The Effect of PBS on Dynamic Mechanical Behavior of Copolymer Networks

Undergraduate Researcher: Robert Spencer Garland

Advisor: Dr. Carl Frick

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Mechanical Engineering

College of Engineering and Applied Sciences

University of Wyoming

Background

What is are SMPs?

Shape-memory polymers (smart materials) are classified as having the capability "to recover to a predetermined and programmed shape after significant mechanical deformation in response" to surrounding environmental forces (Yakacki).

History of SMPs:

- Discovered in 1937
- SMP effect first used in 1960's
- Commercially available in 1984
- FDA approved in 2009

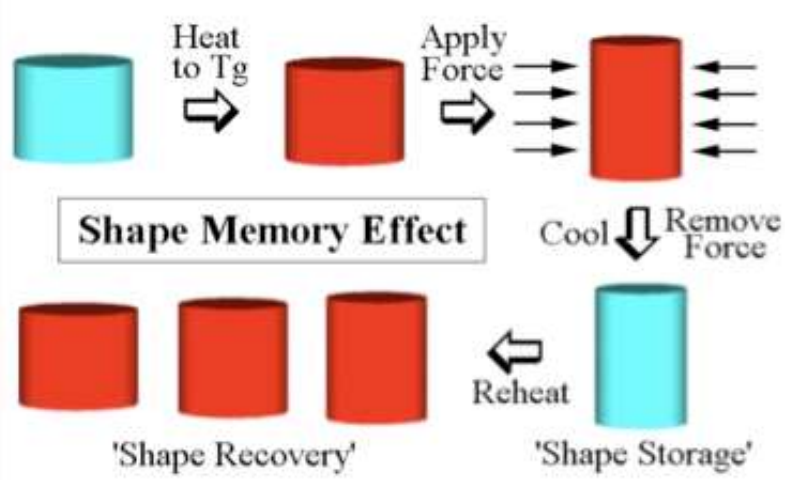


Figure 1: Recovery process of a shape memory polymer reactive to heated stimuli.

Background

Purpose: To understand the effect of Phosphate Buffered Saline (PBS) on the Mechanical Behavior of Copolymer Networks

Achieved through the fabrication, preparation, and analysis of photopolymerizable shape-memory polymers (SMPs)

Background

Biomedical Applications:

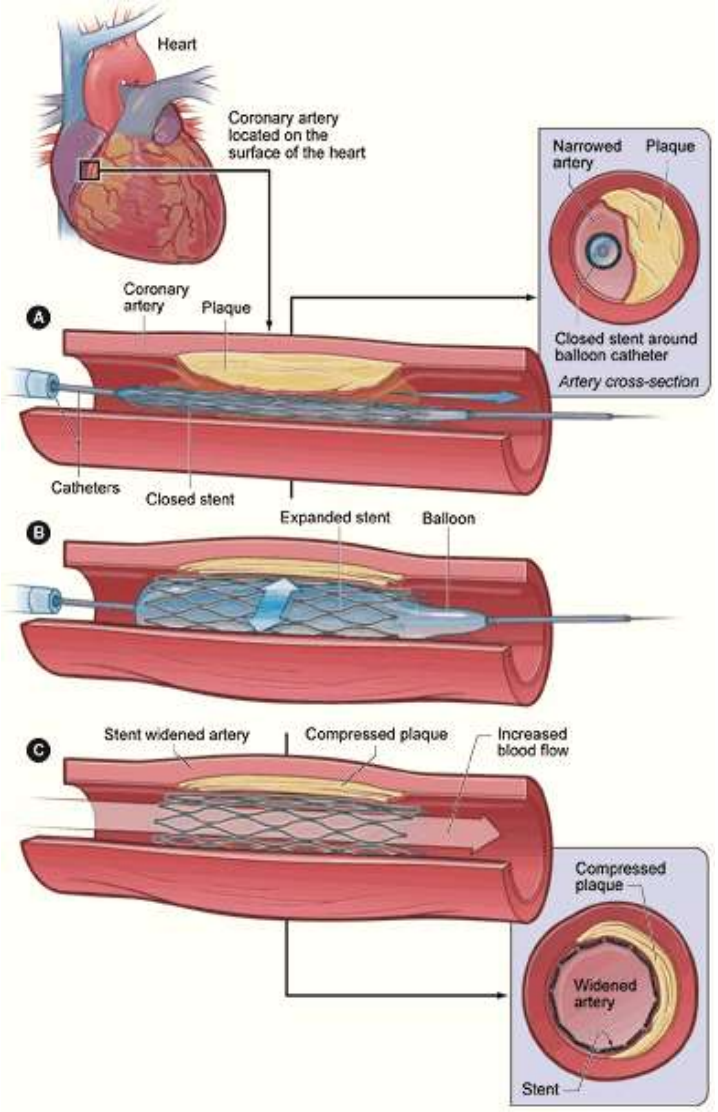
- Cardiovascular Stents
- Wound healing
- Stroke Treatment

Research Strategy:

-Step 1) Effect of PBS on mechanical properties (current research)

