

# Mechanical Properties and Hydrolytic Stability of Elastomers Based on Krasol<sup>®</sup> Polyols

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## ABSTRACT

Krasol<sup>®</sup> polyols are hydroxyl-terminated polybutadienes with functionalities closer to two as opposed to conventional polybutadiene polyols such as Poly bd<sup>®</sup> R-45HTLO which has a functionality of 2.5. Lower functionality makes it possible to prepare TDI prepolymers with lower viscosities and polyurethane/urea elastomers with improved tensile and tear properties. The unique structure of Krasol<sup>®</sup> polyols gives them miscibility with other polyols, such as polypropylene glycols (PPGs) and polytetramethylene glycols (PTMEGs), which was not possible with conventional polybutadiene polyol technology.

For this study, TDI prepolymers were prepared with various molecular weight Krasol<sup>®</sup> polyols. These prepolymers were cured with a variety of primary aromatic diamines. The aromatic diamine curatives, Lonzacure M-CDEA (MCDEA) and Ethacure 300 (Curene 107) were found to have excellent compatibility with Krasol<sup>®</sup> polyol-based TDI prepolymers, however, Versalink<sup>®</sup> 740M and methylene-bis(ortho chloroaniline) (MBOCA) were not compatible. The TDI prepolymers could be modified with other compatible polyols to allow the use of the much lower cost MBOCA. The elastomer processability, properties, and resistance to aqueous acids and bases are presented. Polyurethane/urea elastomers based on Krasol<sup>®</sup> polyols have unique properties which will allow them to go into new applications or perform better in current applications.

## INTRODUCTION

Polybutadiene polyols are well known for their hydrolytic stability and low temperature flexibility due to their hydrocarbon nature [1]. Until recently, these hydroxyl-terminated polymers were made mostly by free-radical polymerization, giving rise to 1,2-, 1,4-cis, and 1,4-trans groups in the backbone with the majority being of the 1,4 type. The radical polymerization causes branching, resulting in a functionality greater than two,

and a low 1,2 vinyl content. Polyurethane elastomers prepared from these don't have good tensile and tear properties.

With the recent development of Krasol<sup>®</sup> polyols, much better elastomers can be made. Krasol<sup>®</sup> polyols are synthesized by anionic polymerization giving a better functionality of 1.9 and high 1,2 vinyl content of 65% [2]. This high 1,2 content gives more flexibility to the chain. They also possess significantly better compatibility with other polyols, especially polypropylene glycols [1]. This compatibility gives the ability to blend and make hybrid prepolymers.

Most of the research in the area of elastomers based on Krasol<sup>®</sup> polyols has been done using MDI, but there has been some research with TDI-based prepolymers cured with MCDEA. These studies show that Krasol<sup>®</sup>-based elastomers have excellent hydrolysis resistance especially when compared to other high performance systems like PTMEG-based elastomers cured with MBOCA [3]. Extensive weathering and aging studies have also been done with MDI-based Krasol<sup>®</sup> prepolymers cured with various diols and diamines showing their superior retention of properties [2].

This study looks not only at MCDEA, but also many other aromatic diamines to determine the compatibility of each with the Krasol<sup>®</sup> polyols. Also researched is the ability to use MBOCA as the chain extender since it is the standard curative for the elastomer industry and much lower cost than MCDEA. The attainable hardness range and properties for Krasol<sup>®</sup> prepolymers cured with MCDEA was evaluated and a thorough chemical resistance study is discussed.

## EXPERIMENTAL

The materials used for the study were Krasol<sup>®</sup> diols of 2000, 3000, and 5000 MW. Mondur TDI-80 (80% 2,4 TDI) and TDS (100% 2,4 TDI) were both used as the isocyanates to synthesize the prepolymers. A variety of curatives was used and will be discussed. The prepolymers were reacted at 80°C with NCO to OH ratios

Table 1. Properties of Mondur TDS/Krasol <sup>®</sup> LBH-3000 (%NCO=2.07) with various curatives					
	Curene 185 (MBOCA/PPG)	Curene 280 (MBOCA/PPG)	MCDEA	Curene 107 (Ethacure 300)	Versalink <sup>®</sup> 740M
Potlife	16'	19'	5' 20"	10' 00"	25'
Demold	60 min.	60 min.	30 min.	40 min.	> 60 min.
Prepolymer Appearance	Slightly Hazy	Hazy	Clear	Clear	Opaque
Elastomer Appearance	Very Slightly Hazy	Opaque	Clear	Clear	Opaque
Shore Hardness	57A	65A	73A	64A	60A
Elongation, %	280	360	370	390	390
Tensile Strength, psi	650	960	2050	1700	1260
100% Modulus, psi	290	390	740	520	430
300% Modulus, psi	----	790	1530	1250	1010
Die C Tear, pli	63	101	139	105	104
Split Tear, pli	14	24	31	24	26

ranging from 1.9-2.0 and all castings were postcured at 100°C for 16 hours. Standard physical properties were performed on the elastomers including tensile properties, tear strength, compression set, abrasion, and rebound.

