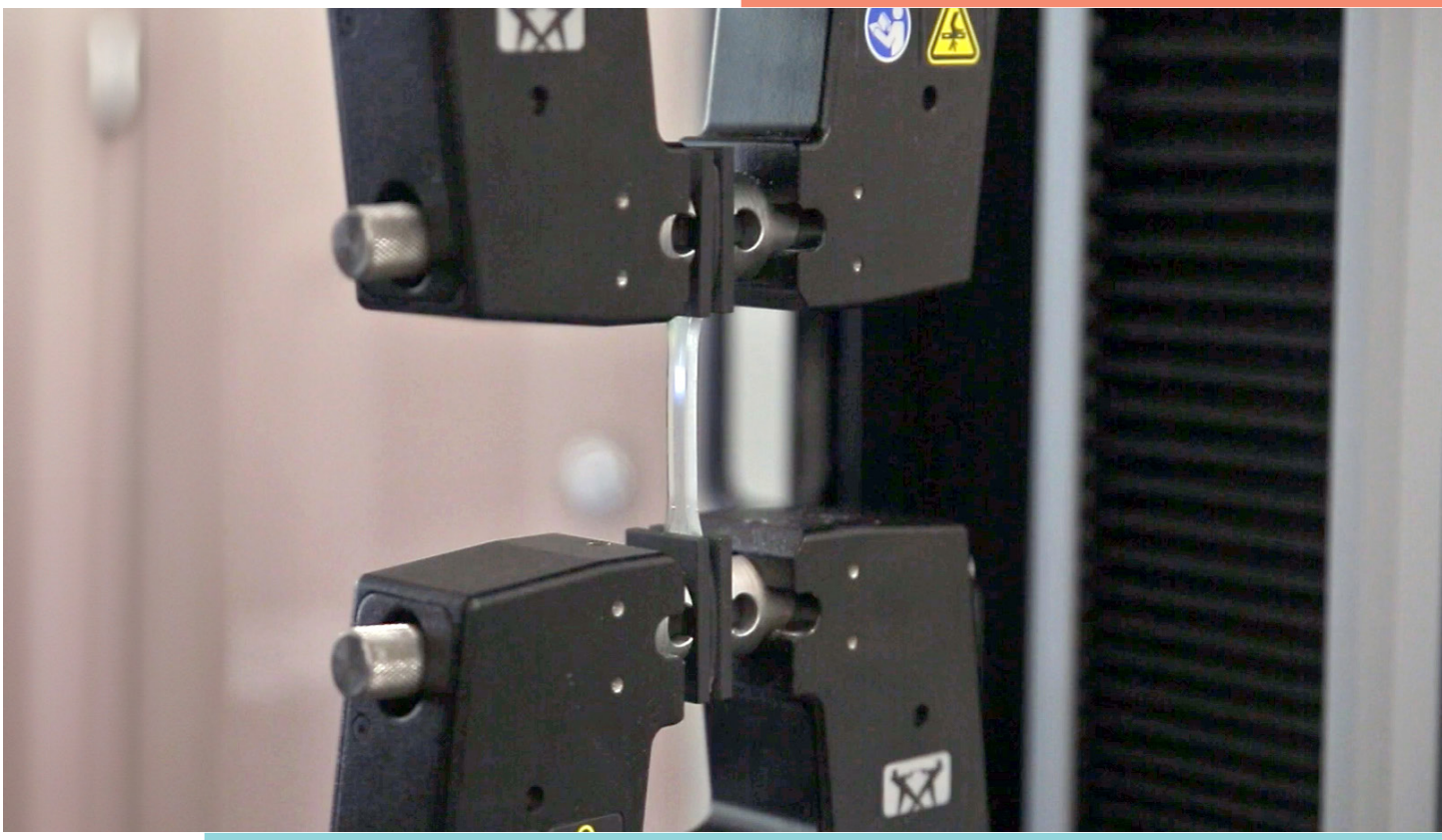
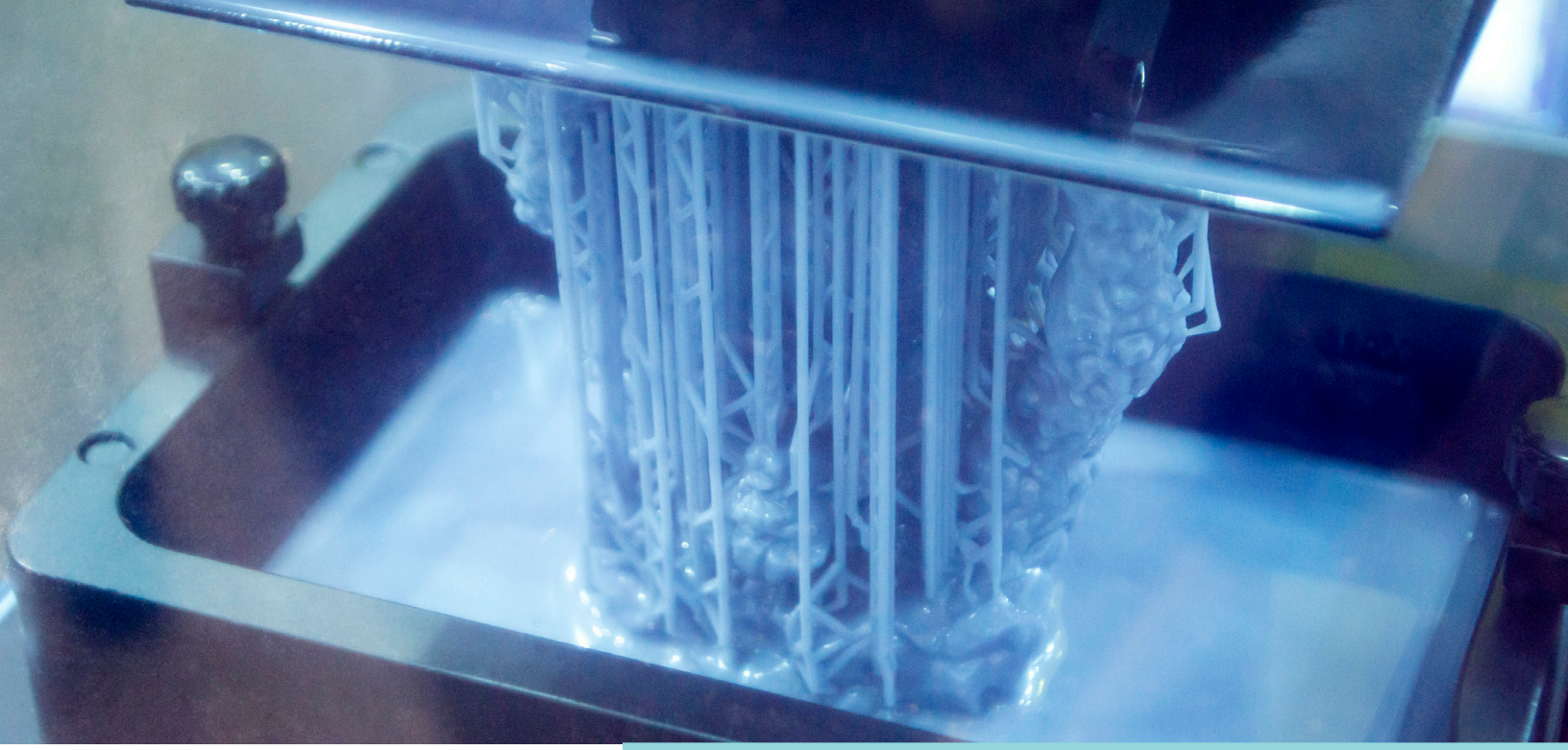
TEAR RESISTANCE IN 3D–PRINTING APPLICATIONS