-Many additional steps

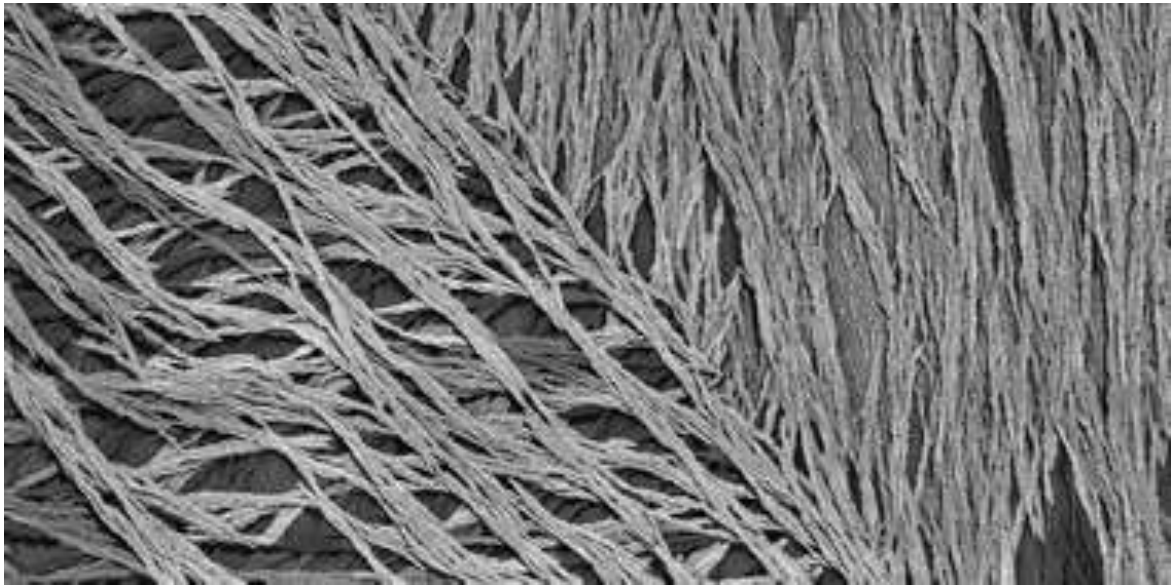
  -how they will affect body, react in blood, deteriorate, etc.



Background

Effect of H_20 on Polymer Mechanics

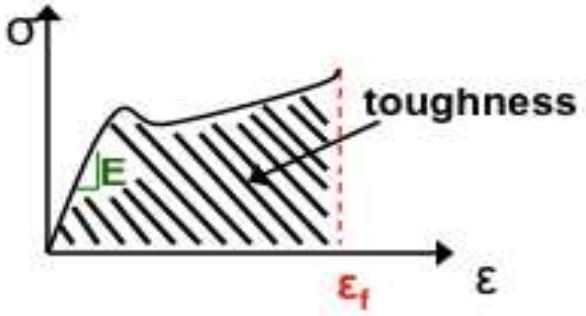
- Use PBS to mimic water
- Usually weakens polymer
  - Lower stiffness
  - Lower strength

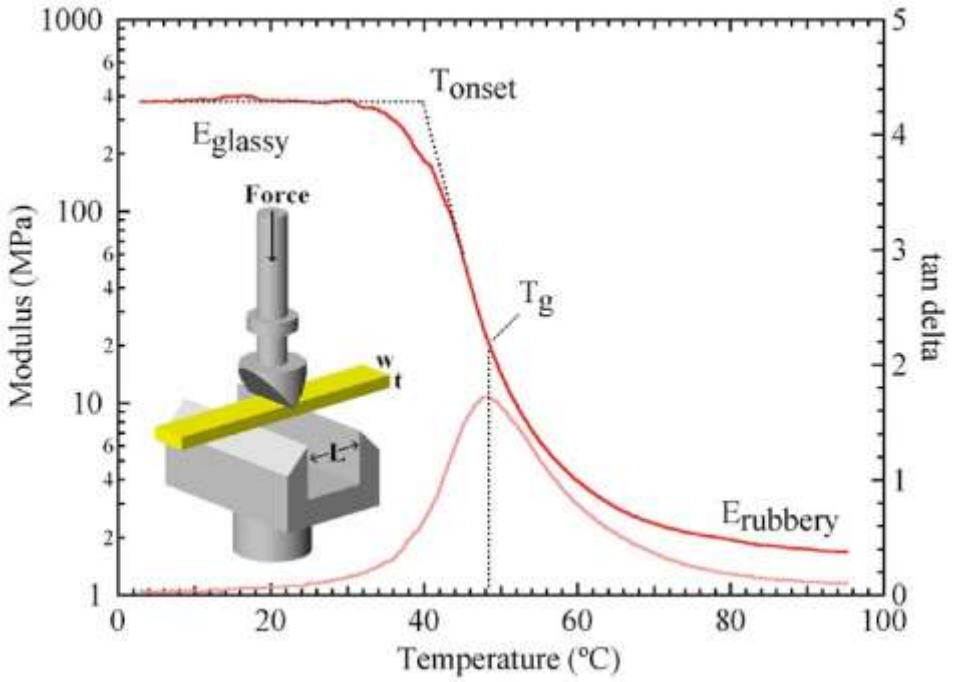


Background

Mechanical Properties:

- Glass Transition Temperature (Tg)-a function of chemistry
  - a function of chemistry
  - generally decreases with water absorption
- Storage Modulus (Modulus of Elasticity)
  - -Glassy Modulus
  - -Rubbery Modulus
- Toughness





Methods

Fabrication Tools:

- Fume hood
- Scale
- Glass cutter
- Mechanical mixer
- Ultraviolet lamp
- Light shield
- Oven
- Glass Slides
- Pipette
- Beaker
- Razor Blade
- Scotch Tape
- Polymer components

Methods

Compositions Tested:

Most samples included 10% PEGDMA with a systematic variation of:

-MA and MMA

-MA and 2HEMA

-BZA and 2HEMA

Polymer Components:

-**PEGDMA**: Cross-linker (increases stiffness and hydrophobic)

-**Photoinitator**: Acts to solidify polymer solution through exposure to ultra violet light (only 0.5% of the mixture)

