# Thermomechanical Characterization of PBAE-MMA-MA Copolymers

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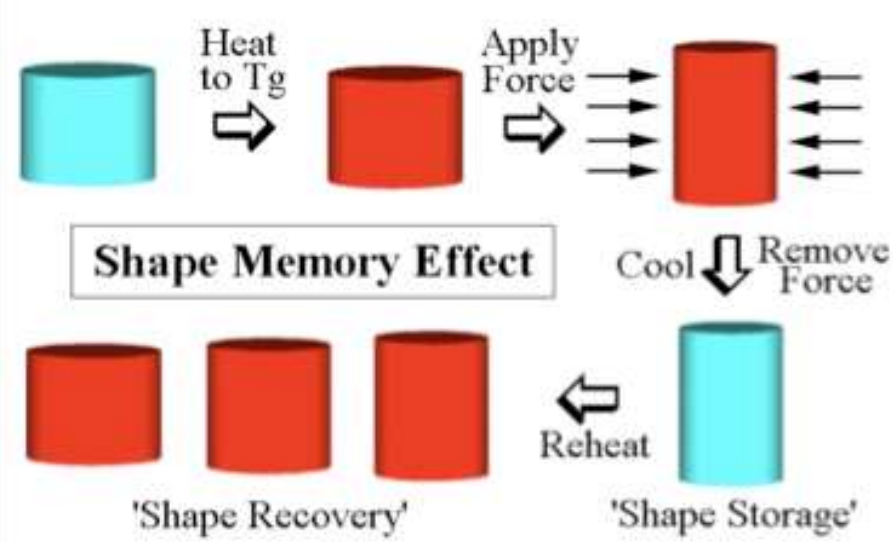
April 30, 2011

# Overview

- Background of Shape Memory Polymers
- Intent
- Constituents
- Copolymer mixtures
- Shape recovery rate
- Mechanical behavior
- Degradation characteristics

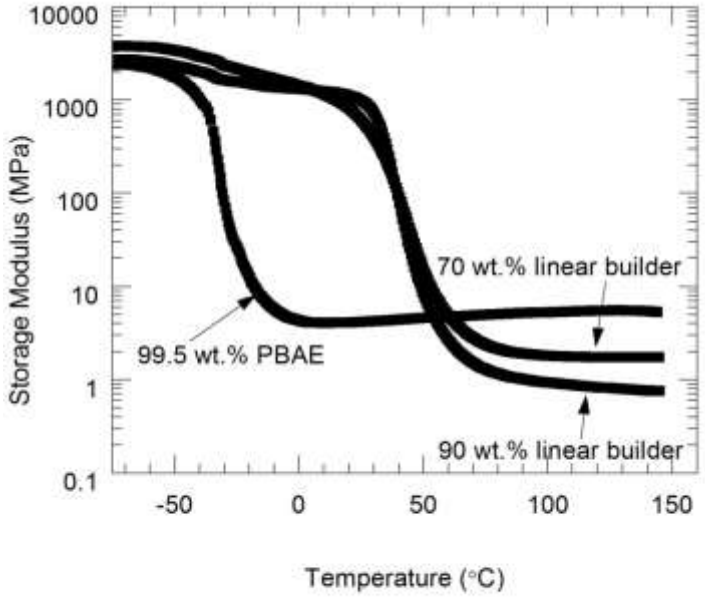
# Background - SMP

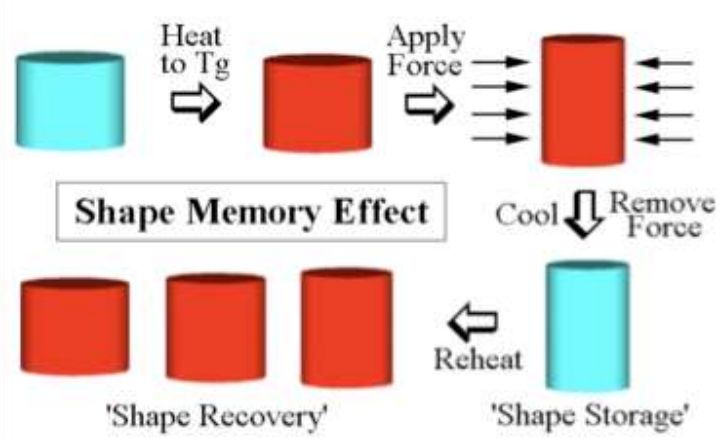
- Shape Memory Polymers (SMP)
  - Undergo and hold deformations
  - Return to original shape under specific stimuli
  - Advantageous for biomedical procedures



# Glass Transition

- Polymers often display two solid regions
  - Glassy region
  - Rubbery region
- Glass Transition Temperature
- Exploited for SMP stimulus



