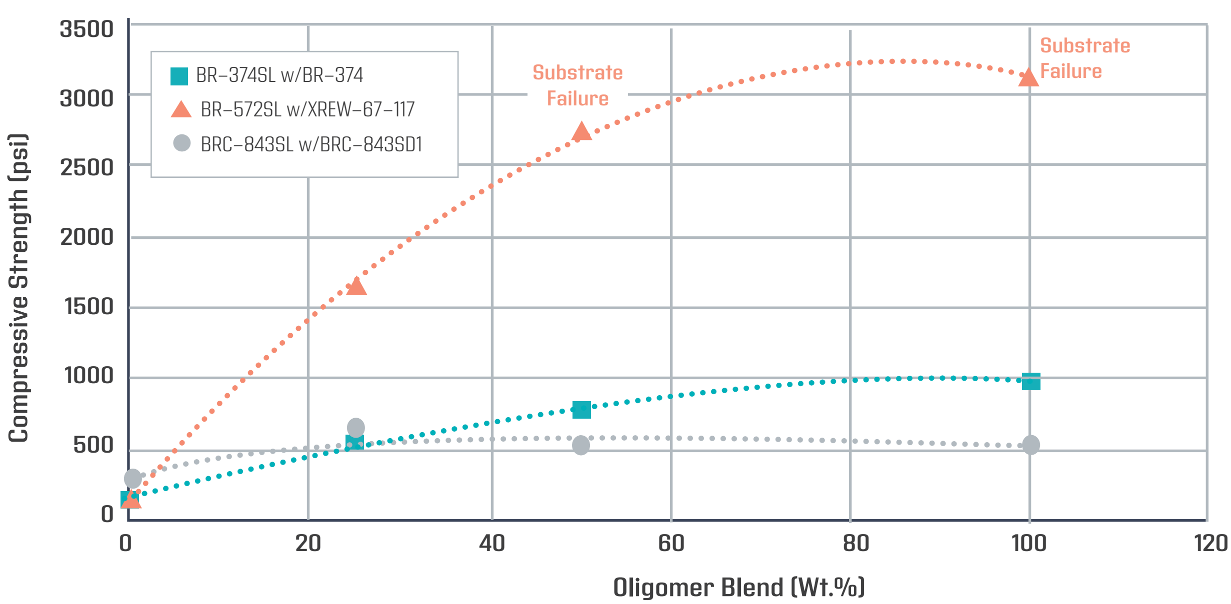
The second method introduced environmental stress by conditioning the samples at an elevated temperature of 60°C and 50% relative humidity humidity chamber for five days then testing their compressive strength. The results of this testing are shown in Figure 4. The results from this more rigorous method clearly show that BR-572SL blends maintained significantly higher adhesion after environmental exposure, suggesting good durability and resistance to heat and moisture Together, these findings highlight BR-572SL's potential for applications where both initial bond strength and environmental stability are critical.

Figure 3. Glass-to-Glass Adhesion (Pre-Humidity Chamber)



Components	Wt%
Oligomer Blend	---
IBOA	25.00
TPGDA	15.00
Irgacure 184	2.00
Darocur 1173	3.00
Total Weight	100.00

Figure 4. Glass-to-Glass Adhesion (Post-Humidity Chamber, 5 days at 60°C/50% RH)