Technology Bulletin



bomar–chem.com

BOMAR



The tear resistance of oligomers is a critical parameter in 3D printing applications for ensuring the durability and functional integrity of printed parts. The oligomers which provide the core properties of many photopolymer resins – especially in Stereolithography (SLA) and Digital Light Processing (DLP) resins – must exhibit the right tear resistance to withstand the mechanical stresses encountered in end–use environments. Fragile materials without resiliency may break if tear strength is too high after an initial impact. If the tear strength is too low, a 3D part may be mechanically weak and fail during printing process or result in part deformation. The proper balance of strength and flexibility will result in a 3D printed part having the desired appearance and image definition.

TESTING & RESULTS

Procedure

Tear strength was evaluated for a sampling of thirty–three Bomar oligomers, including both commercial and experimental options. Tear testing was done following ASTM D624 "Standard Test Method for Tear Strength of Conventional Vulcanized Rubber and Thermoplastic Elastomers". The oligomers in Table 1 were formulated with 28% IBOA, and 2% TPO. Rectangular molds were created using Teflon plaques measuring 125 mm x 75 mm x 3 mm. The formulations were cured using a Dymax BlueWave® LED Flood Visicure unit at 405 nm. Cure dosage was measured at 4.766 J/cm^2. Test specimens were nicked with a Wallace Instruments Specimen Nicking Cutter and teared using an Instron 34–10 fatigue tester. Four test specimens per oligomer were tested.

Table 1. Bomar Oligomer Sample Group

Oligomers		
BR-1042MB	BR-541S	BR-744BT
BR-1043MB	BR-542MB	BR-744SD
BR-204	BR-543	BRC-4421
BR-302	BR-543TF	BRC-843D
BR-344	BR-5541M	BRC-843S
BR-345	BR-571	BRS-14320S
BR-372	BR-571MB	XCAC-30-72
BR-374	BR-640D	XRLH-3-142
BR-541MB	BR-7432GB	

Results

Table 2 contains the results to the tear strength testing in numerical order. Seven oligomers were found to be too rigid for the tear test and shattered upon sample preparation.

The Bomar product selector guide classifies our resins into groups based on their chemical structures. Figure 1 shows the tear strength data grouped by the oligomer product backbone chemistry type.