## RESULTS AND DISCUSSION

### Curative Compatibility with Krasol<sup>®</sup>

Since polybutadienes are so hydrophobic, many compounds are not compatible with them. When the curative is not soluble in the soft segment of the elastomer, it will phase out and give opacity or even solidify to form flakes. This happened with many of the curatives used in the study. Tables 1 and 2 show a summary of the data from a Mondur TDS and a TDI-80 based prepolymer. Data using MBOCA was not included in the table because it was so incompatible that it formed flakes throughout the elastomer.

Looking at the prepolymer appearance (after mixing) and the elastomer appearance, the Curene 185 and 280 were incompatible as expected due to the MBOCA in their makeup. Since MCDEA has four ethyl groups, it has quite a bit more hydrophobic character than MBOCA and thus is compatible with the Krasol<sup>®</sup>. Curene 107 (Ethacure 300), which also has hydrocarbons on its aromatic ring, is also compatible. Versalink<sup>®</sup> 740M gave an opaque elastomer which makes sense looking at its structure, which is a diaminobenzoate having ester bonds.

The two candidates that were compatible, MCDEA and Curene 107, had very reasonable processing parameters, with potlives of ~5.5 minutes and 10 minutes and with demold times of 30 and 40 minutes, respectively.

The physical properties of all the samples are not too bad when compared with other elastomers at the same hardness. With no hydrogen bonding in the backbone, one would not expect the polybutadienes to give superior tensile or tear strength and that is what we see here.

Table 2. Properties of Mondur TDI-80/Krasol <sup>®</sup> LBH-3000 (%NCO=2.04) with various curatives					
	Curene 185 (MBOCA/PPG)	Curene 280 (MBOCA/PPG)	MCDEA	Curene 107 (Ethacure 300)	Versalink <sup>®</sup> 740M
Potlife	9' 30"	13'	4' 30"	6' 00"	25'
Demold	40 min.	60 min.	30 min.	35 min.	> 60 min.
Prepolymer Appearance	Slightly Hazy	Hazy	Clear	Clear	Opaque
Elastomer Appearance	Very Slightly Hazy	Opaque	Clear	Clear	Opaque
Shore Hardness	58A	62A	73A	65A	65A
Elongation, %	270	380	290	350	350
Tensile Strength, psi	630	1060	1510	1560	1240
100% Modulus, psi	300	360	750	540	510
300% Modulus, psi	----	770	----	1280	1100
Die C Tear, pli	64	89	145	113	112
Split Tear, pli	9	19	29	27	24

	75	67	60	50	25	0
Weight% TDI-80/Krasol <sup>®</sup> LBH2000; 3.45% NCO	75	67	60	50	25	0
Weight% TDI-80/PPG 2000 Diol; 3.25% NCO	25	33	40	50	75	100
Potlife	5' 30'	5' 00"	5' 00"	5' 00"	6' 00"	9' 30"
Demold	35 min.	35 min.	35 min.	40 min.	50 min.	60 min.
Prepolymer Appearance	v. hazy	Hazy	hazy	Clear	Clear	Clear
Elastomer Appearance	Very hazy; flakes	Very hazy; flakes	Hazy; particles	Translucent	Translucent	Clear
Shore Hardness	85A	82A	82A	81A	77A	70A
Elongation, %	340	240	380	490	530	580
Tensile Strength, psi	2040	1390	1880	3180	2110	2400
100% Modulus, psi	1090	930	900	840	650	460
300% Modulus, psi	1850	----	1500	1420	1060	780
Die C Tear, pli	218	201	216	212	185	141
Split Tear, pli	48	49	55	60	55	42

## MBOCA Compatibility Study

### EFFECT OF PPG CONTENT

Table 3 shows the physical properties of blends of a Krasol<sup>®</sup>-based and a PPG-based prepolymer cured with MBOCA. At 25% PPG, the elastomers were hazy and the MBOCA still flaked out. It was found that 50% PPG was needed to give a good translucent elastomer that had no flakes. Tensile and tear properties were also at their maximum at this level of PPG. It is apparent that the Krasol<sup>®</sup> materials have higher reactivity as the potlife and demold times got longer as more PPG was added. The shorter potlives of the Krasol materials may be due to the MBOCA's incompatibility with the soft segment causing premature phase out. They also inherently give harder elastomers than PPGs do as the hardness went from 85 Shore A down to 70 Shore A for 100% PPG. This

relationship is the same as has been reported for PTMEG versus PPG polyols regarding the effect of polyol molecular weight distribution (MWD) [4]. Krasol<sup>®</sup> and PTMEG polyols have broad MWDs resulting in higher hardness elastomers, whereas PPG polyols have narrow MWDs.

### EFFECT OF TRIOL CONTENT

A study was done to test if the 50/50 blend of Krasol<sup>®</sup> and PPG had achieved a fully developed, phase-separated network. A 3000 MW PPG triol was added at various amounts and the data is in Table 4. It is clear that once triol was added, the DieC and split tear start to decrease, and so it was concluded that it had achieved a fully developed network, eliminating the need for any triol.