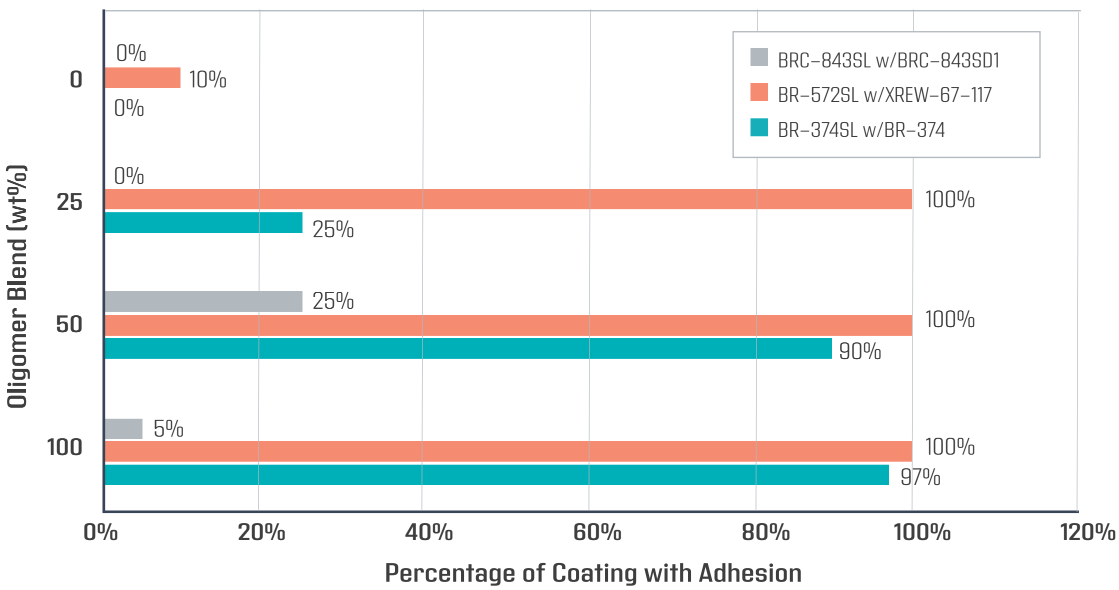
Components	Wt%
Oligomer Blend	---
IBOA	25.00
TPGDA	15.00
Irgacure 184	2.00
Darocur 1173	3.00
Total Weight	100.00

Metal Adhesion Screening

To evaluate how well the oligomer blends adhered to metal, two types of metal substrates, cold–rolled steel and polished aluminum, were tested using crosshatch adhesion methods. Adhesion was measured by the percentage of the coating that remained on the metal surface after testing. The results are shown in Figures 5 and 6.

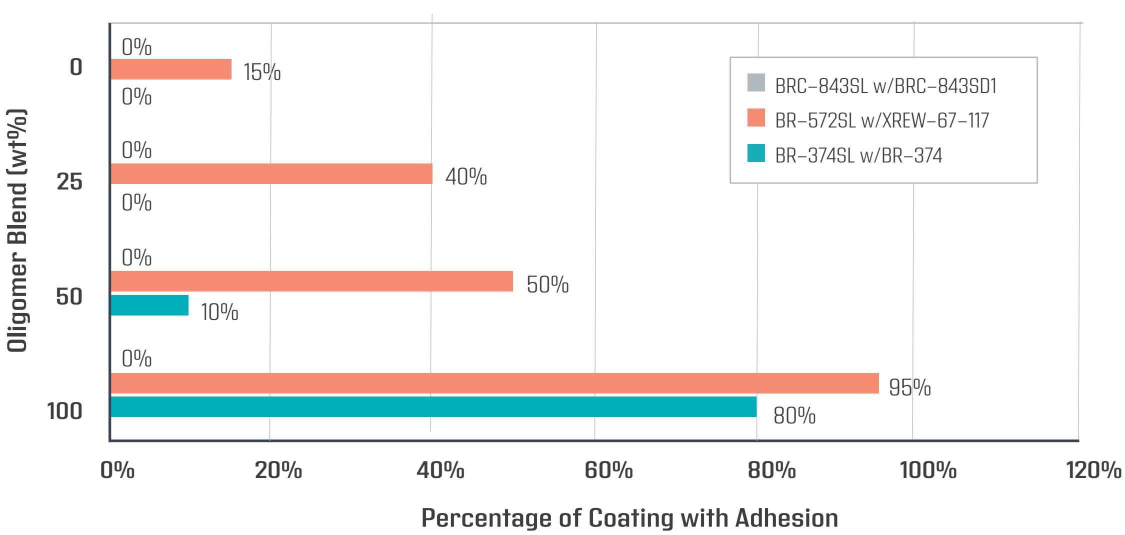
Blends containing BR–572SL and BR–374SL demonstrated good adhesion to steel and moderate adhesion to aluminum. It's important to note that these tests were conducted without controlling for temperature or humidity. One would expect higher values or better metal adhesion if these oligomers were tested under moisture–cure conditions.