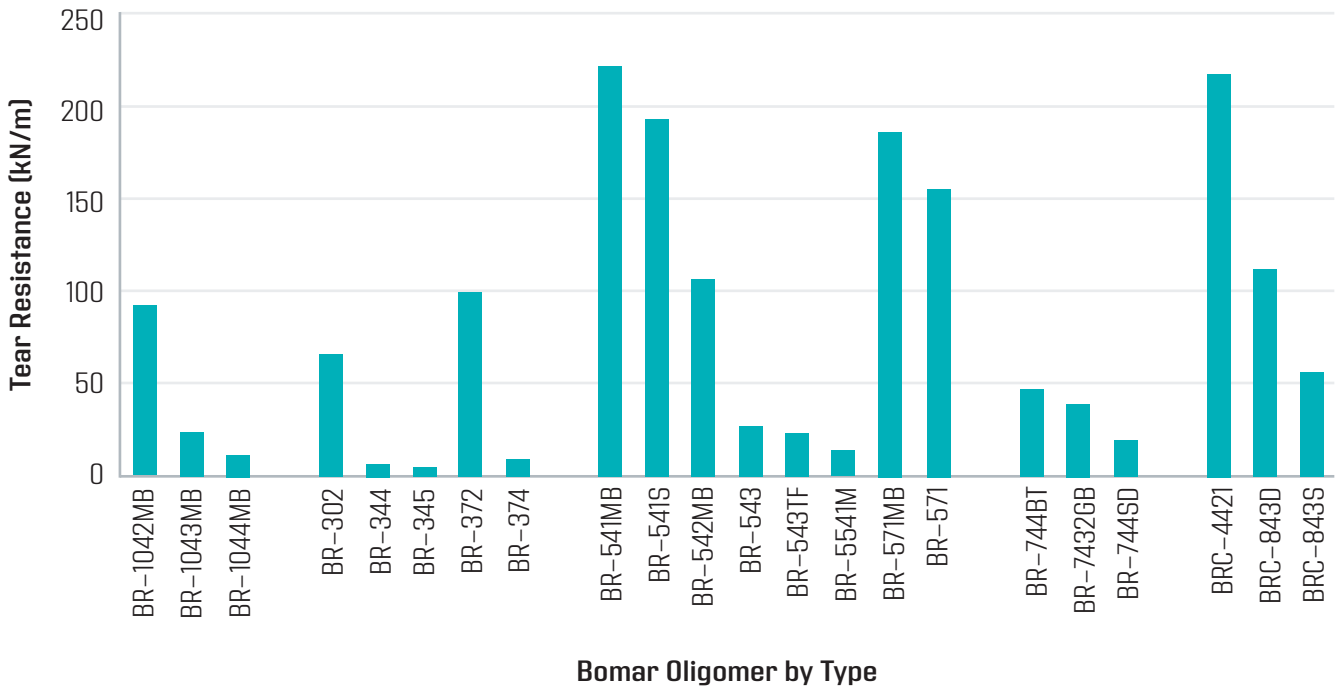
Table 2. Shear Strength Test Results

Oligomer	Tear Strength (kN/m)
BR-345	5.43
BR-344	7.00
BRS-14320S	7.53
BR-204	7.88
BR-374	9.11
BR-1044MB	11.38
BR-5541M	14.36
XRLH-3-142	18.04
BR-744SD	19.79
BR-543TF	23.64
BR-1043MB	24.16

Oligomer	Tear Strength (kN/m)
BR-543	27.49
BR-7432GB	39.92
BR-744BT	47.45
BRC-843S	56.03
BR-640D	57.43
BR-302	66.36
BR-1042MB	92.28
BR-372	99.81
BR-542MB	106.29
BRC-843D	112.24
BR-571	155.49

Oligomer	Tear Strength (kN/m)
BR-571MB	185.61
BR-541S	192.79
BRC-4421	216.95
BR-541MB	222.03
BR-1041MB	too rigid
BR-144B	too rigid
BR-441BI20	too rigid
BR-741	too rigid
BR-741MD1	too rigid
BRC-841	too rigid
XR-741MS	too rigid