	50	50	50	50
Wt.% TDI-80/Krasol <sup>®</sup> LBH2000; 3.45% NCO	50	50	50	50
Wt.% TDI-80/PPG 2000 Diol; 3.25% NCO	50	40	25	0
Weight% TDI-80/3000 MW PPG Triol; 3.22% NCO	0	10	25	50
Potlife	5' 00"	5' 00"	5' 30"	5' 10"
Demold	40 min.	35 min.	25 min.	20 min.
Prepolymer Appearance	Clear	Clear	Very slightly hazy then clear	Hazy then clear after 4 min.
Elastomer Appearance	Translucent	Translucent	Translucent	Translucent
Shore Hardness	81A	80A	81A	80A
Elongation, %	490	290	370	230
Tensile Strength, psi	3180	1690	2050	1620
100% Modulus, psi	840	870	850	890
300% Modulus, psi	1420	1780	1550	----
Die C Tear, pli	212	163	168	131
Split Tear, pli	60	39	49	25

Table 5. Properties of Krasol <sup>®</sup> with MCDEA/Polyol and Curene 107/polyol blends						
Name	Krasol prepolymer	Krasol prepolymer	Krasol prepolymer	Krasol prepolymer	Krasol prepolymer	Krasol prepolymer
Elastomer Appearance	clear	clear	clear	clear	clear	clear
<b>Processing Characteristics</b>						
Stoichiometry	0.92	0.95	0.95	0.95	0.93	0.95
Curative	MCDEA/PPG triol	C107/polyester	C107/LBH2000	C107/PPG2000	MCDEA	MCDEA
Pot Life, minutes	6*	5.25	7.75	7.25	4.5	2
Demold Time, 212 F, minutes	50	65	60	60	40	15
	*DBDTL used					
<b>Elastomer Properties</b>						
Shore Hardness	40A	59A	61A	60A	70A	90A
Tensile, psi	397	1319	1600	1137	1590	2360
100% Modulus, psi	126	340	420	392	600	1165
300% Modulus, psi	265	666	855	792	1203	2140
Elongation, %	412	586	520	431	383	334
Die C Tear, pli	45	132	150	134	152	174
Split Tear, pli: AVG.	10	39	30	34	28	64
Bashore Rebound (%)	56	43	50	50	56	n.d.
Compression Set, %	14	26	28	28	n.d.	n.d.

### Attainable Hardness Range with MCDEA/Polyol

As seen previously, the hardness of a 3000 MW Krasol<sup>®</sup>-based prepolymer gave a 73A Shore A elastomer when cured with MCDEA. Experiments then followed with MCDEA and Curene 107 since they were compatible to see what kind of hardness range was attainable and the physical properties of the resulting elastomers as shown in Tables 5 and 6.

The highest hardness was 90 Shore A by taking a Krasol<sup>®</sup> LBH 2000/TDI as shown in Column 7 of Table 5. The physical properties were okay, but what stood out was the very short potlife of two minutes. MCDEA is known to be a fast reacting curative, so a different curative could be used such as Curene 107 for a slightly

longer potlife of three to four minutes, but at the expense of being softer. Three to four minutes is still a short potlife for a material of that hardness.

Two directions were taken with the lower hardness materials. Prepolymers based on all Krasol were made using combinations the LBH 3000 and LBH 5000, and a prepolymer was made from a blend of the LBH 3000 and Acclaim 4200, a 4000 MW PPG diol, both of which gave around 70A when cast with MCDEA. The reason for the blend was to have a lower cost and lower viscosity prepolymer and to see what the difference in physical properties would be. Table 5 has the Krasol<sup>®</sup> data and Table 6 has the Krasol<sup>®</sup>/Acclaim blend data.

For lowering the hardness below 70A, blends of MCDEA or Curene 107 with other polyols were used in

Table 6. Krasol <sup>®</sup> /Acclaim Prepolymer Cured with Various Curative Blends					
Name	Krasol <sup>®</sup> /Acclaim	Krasol <sup>®</sup> /Acclaim	Krasol <sup>®</sup> /Acclaim	Krasol <sup>®</sup> /Acclaim	Krasol <sup>®</sup> /Acclaim
Elastomer Appearance	clear	clear	clear	white/opaque	white/opaque
<b>Processing Characteristics</b>					
Stoichiometry	0.92	0.93	0.92	0.92	0.92
Curative	MCDEA/ EO capped PPG	MCDEA/ PPG triol	MCDEA/ PTMEG	MCDEA/ Polycaprolactone	MCDEA/ EG/PG adipate
Pot Life, minutes	6-7	12	11.5	10	6
Demold Time, 212 F, minutes	Not determined	120	120	Not determined	45
<b>Elastomer Properties</b>					
Shore Hardness	39A	40A	40A	50A	61A
Tensile, psi	229	451	487	719	789
100% Modulus, psi	126	166	126	229	347
300% Modulus, psi	186	308	190	336	694
Elongation, %	555	444	>1166	908	340
Die C Tear, pli	56	50	88	129	64
Split Tear, pli: AVG.	38	20	76	65	13
Bashore Rebound (%)	40	45	52	48	50
Compression Set, %	24	13	32	n.d.	n.d.