Figure 5. Adhesion on Cold–Rolled Steel, Pre–Humidy Chamber



Components	Wt%
Oligomer Blend	---
IBOA	25.00
TPGDA	15.00
Irgacure 184	2.00
Darocur 1173	3.00
Total Weight	100.00

Figure 6. Adhesion on Aluminum, Pre–Humidy Chamber



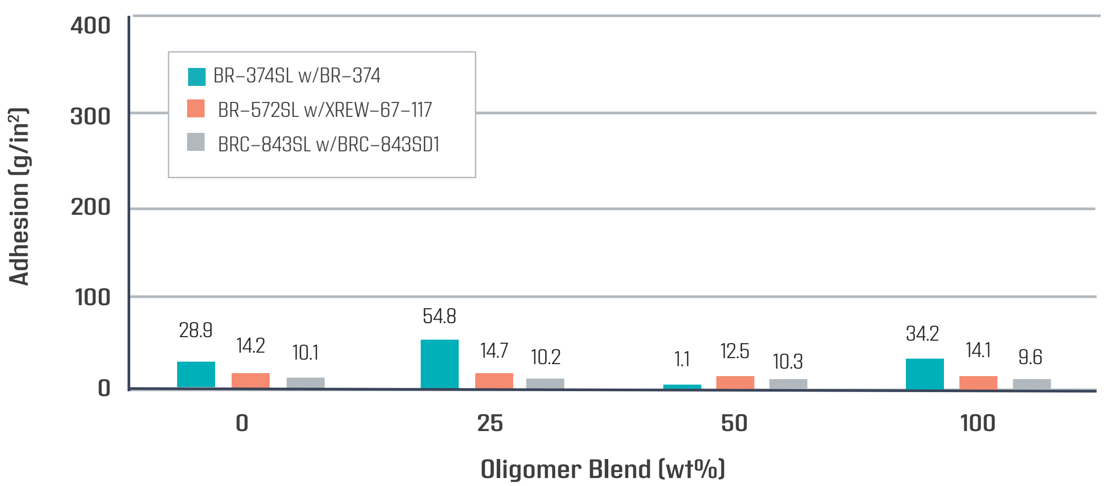
Components	Wt%
Oligomer Blend	---
IBOA	25.00
TPGDA	15.00
Irgacure 184	2.00
Darocur 1173	3.00
Total Weight	100.00

Laminate Adhesion Screening

Laminate adhesion of the oligomer blends was evaluated on two substrates: BOPP and PET. None of the urethane acrylate oligomers or their analogs showed any adhesion to BOPP (Figure 7).