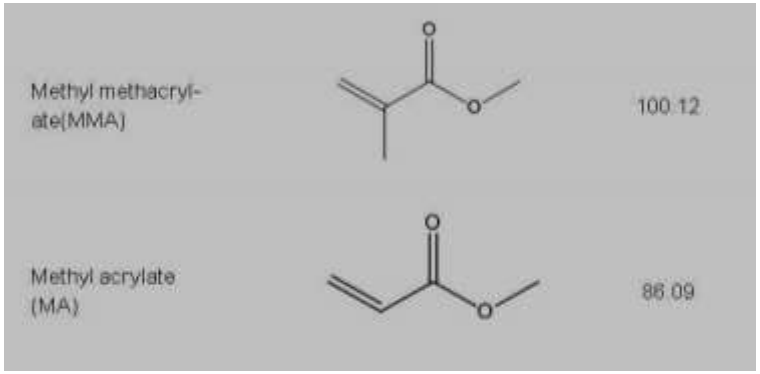



# Intent

- Custom tailor thermomechanical properties of a biocompatible copolymer
- Tailor glass transition
  - Stable at room temperature (25°C)
  - Recovers at body temperature (37 °C)
- Tailor material strength in the rubbery regime
- Vary three different constituents
  - Two linear builders
  - One crosslinking unit
  - Create thermoset polymer

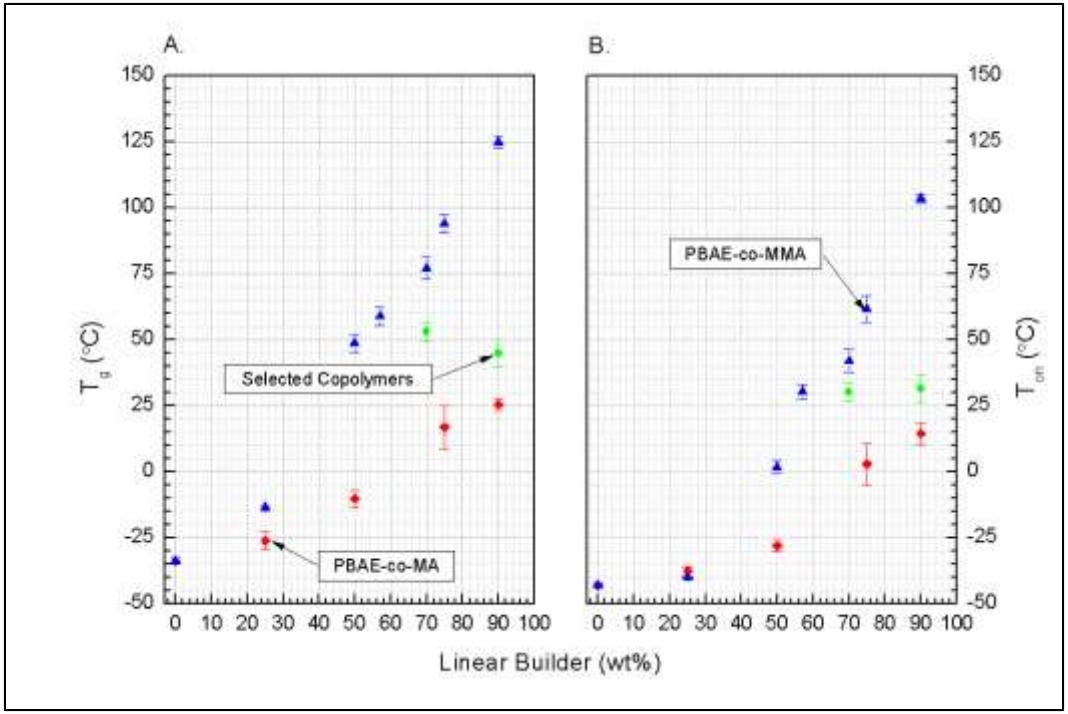
# Constituents

- Constituents chosen for three reasons
  - Photopolymerizable
  - Shape memory properties
  - Biodegradable
- Linear Building Macromer
  - Methyl methacrylate - MMA
  - Methyl acrylate – MA
- Crosslinking Macromer
  - Poly(ß-amino ester) – PBAE
    - Broad family comprise of an acrylate and amine substructure
    - Dr. David Safranski has characterized structure-property behavior of the broad class
  - Acrylate - poly(ethylene glycol) diacrylate  258
  - Amine - 3-Methoxypropylamine
  - Ratio 1.15:1