Table 7. Samples for Immersion and Test Solutions – Study 1	
Samples (All TDI-based): Polyol backbone / Curative	Immersion Solutions / Time Immersed
2000 MW PPG / MBOCA	90°C Water / 3 weeks
2000 MW PTMEG / MBOCA	60% Sulfuric acid / 3 weeks
2000 MW Krasol® / MCDEA	40% Nitric acid / 3 weeks
2000 MW Krasol® / CURENE 107	50% Sodium hydroxide / 3 weeks
2000 MW Krasol®:2000 MW PPG(50:50) / MBOCA	4% (Cl) Sodium Hypochlorite / 5 weeks
2000 MW Krasol®:2000 MW PPG(75:25) / MCDEA	
2000 MW Krasol®:2000 MW PPG(50:50) / MCDEA	
2000 MW Krasol®:2000 MW PPG(25:75) / MCDEA	

the curative. A wide variety of polyols were chosen to look at their compatibility with the Krasol® and the difference in elastomer properties. As a whole, none of the elastomers have extremely high strength, likely due to the lack of hydrogen bonding, as had been previously mentioned. The compression set and rebound, which are very important in some applications, are pretty good for all the elastomers.

Looking at Table 5, it is notable that a polyester was used in the curative (2<sup>nd</sup> column of data) and it was compatible with the Krasol® prepolymer. It was hopeful that the physical properties of the elastomer would be better having a polyester rather than a PPG, but the tear strength increased little over the other 60A formulations. However, looking at Table 6 where an EG/PG adipate polyester was used (4<sup>th</sup> column of data) that was incompatible with the Krasol®, the physical properties were very poor, which makes sense since the incompatibility may have caused a poor elastomeric network to form. What is unexpected, though, is that a polycaprolactone polyol in the curative, also shown in Table 6, had definite incompatibility with the Krasol®, but the tear properties were very good, showing that possibly the polycaprolactone had a little more affinity for the Krasol®. Since it does have a longer hydrocarbon chain in between ester linkages, it makes sense, though.

It was found that a 40 Shore A hardness was attainable with 10% MCDEA in the curative blend. Lower hardness would be possible with a prepolymer made from entirely 5000 MW Krasol, but the viscosity would make processing difficult. Also, if more polyol had been used, then lower hardness could be expected.

### Hydrolytic Stability of Krasol®-based Prepolymers

It has been seen that Krasol®-based elastomers cured with MCDEA have shown excellent resistance to aqueous environments, whether acidic or basic [3]. It was investigated whether other curatives would give the same

performance and whether MBOCA-cured elastomers with the Krasol®/PPG blended prepolymers would do as well as the straight Krasol® prepolymers. Very concentrated acidic and basic solutions were used to be very aggressive and test the limits of the Krasol®. Two studies were done for hydrolytic stability. Study 1 looked at various prepolymers with different backbones and Study 2 looked at lower hardness materials with blends of CURENE 107 and various polyols as the curative, and using a Krasol®-based prepolymer.

Table 7 identifies the samples tested and the media in which they were tested for Study 1. For references to compare against, a TDI/PPG and a TDI/PTMEG, both MBOCA cured, were prepared using 2000 MW polyols. Then the two compatible curatives with Krasol® from Tables 1 and 2, the MCDEA and CURENE 107, were used. Also, hybrid systems made of a PPG and Krasol® were used so that a sample could be cast with MBOCA. Other hybrids were cast with MCDEA in differing PPG amounts of 25%, 50%, and 75% to see the relationship of PPG content vs. the hydrolytic stability.

Table 8 identifies the softer materials and test solutions used in Study 2. As previously stated, this study looked at changes in the curative holding the prepolymer constant, which was an all Krasol® prepolymer based off of LBH 3000. The hardness for these was 60 Shore A. For reference, the graphs showing the second study include the data from the first study of the Krasol® sample cured with CURENE 107.

### H<sub>2</sub>O STABILITY

Figure 1 shows the results from immersion in water at 90°C for Study 1. The MCDEA-cured elastomer was virtually unaffected by the water medium. The CURENE 107 did second best losing a little hardness and a little tensile strength. All the Krasol®-based elastomers outperformed the standards, which lost most of their hardness and had less than 10% of their original tensile

Table 8. Samples for Immersion and Test Solutions – Study 2	
Samples: Krasol Prepolymer cured with CURENE 107 and diol listed	Immersion Solutions / Time Immersed
1000 MW Hydrophobic polyester diol*	90°C Water / 3 weeks
2000 MW Krasol diol	60% Sulfuric acid / 3 weeks
2000 MW PPG diol	4% (Cl) Sodium Hypochlorite / 5 weeks