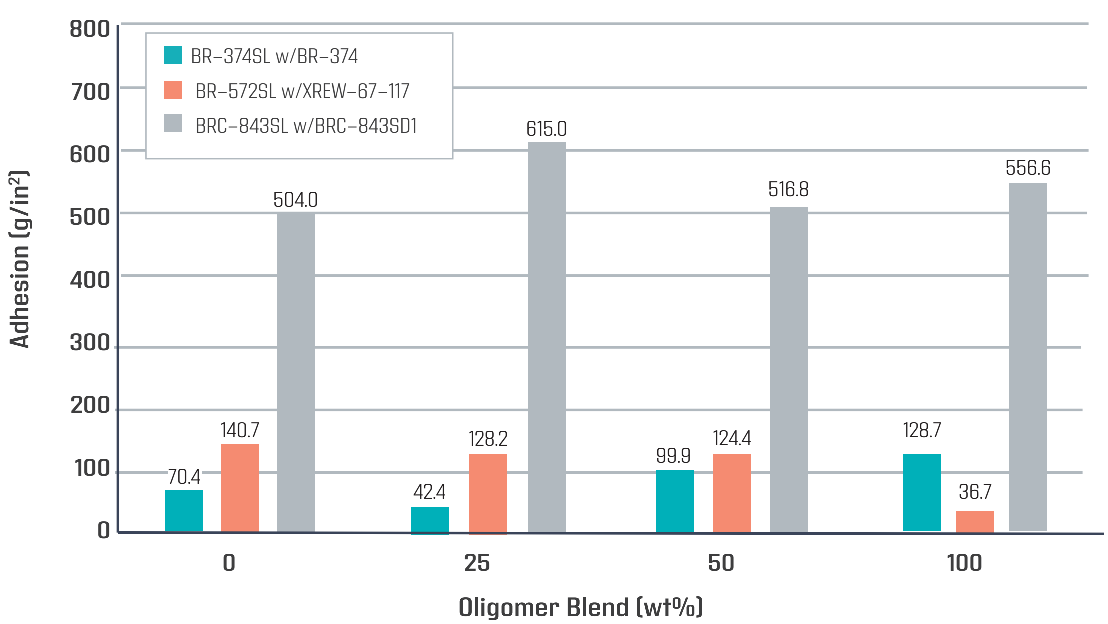
However, samples containing BRC-843SL and BRC-843SD1 demonstrated excellent adhesion to PET laminates. Peel test results for PET are shown in Figures 8. This outcome was unexpected, as urethane acrylates typically show poor adhesion to PET. The improved performance may be attributed to a higher concentration of IBOA in both the oligomer composition and the test formulation.

Figure 7. Laminating Adhesion, BOPP to BOPP



Components	Wt%
Oligomer Blend	---
IBOA	25.00
TPGDA	15.00
Irgacure 184	2.00
Darocur 1173	3.00
Total Weight	100.00

Figure 8. Laminating Adhesion, PET to PET



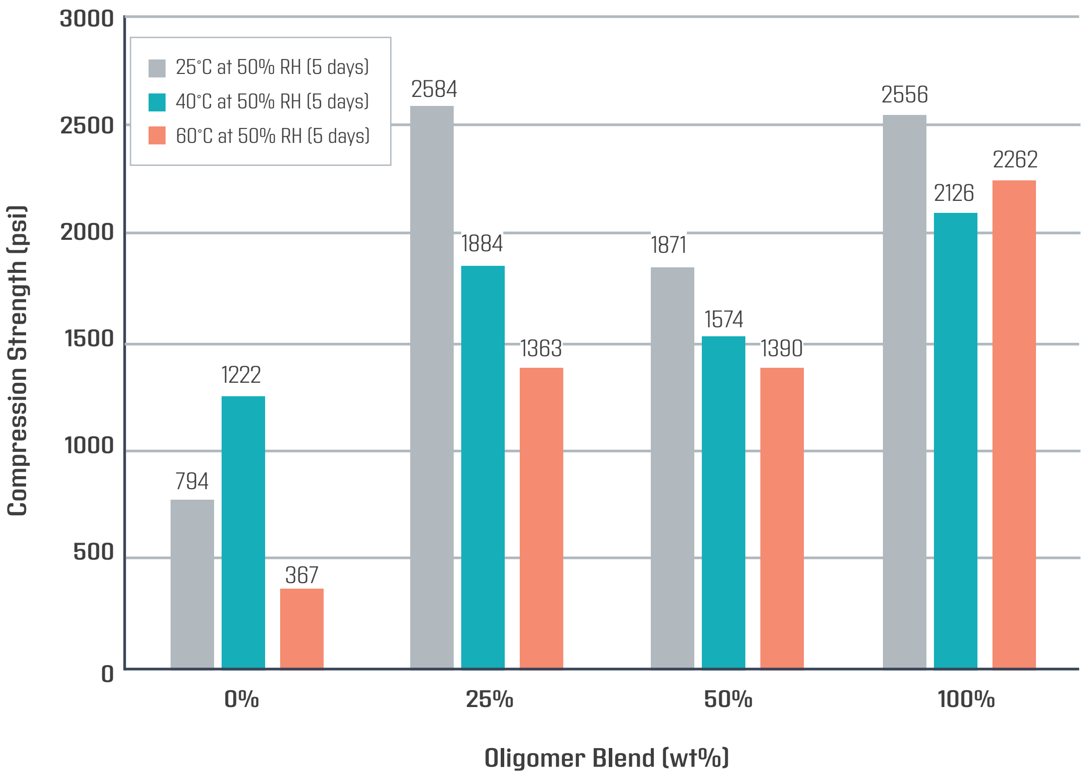
Components	Wt%
Oligomer Blend	---
IBOA	25.00
TPGDA	15.00
Irgacure 184	2.00
Darocur 1173	3.00
Total Weight	100.00