-**2HEMA**: Extremely hydrophilic

-**MMA**: Increases Tg

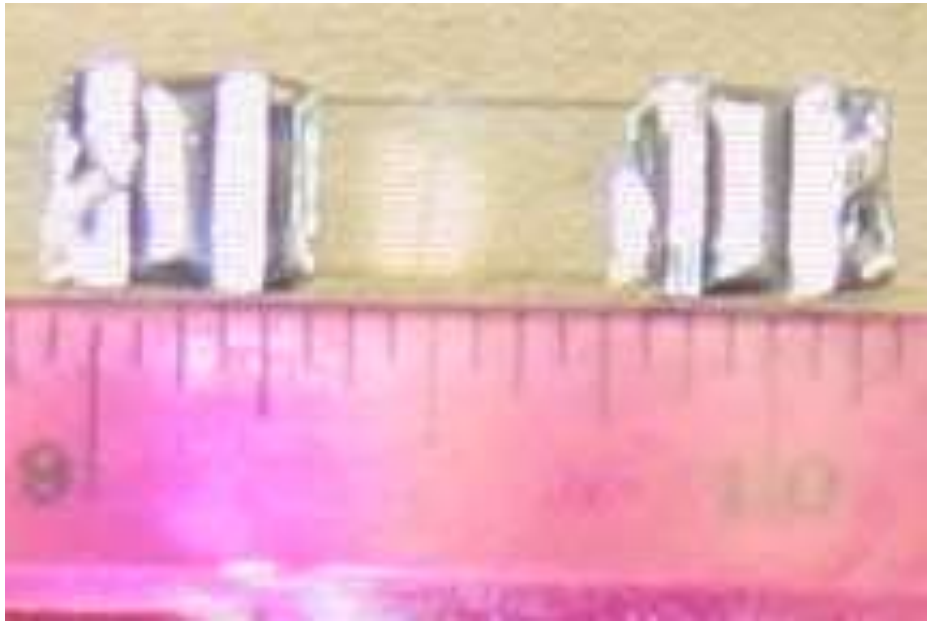
-**MA**: Decreases Tg

-**BZA**: Relatively hydrophobic

Methods

Sample Preparation:

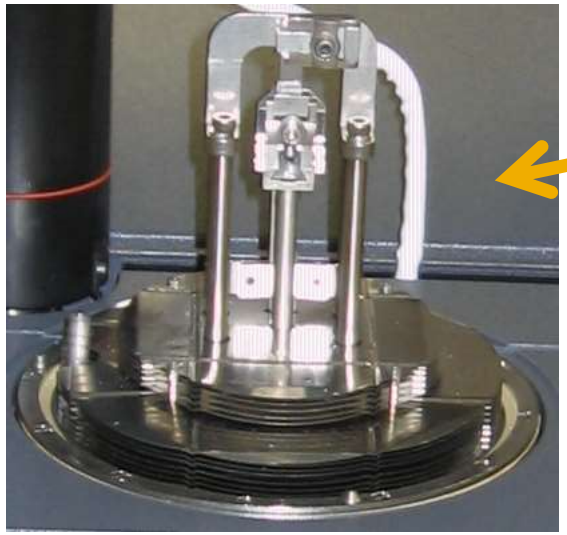
- Sanding
- Soaking in PBS for 24 hrs. (for wet samples only)
- After soaking wet samples were dried
- Sample weighed
- Foil Wrapping

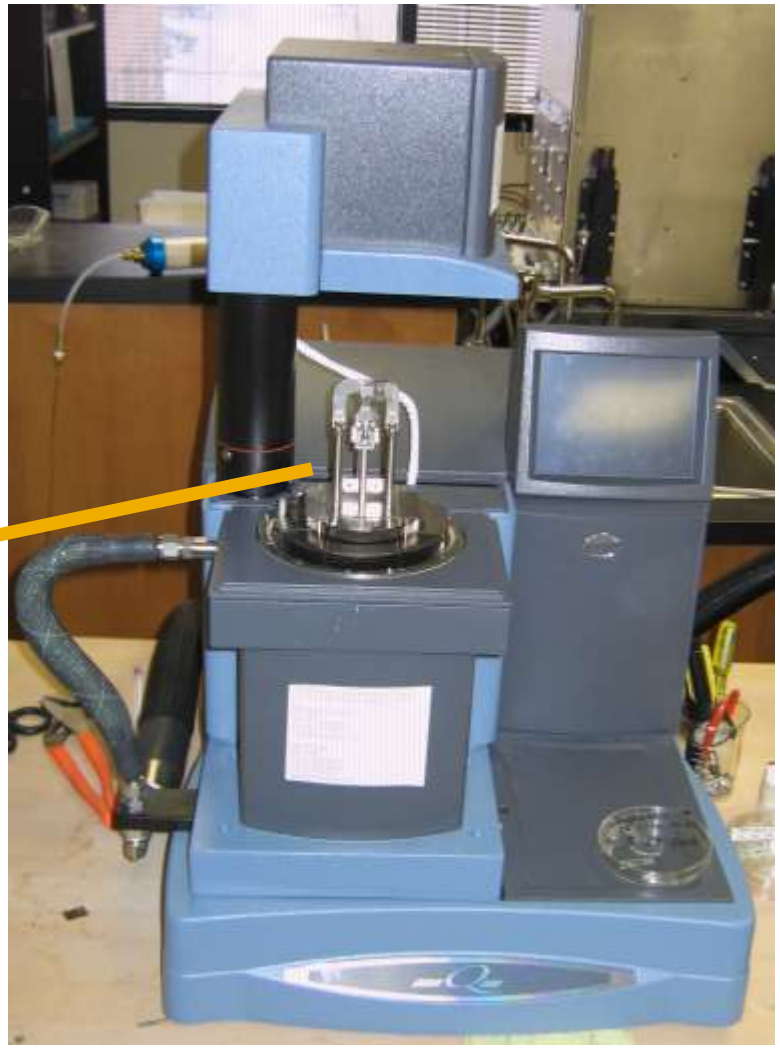


Methods

Dynamic Mechanical Analyzer (DMA) Protocol (Testing Procedures):