\*Lexorez 1180-120 form Inolex Chemical Company

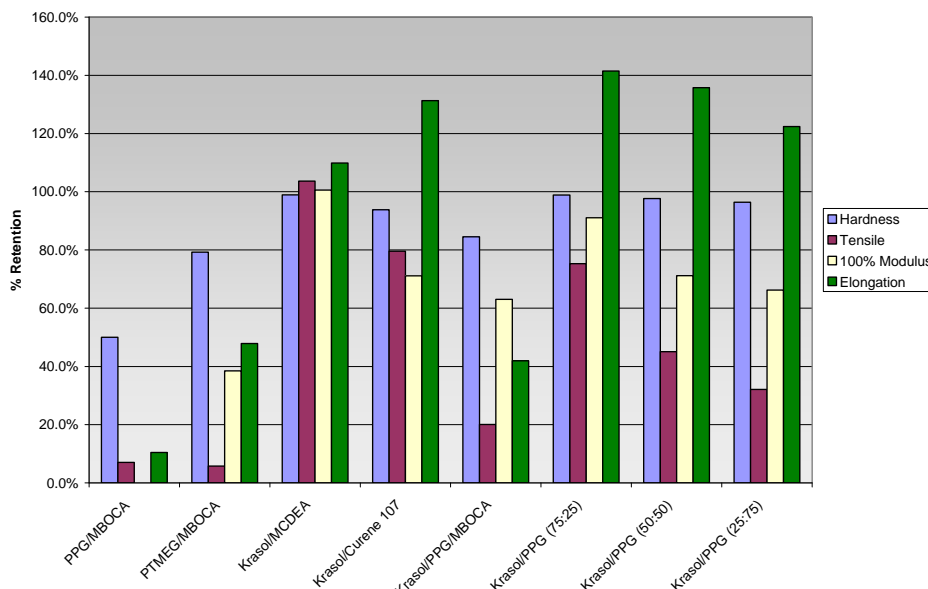


Figure 1. Water, 3 weeks @ 90°C

strength. The three MCDEA-cured hybrids dropped in property retention at a fairly linear rate with increasing PPG. As expected, the MCDEA-cured Krasol® (50:50) elastomer fared better than the MBOCA-cured version. The hardness of all the samples containing some Krasol® stayed close to the original, even with the MBOCA-cured sample.

In Study 2 (Figure 2), the material cured with Krasol® in the curative was the most resistant as expected. The materials cured with PPG and polyester diols performed poorly, although hydrolysis of the polyester was expected and it didn't deteriorate too badly when compared to the PPG polyether sample.

#### ACID STABILITY

The acid stability results for Study 1 (Figures 3 & 4) were a little different than the water stability testing. In both acids, the standards were both literally degraded beyond testing. The MCDEA and Curene 107-cured Krasol® elastomers again had the highest retention of properties. The interesting result is that the 25% PPG blend cured with MCDEA had nearly the same results as the pure Krasol® samples. However, when more PPG was added, property retention dropped off significantly. The MBOCA-cured sample behaved like the other 50% PPG sample cured with MCDEA.