Figure 1. Tear Resistance vs Bomar Oligomer type

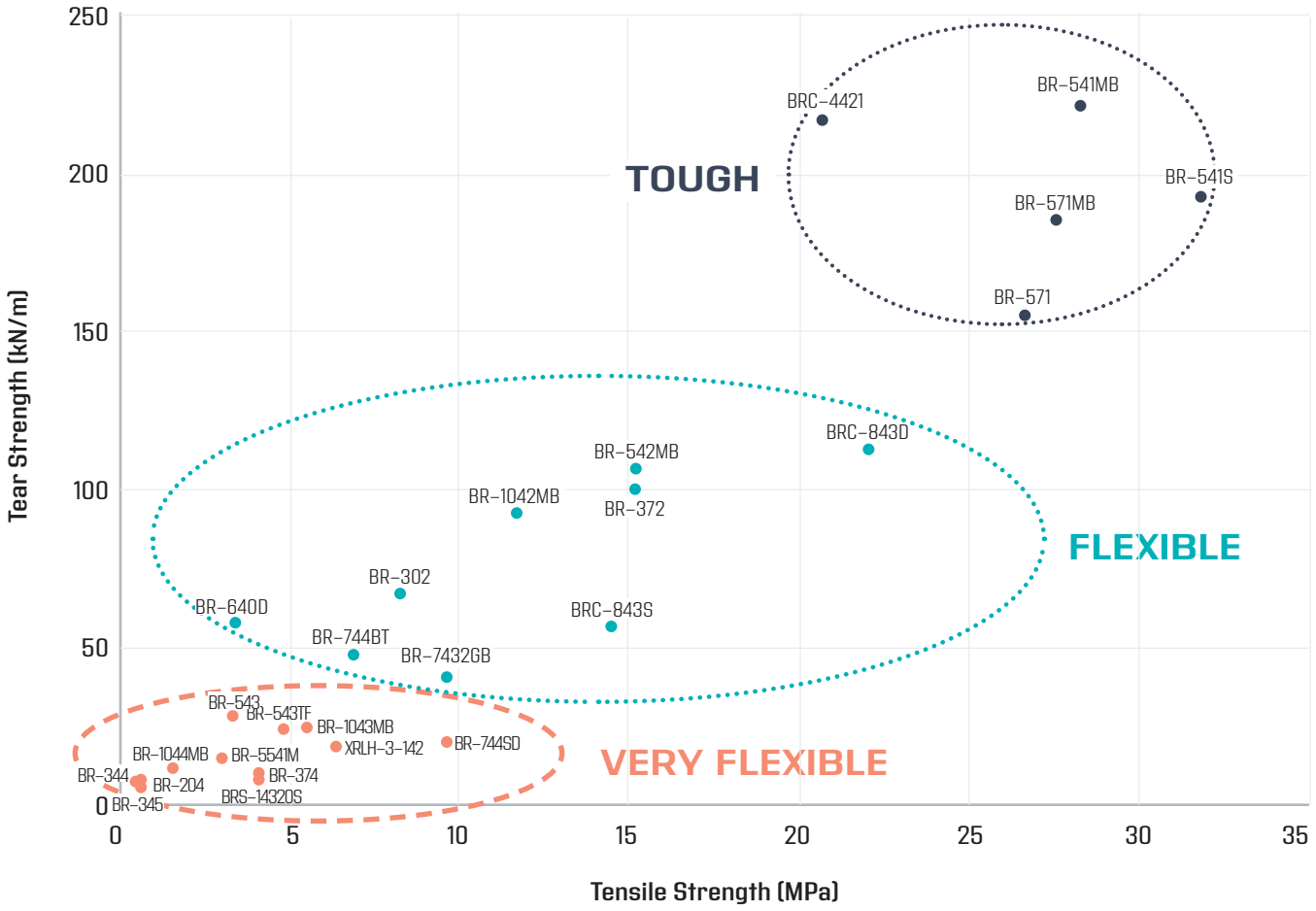


DISCUSSION

A relative correlation of tear strength to tensile strength is shown in Figure 2. Tensile strength and tear resistance are two important mechanical properties of materials that are used to evaluate their durability and strength. Tensile strength is a measure of the force required to break a material under tension, while tear resistance is a measure of a material's ability to resist tearing or ripping under stress. Tear resistance is similar to tensile strength, but it differs in that it measures the tear propagation of the material, not its breaking point.

Figure 2 shows a relative correlation of tear strength to tensile strength for the various Bomar oligomers. They can be divided into three basic groups: Tough / Flexible / Very Flexible.