# Copolymer Mixtures

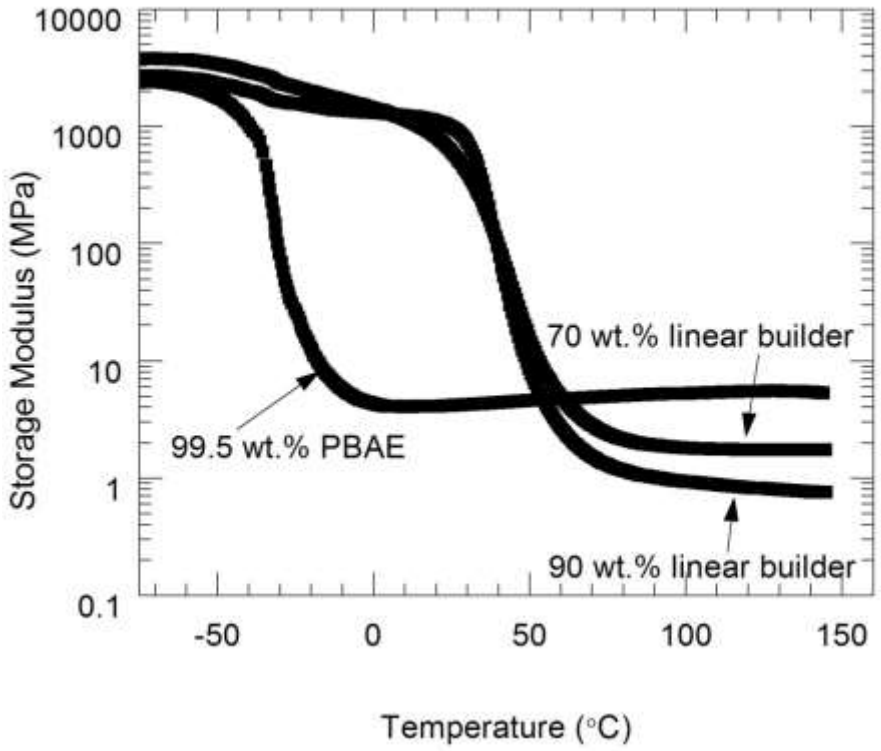
- Materials could increase storage modulus by addition of higher weight percent crosslinking unit
- Co-effect of lowering transition Temperature
- Counteract by varying linear builder




| PBAE | MMA | MA | $T_{on}$ (°C) | $T_g$ (°C) | $E_r$ (MPa) |
|---|---|---|---|---|---|
| **10** | **35** | **55** | 31.50±5.30 | 44.80±5.08 | 0.71±0.05 |
| **30** | **55** | **15** | 30.18±3.60 | 53.05±3.72 | 1.72±0.11 |

# Copolymer Mixtures

- Addition of crosslinker broadens transition region
- Copolymers larger than 30% crosslinking proved ineffective for the shape memory effect