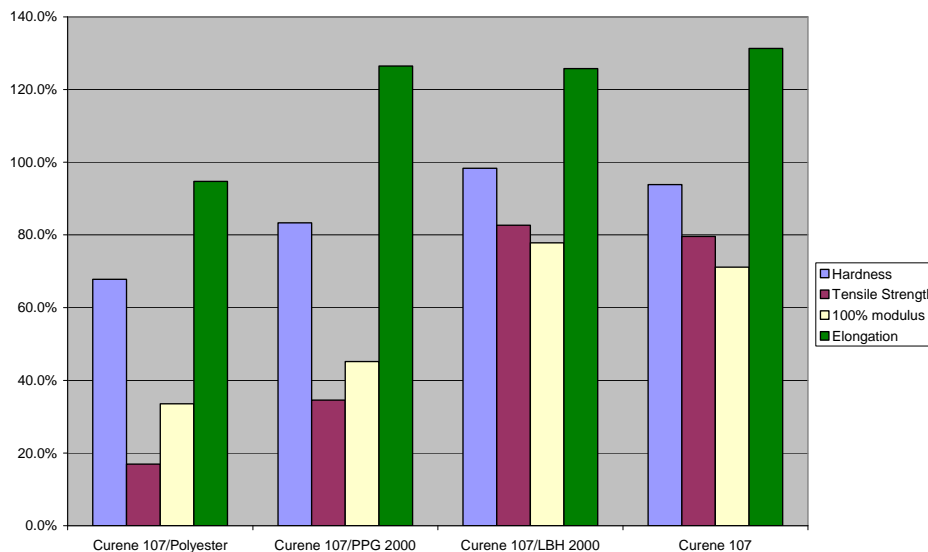


Figure 2. Water, 3 weeks @ 90°C

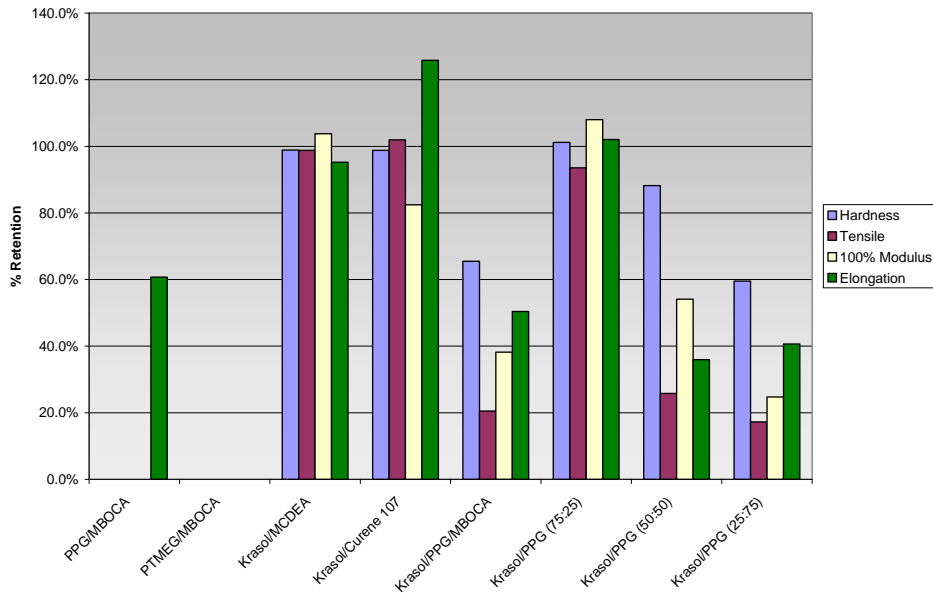


Figure 3. 60% Sulfuric Acid Immersion, 3 weeks @ R.T.

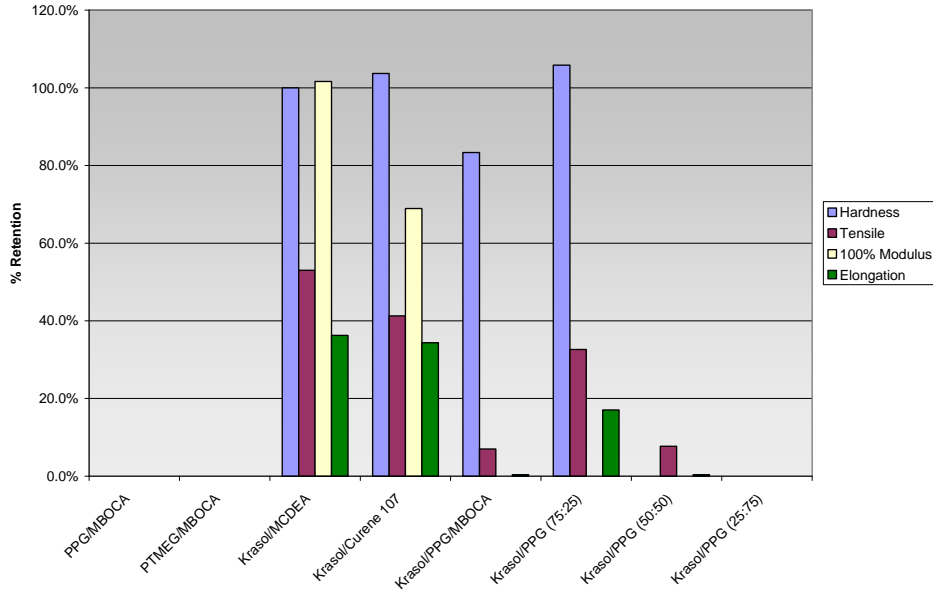


Figure 4. 40% Nitric Acid Immersion, 3 weeks @ R.T.

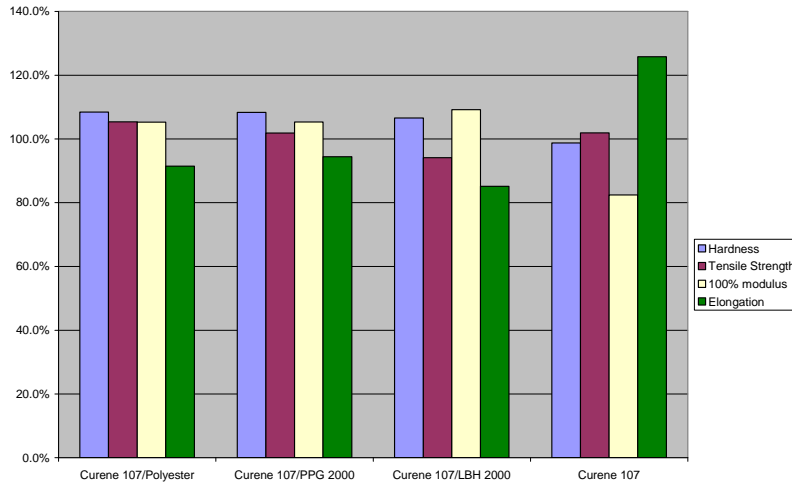


Figure 5. 60% Sulfuric Acid Immersion, 3 weeks @ R.T.