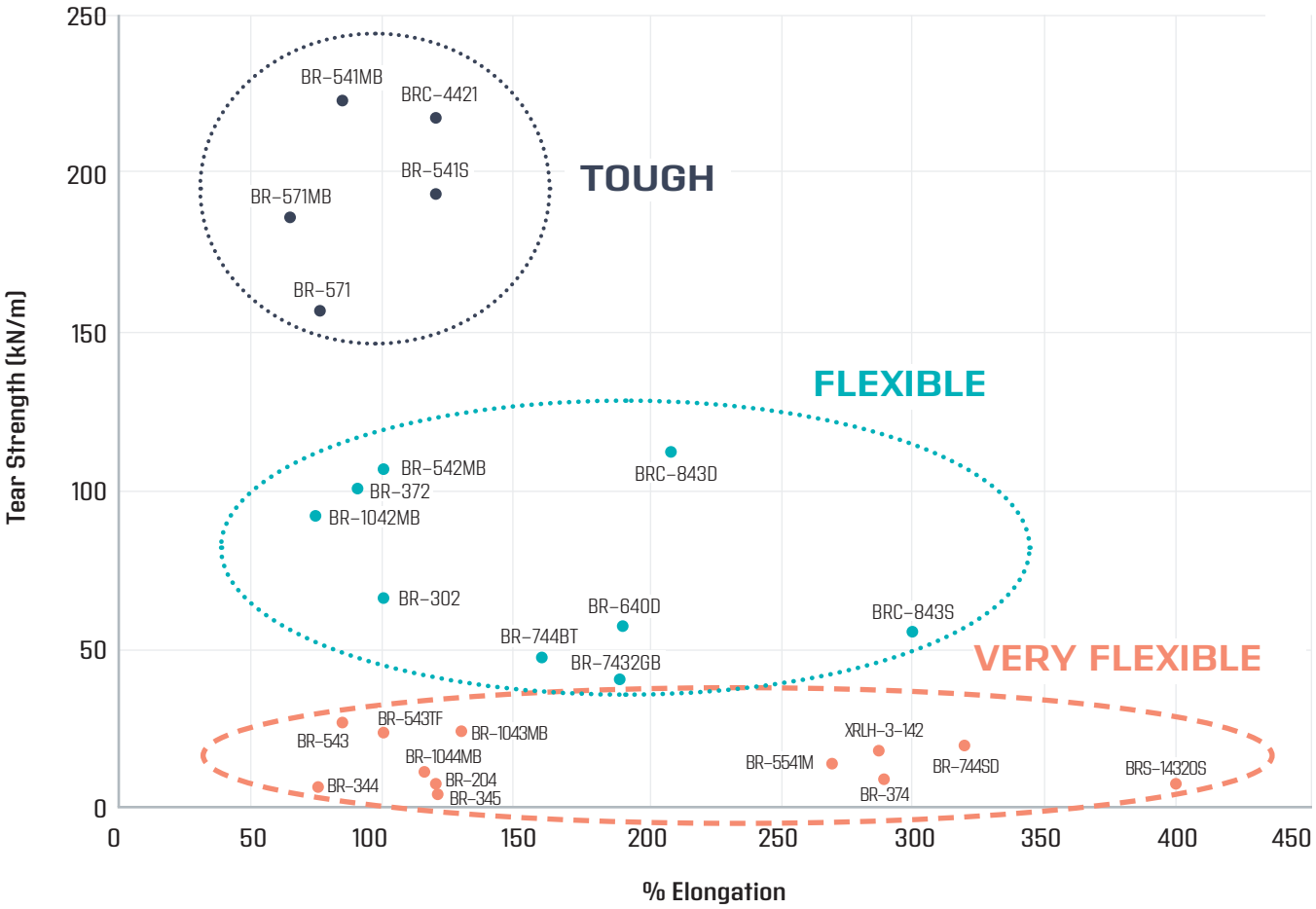
Figure 2. Bomar Oligomers: Tear Strength vs Tensile Strength



When considering the relationship between tear strength and elongation, it is important to understand that tear strength is a measure of the maximum amount of force that a material with a pre–existing weak point can withstand before breaking further, while elongation is a measure of the amount a material can stretch or deform prior to breaking. It can be a challenge to find the right balance between these two properties as they are often seen as opposing forces, with each having an effect on the other.