Determining Optimum Cure Conditions

Optimum Temperature Conditions

Three different humidity chambers were used to measure the compressive strength of glass-to-glass adhesion. Each humidity chamber was set at a different temperature, but all had the same relative humidity (50%). The temperatures tested were 25°C, 40°C, and 60°C. A choice was made to test the BR-572SL w/XREW-67-117 blend because it showed the greatest adhesion performance in the previous screening tests for glass adhesion. Figure 9 shows testing at a temperature of 25°C with 50% relative humidity (RH) after 5 days had greatest compressive strength for this blend.

Figure 9. Glass Adhesion vs Temperature (BR-572SL w/ XREW-67-117)

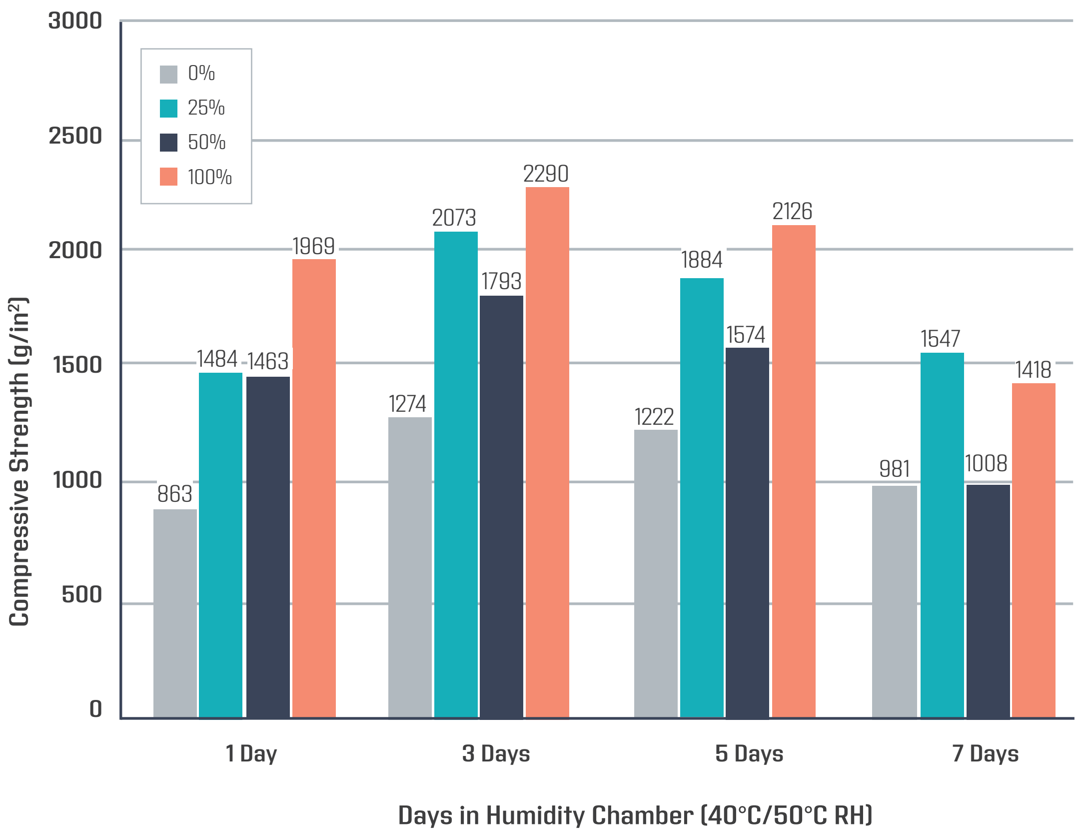


Components	Wt%
Oligomer Blend	---
IBOA	25.00
TPGDA	15.00
Irgacure 184	2.00
Darocur 1173	3.00
Total Weight	100.00

Optimum Moisture Cure Time

The oligomer blend BR–572SL w/XREW–67–117 was again chosen for glass–to–glass compression testing at constant temperature and humidity (40°C / 50% RH). However, the length of time each blend was conditioned was varied by the number of days in the humidity chamber. Figure 10 shows that the greatest compressive strength was found after three days in the humidity chamber. It also shows that as little as 25% urethane acrylate analog oligomer may yield comparable performance to the neat (100%) urethane acrylate oligomer.

Figure 10. Glass Adhesion vs Humidity Days (BR–572SL w/ XREW–67–117)



Components	Wt%
Oligomer Blend	---
IBOA	25.00
TPGDA	15.00
Irgacure 184	2.00
Darocur 1173	3.00
Total Weight	**100.00**

CONCLUSION

This study set out to evaluate the adhesion performance of several modified urethane acrylate oligomers, with the goal of supporting formulators in selecting materials that combine strong adhesion, formulation flexibility, and environmental durability. Through a multi-phase approach, encompassing physical property assessment, substrate adhesion testing, and cure condition optimization, the performance landscape of three unique oligomer blends was thoroughly explored.