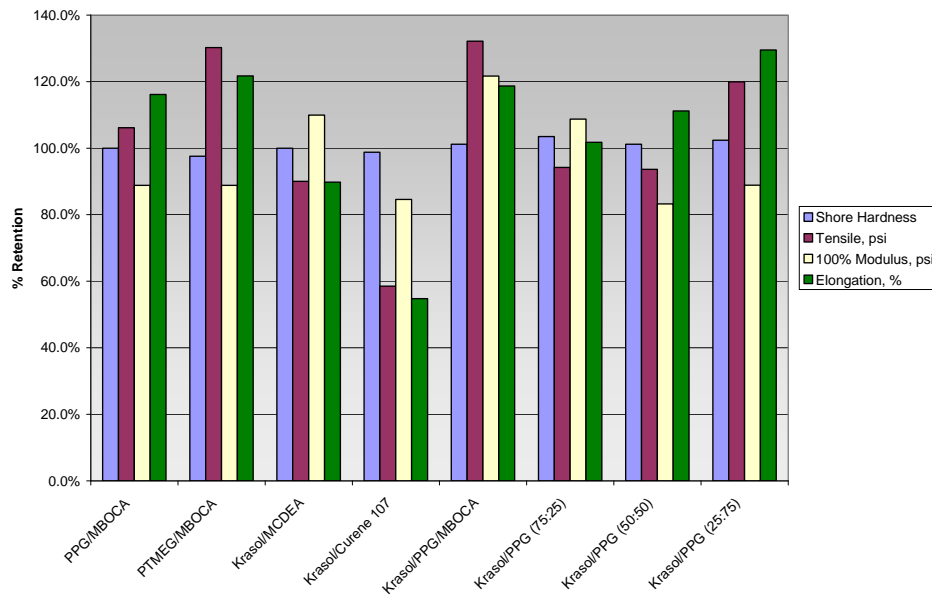


Figure 6. 50% Sodium Hydroxide Immersion, 3 weeks @ R.T.

The samples from Study 2 in acid (Figure 5) had identical results in that the addition of the non-Krasol<sup>®</sup> constituents didn't decrease the resistance to the sulfuric acid. It makes sense, though, as the diols in the curative are only ~9% by weight of the system. Another key point is that when comparing like compositions, typically harder elastomers give better resistance to different media than softer elastomers. In the acid (as well as the H<sub>2</sub>O immersion), the 60A material retained its properties as well as the 81A material showing that the Krasol materials have the same resistance at a wide hardness range.

#### BASE STABILITY

The immersion in sodium hydroxide (Figure 6) did not show any significant results as all samples were basically unaffected in properties. The only exception would be the Curene 107 sample which lost some tensile strength. Based on previous internal studies, more meaningful results could have been achieved if the test temperature had been elevated to 60°C, where the degradation would have been accelerated. Future studies may look at higher temperatures to confirm whether the Krasol<sup>®</sup> would perform better than the controls.

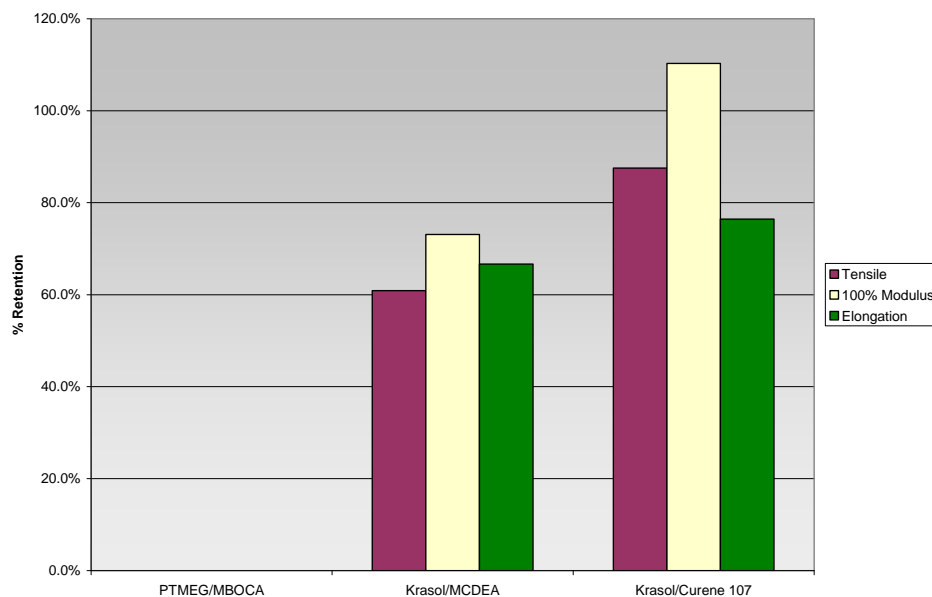


Figure 7. Sodium Hypochlorite (4% Cl) Immersion, 5 weeks @ R.T.