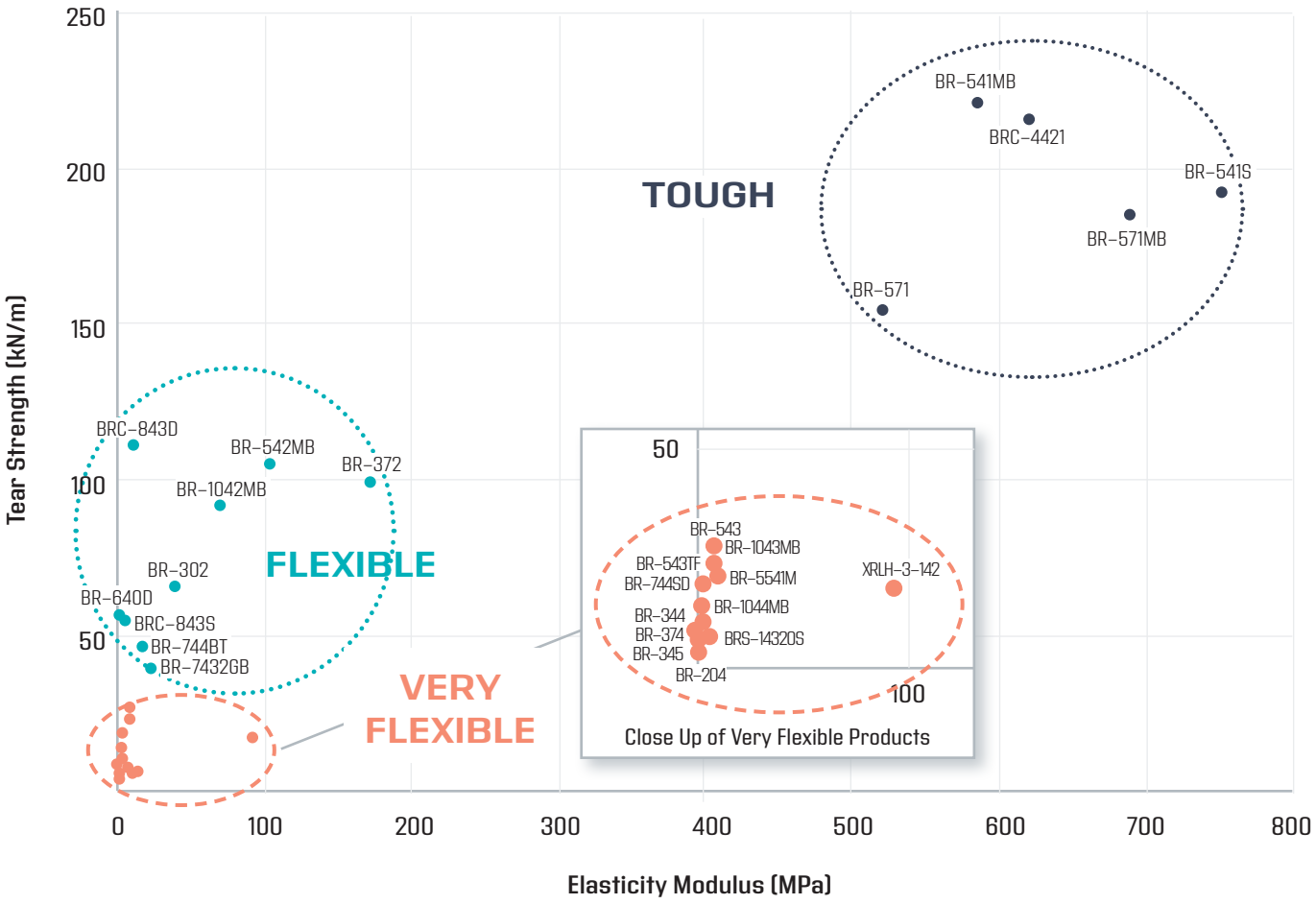
While tough oligomers with high tear strength in this study generally exhibit low elongation values, the flexible oligomers – and the very flexible oligomers even more so – exhibit elongation values distributed over a wider elongation range (see Figure 3).