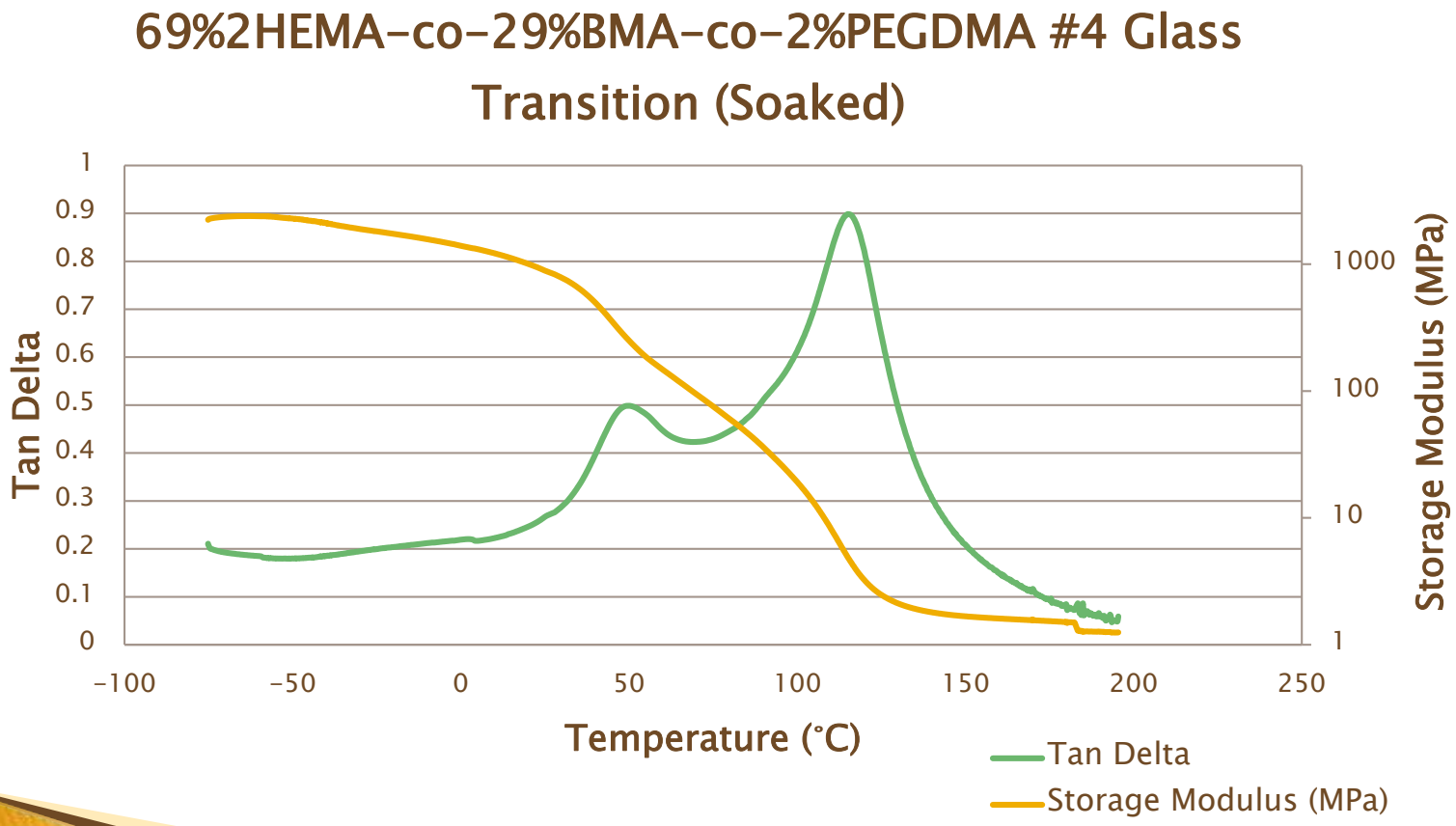
- Tension Tests
- 2 wet and 2 dry samples of each composition tested