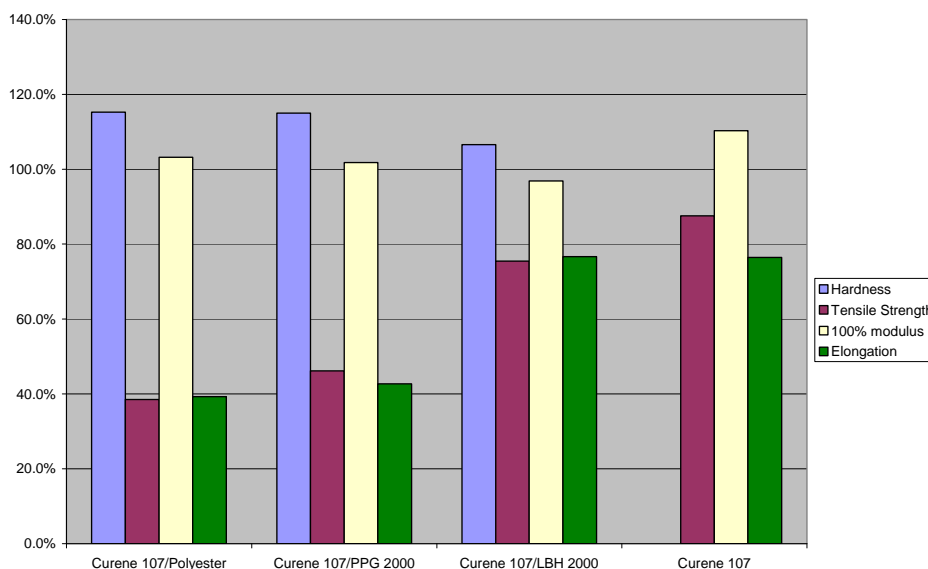


Figure 8. Sodium Hypochlorite (4% Cl) Immersion, 5 weeks @ R.T.

## CHLORINE STABILITY

Only the PTMEG standard and the two straight Krasol® systems cured with MCDEA and Curen 107 were immersed in the sodium hypochlorite solution (Figure 7). The Curen 107 performed the best retaining about 80% or more of its tensile properties. The MCDEA sample was at 60-70% retention of its properties. As expected, the PTMEG completely dissolved. Typically, polyesters perform the best in chlorinated environments, but have poor performance in aqueous solutions. The Krasol®-based elastomers perform well in both aqueous acids and bases and sodium hypochlorite solution.

In Study 2, again the system with Krasol® in the curative retained identical strength as did the Curen 107 sample from Study 1 (Figure 8). The samples cured with PPG and polyester performed okay with about a 40% retention of strength. One thing the graph doesn't show, though, is the change in flexibility. The all Krasol® sample was close to its original hardness and still quite flexible whereas the other samples became harder and a little more brittle. When they were elongated, many cracks appeared; the Krasol® sample had none.

### Abrasion Resistance of Krasol®-based Elastomers

Another property of importance in many applications besides tensile or tear strength and resistance to environment is abrasion resistance. Polyurethane elastomers typically have superior abrasion resistance when compared with other plastics or elastomers. Table 9 shows some standard urethane systems cured with MBOCA compared to the Krasol materials. The relative outcome is that the Krasol materials are somewhere in between the best (polyesters and PTMEGs) and the worst (PPGs).

Hardness	Backbone/Curative	Abrasion (mg loss/1000 cycles)
86A	PTMEG/MBOCA	40
85A	Polyester/MBOCA	43
85A	Krasol/Curen 107	77
85A	Krasol/MCDEA	99
87A	PPG/MBOCA	126

## CONCLUSIONS

TDI prepolymers based on Krasol® polyols are only compatible with a small number of standard diamine curatives. MCDEA and Curen 107 (Ethacure 300) are among these, but MBOCA is incompatible. However, Krasol® polyols can be blended with PPG polyols to give prepolymers which are compatible with MBOCA. Elastomers with 40 to 90 Shore A hardness can be cast using Krasol®-based prepolymers cured with MCDEA, Curen 107, and blends of these two with various polyols. The physical properties vary for these systems, but as a whole the properties are similar to what might be typical for a PPG system.

Krasol®-based elastomers show excellent resistance to any hardness to aqueous environments, whether they be acidic or basic. When Krasol® is blended with a PPG, these elastomers are not as resistant to those acidic and basic solutions. For highly acidic solutions, it has been shown that up to 25% PPG can be added to the prepolymer and have very little effect on the resistance properties. Along with the great performance in aqueous environments, excellent chlorine resistance gives a unique characteristic that polyethers and polyesters do not possess. This will enable Krasol®-based elastomers to be put in applications where other traditional polyurethane elastomers have very short service life or cannot be used at all.

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## BIOGRAPHIES

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