Figure 3. Bomar Oligomers: Tear Strength vs Elongation



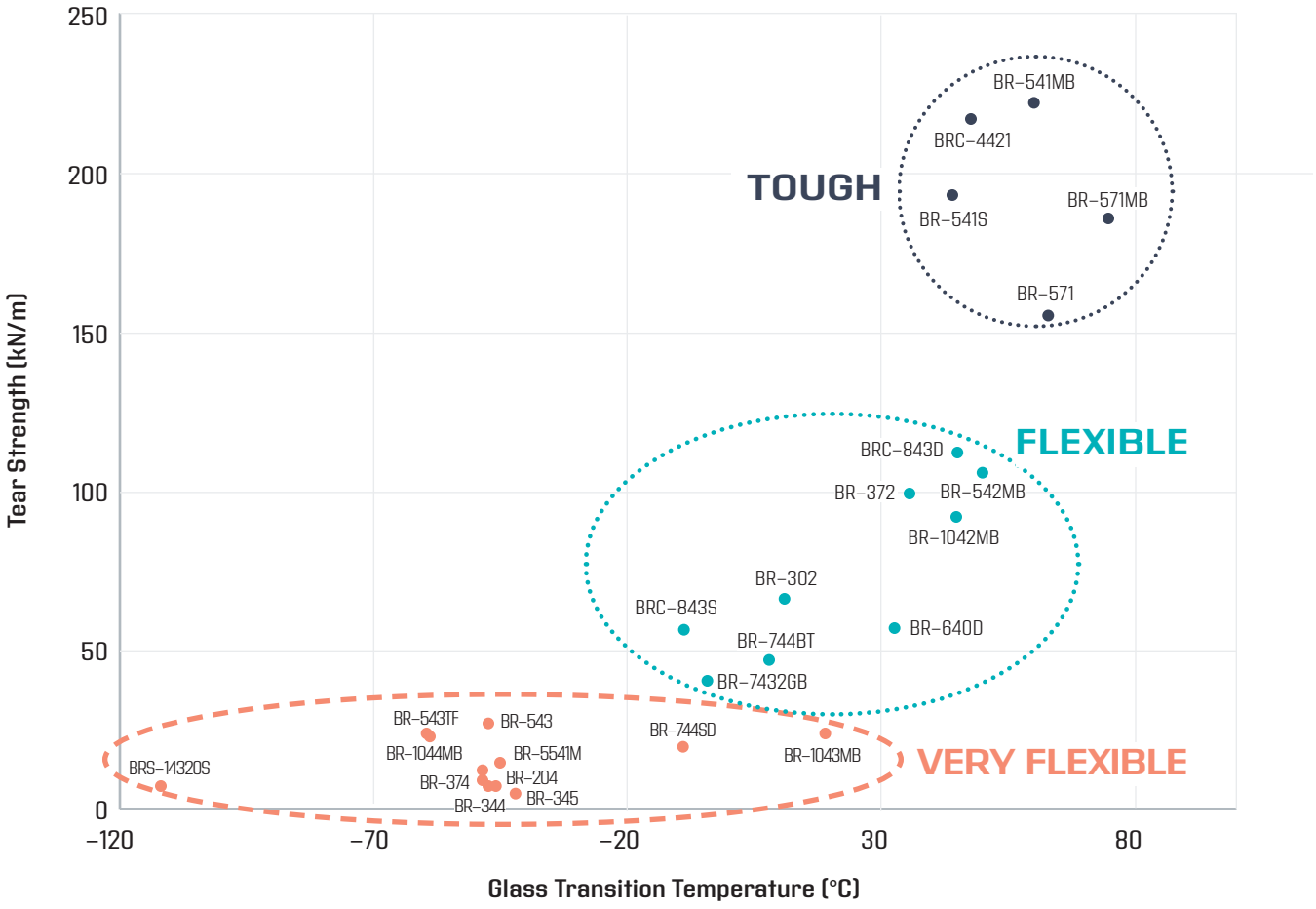
The Elastic modulus is a measure of a material´s resistance to elastic deformation. A higher value indicates that the material experiences less elastic deformation under a given stress. A stiffer/tougher material will have a higher elastic modulus as shown in Figure 4, whereas more flexible materials exhibit significantly lower values for the E–modulus.

Figure 4. Bomar Oligomers: Tear Strength vs Elasticity Modulus



The glass–transition temperature (Tg) is the temperature at which molecular mobility begins to take place, below which molecular mobility is frozen, and the oligomer becomes rigid and glassy. As shown in Figure 5, oligomers with high tear strength values also possess high Tg´s, whereas oligomers with lower Tg´s also show lower resistance to tear.

Figure 5 Bomar Oligomers: Tear Strength vs Tg



Understanding the tear strength of oligomers is essential for material selection and design in various industrial applications, where mechanical integrity and durability are of utmost importance.

Global Headquarters: 51 Greenwoods Road | Torrington, CT 06790 | USA | +1 860–626–7006

www.bomar–chem.com