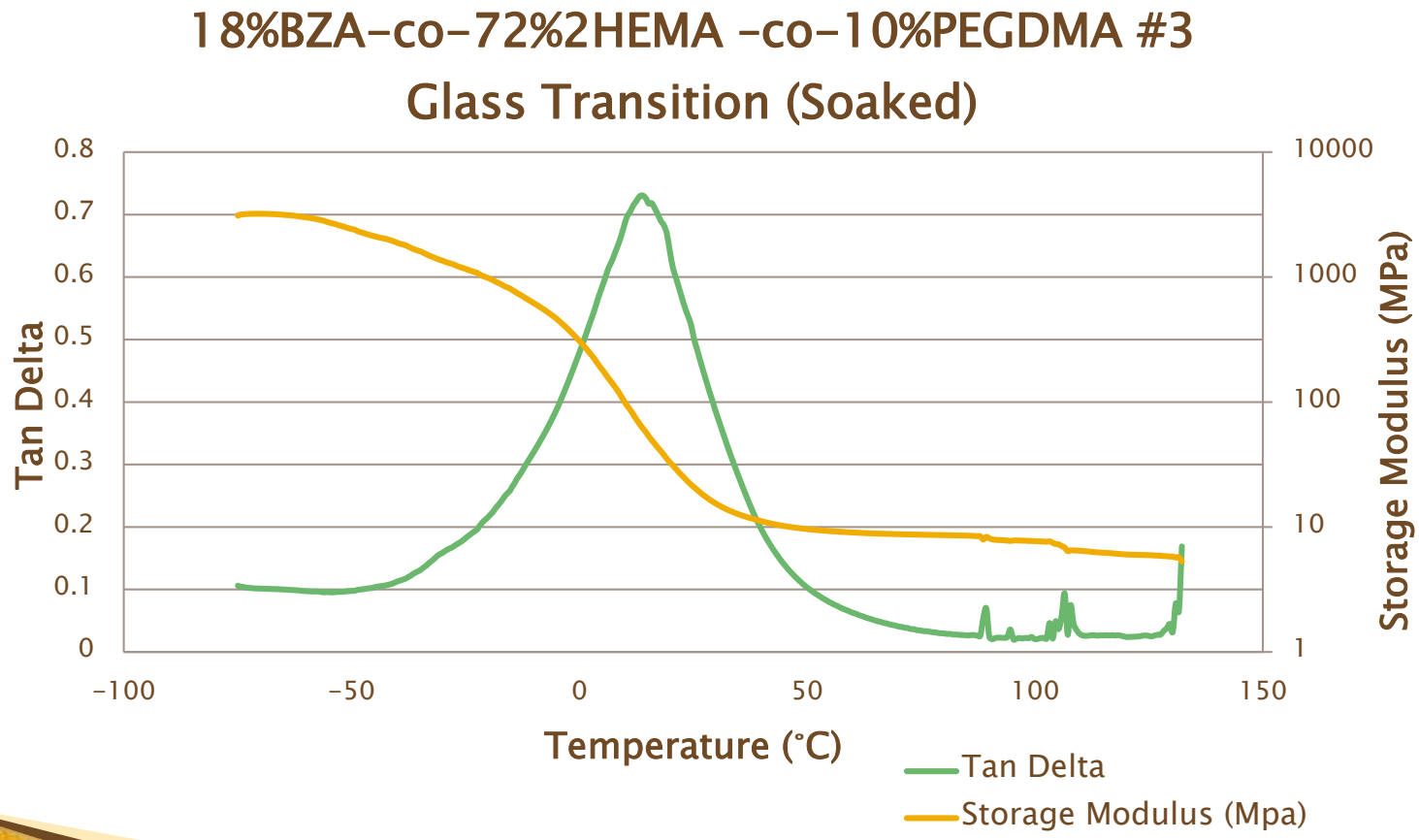
Results

Double Peak Phenomenon:



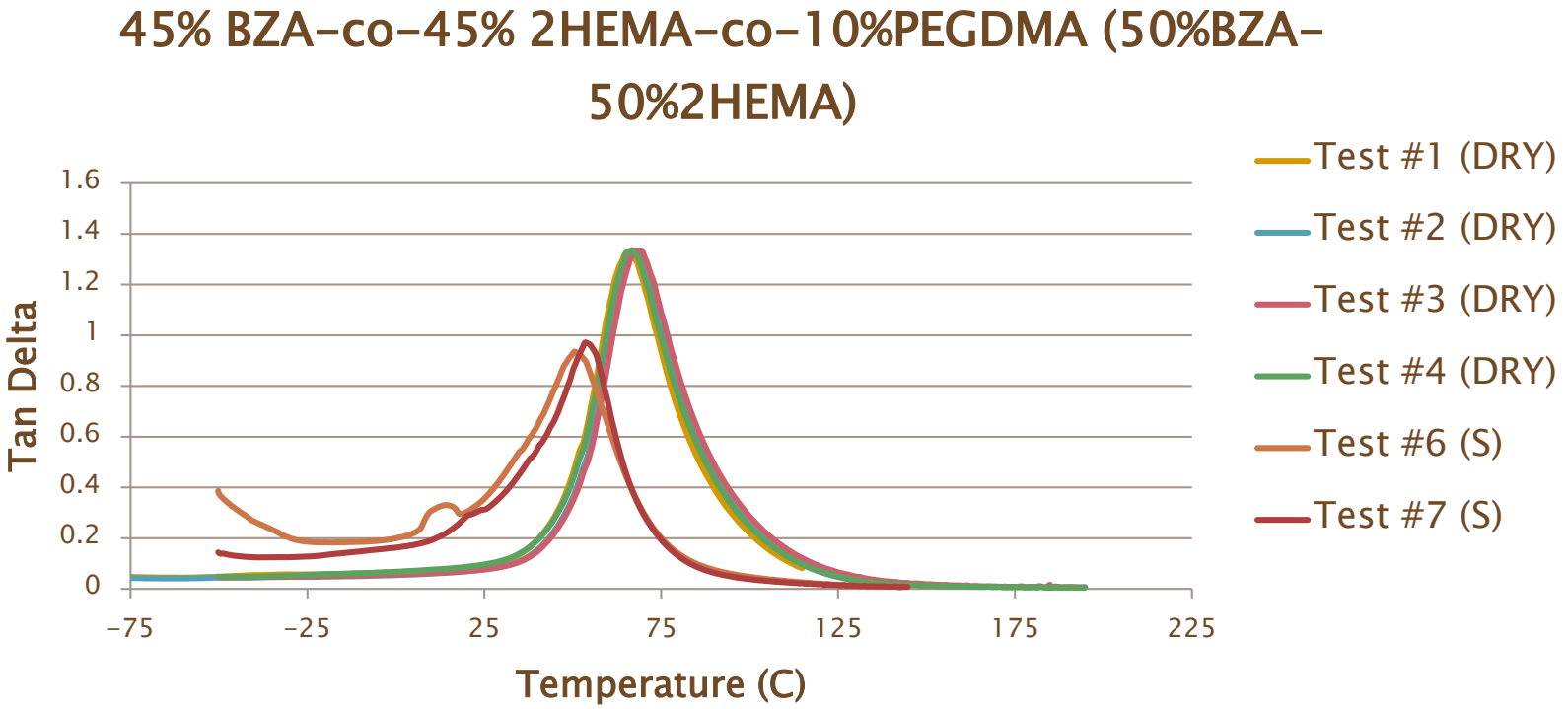
Results

Double Peak Phenomenon Solution:



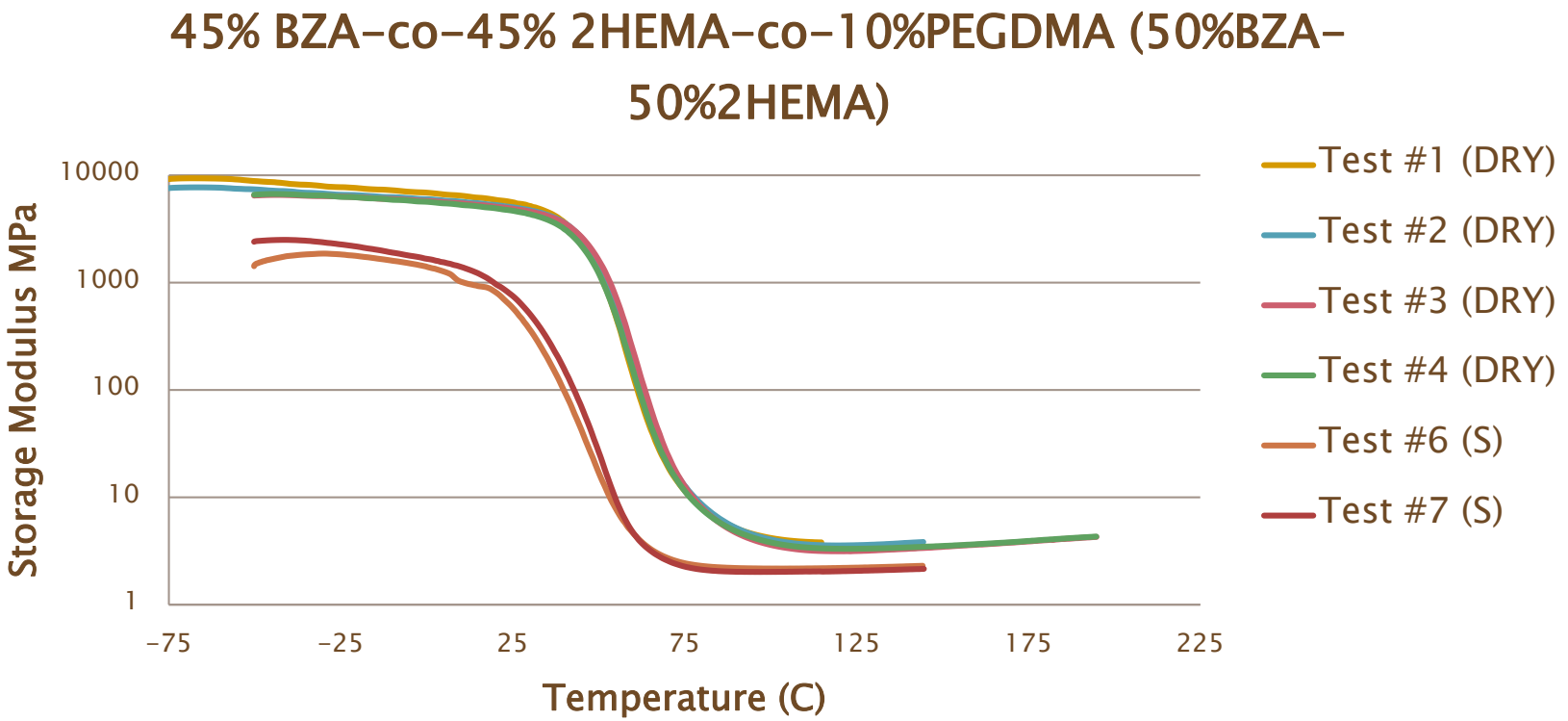
Results

Shift in Glass Transition:



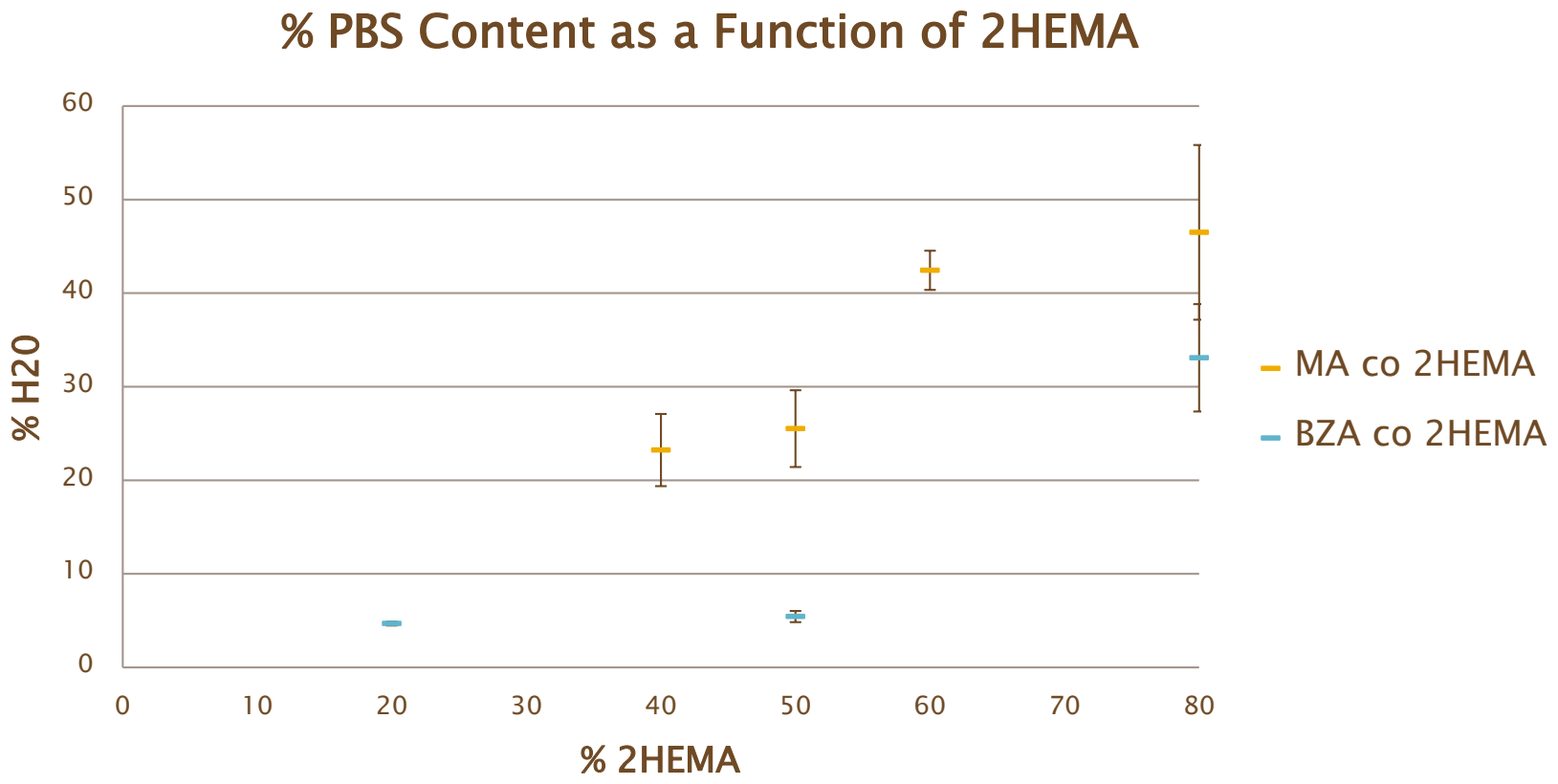
Results

Shift in Storage Modulus:



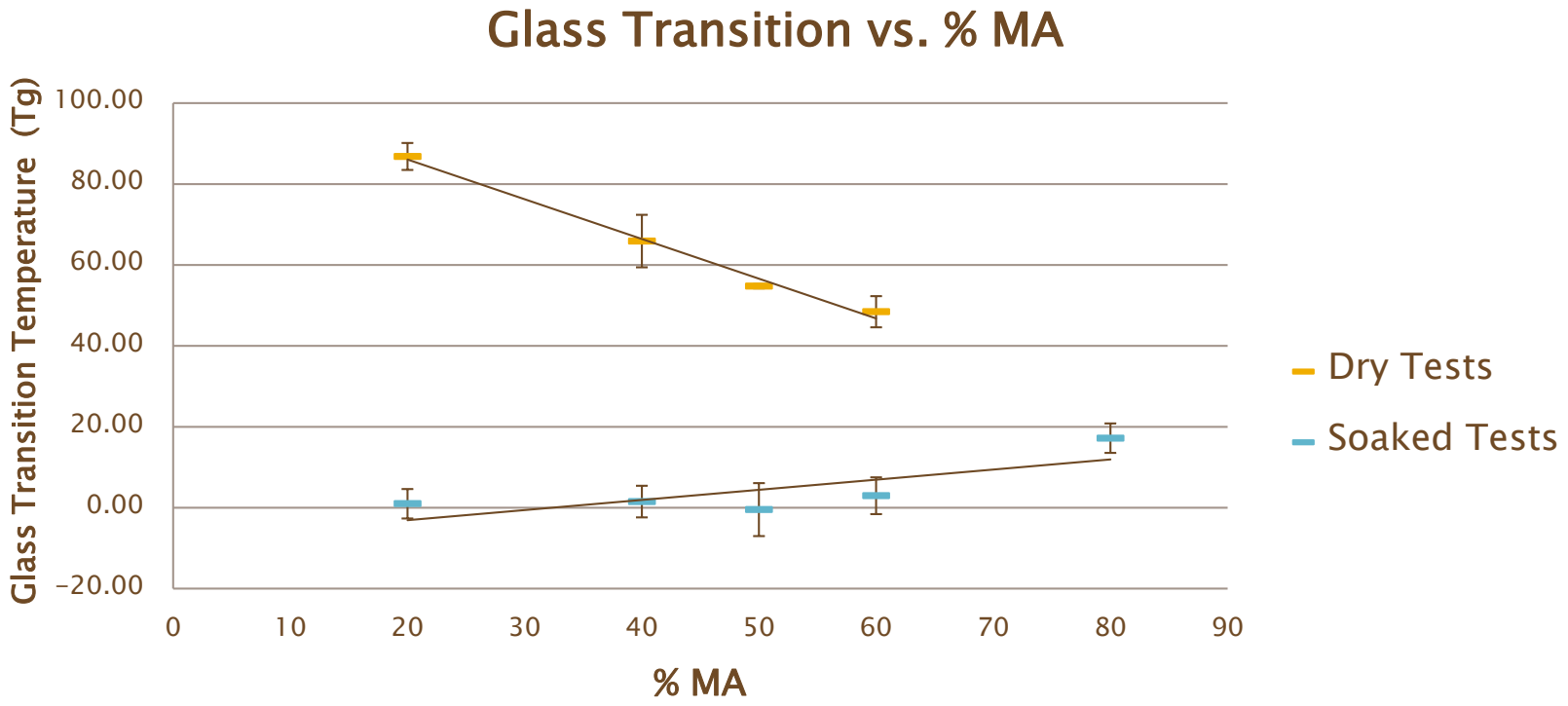
Results

PBS Absorption:



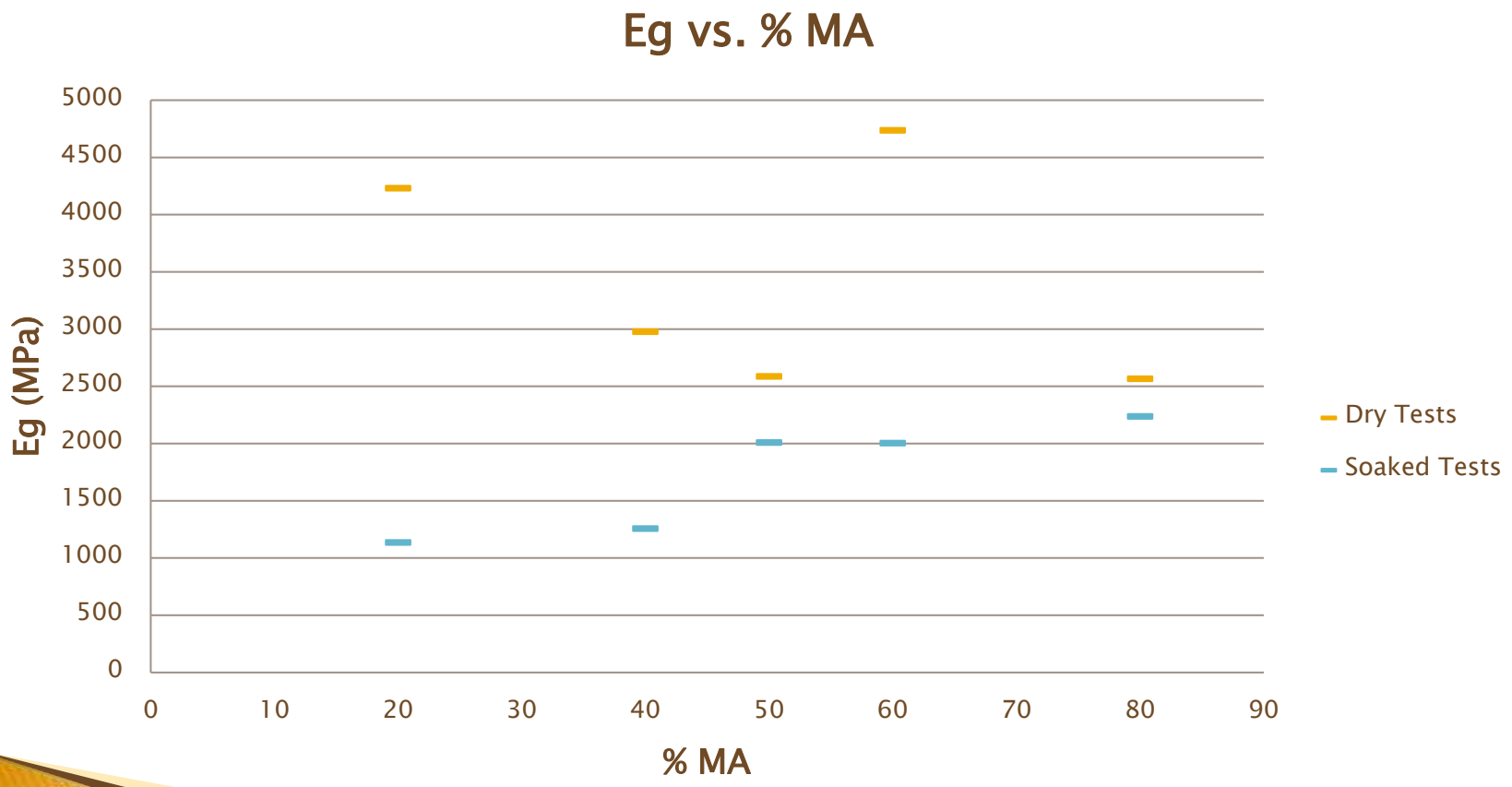
Results

Glass Transition for MA-co-2HEMA networks



Results

PBS Effect on Glass Modulus for MA:



Results

Maximum Toughness:

- Max. toughness occurs at lower temperatures for MA than BZA compositions
- Max. toughness for MA is less composition dependant than for BZA

% BZA	Avg. Tg (D)	St. Dev. (D)	Avg. Tg (S)	St. Dev. (S)
20	101.25	6.77	18.83	7.01
50	67.01	1.36	51.90	2.17
80	37.52	3.34	33.62	1.05

% MA	Avg. Tg (D)	St. Dev. (D)	Avg. Tg (S)	St. Dev. (S)
20	86.82	3.35	0.98	3.65
40	65.90	6.49	1.52	3.92
50	54.75	0.52	-0.46	6.53
60	48.44	3.86	2.95	4.55
80	N/A	N/A	17.19	3.65

Conclusions

-Vacuum grease allows for more accurate testing of soaked samples

- More % 2HEMA means more PBS absorption and less stiffness

-PBS absorption shifts the glass transition to lower temperatures resulting in maximum toughness at lower temperatures

-Different MA compositions are less variable in the location of the glass transition temperature than BZA compositions

-BZA compositions absorb less PBS than MA compositions

Conclusions

Future Research

-Measure changes in thermomechanical behavior with varying cross-linking density (amount of PEGDMA)

-Measure toughness directly using a MTS load frame, an environmental chamber, and a submersion tank

- Fourier Transform Infrared Spectroscopy (FTIR) to obtain a qualitative assessment of the secondary bonding of the water molecules with the internal structure

Questions?