Several key conclusions emerged:

- BR-572SL stood out as the top-performing oligomer for glass adhesion, achieving substrate failure in nearly 80% of tests – a strong indicator of excellent bond strength.
- Both BR-572SL and BR-374SL demonstrated strong adhesion to metal substrates, particularly cold-rolled steel, while showing more moderate performance on polished aluminum.
- None of the tested oligomers adhered to BOPP, a known challenge in the industry. However, BRC-843SL and BRC-843SD1 showed promising adhesion to PET, which is notable given the generally poor interaction of urethane acrylates with PET substrates.
- Environmental conditioning played a significant role in adhesion strength. Optimization experiments revealed that a temperature of 25°C and 50% relative humidity for 3-5 days yielded the best glass-to-glass adhesion results for the BR-572SL/XREW-67-117 blend.
- A novel data visualization approach was introduced for tensile and elongation performance, using circle size to represent modulus. This format offered a clearer and more intuitive understanding of oligomer fatigue characteristics.

Taken together, these findings can help guide future formulation strategies by identifying which oligomers are best suited for specific substrates and environmental conditions. They also underscore the importance of continued optimization, particularly with respect to substrate conditioning and blend composition. Future work may expand on these results by including additional substrate types, extended cure environments, and long-term aging studies to fully characterize these materials in real-world applications.

Let's Partner on Your Next Project

To support your formulation development, we offer samples of our oligomers along with expert guidance from our application engineering team. Contact us today to request materials or start a conversation about your formulation goals.