# Shape Recovery Rate

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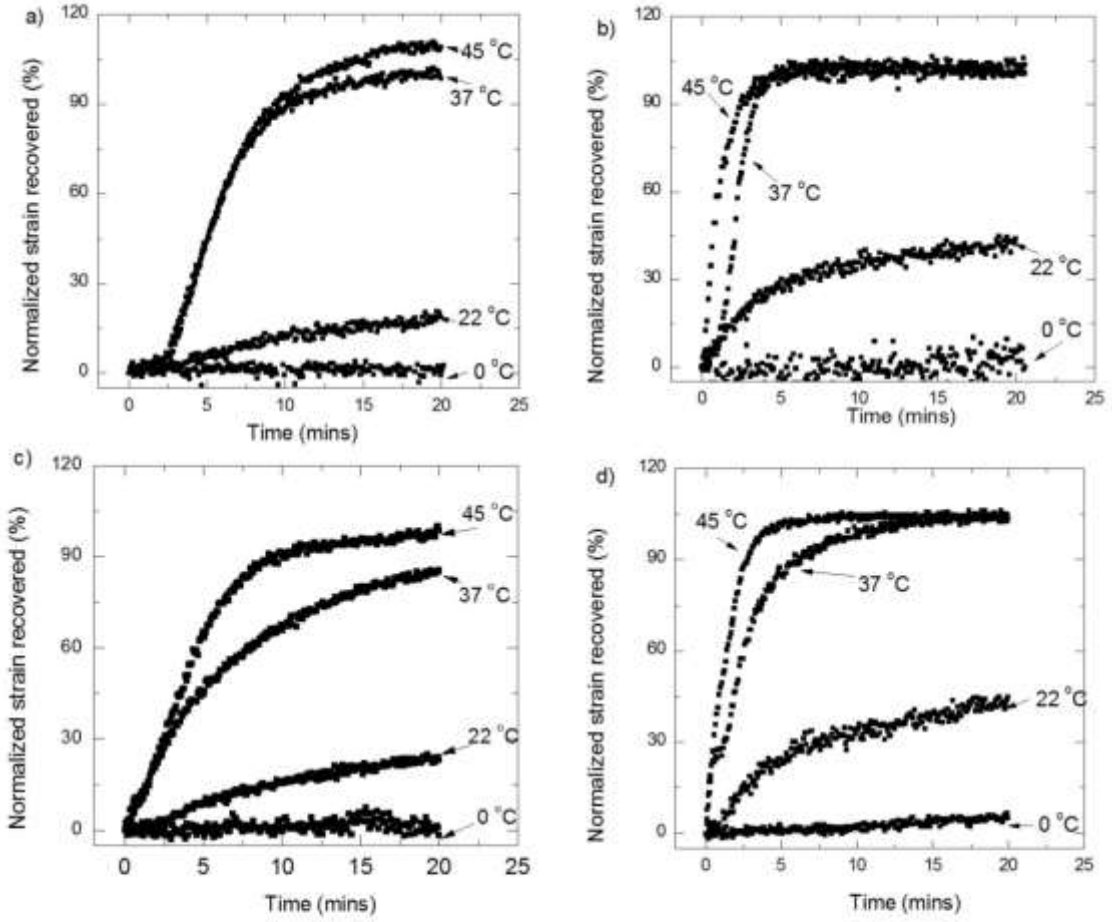
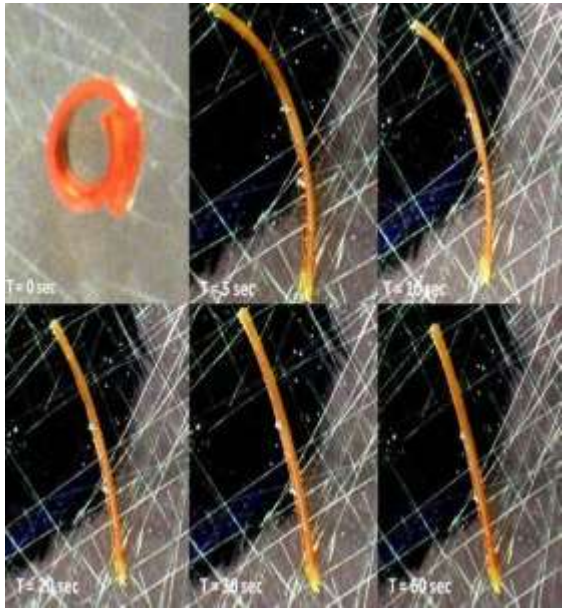
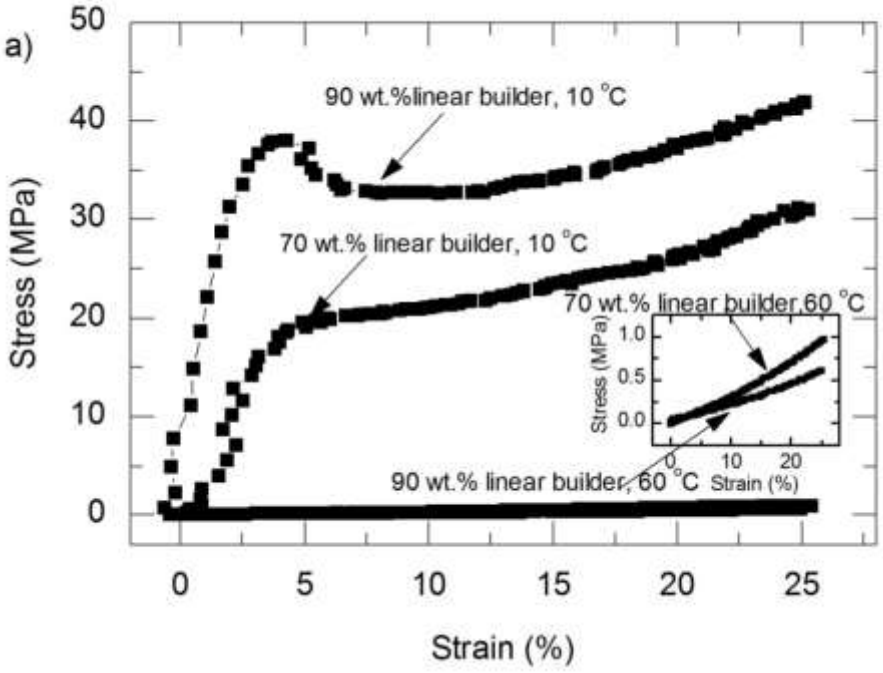


- a) 90% linear builder in air • b) 90% linear builder in water
- c) 70% linear builder in air • d) 70% linear builder in water

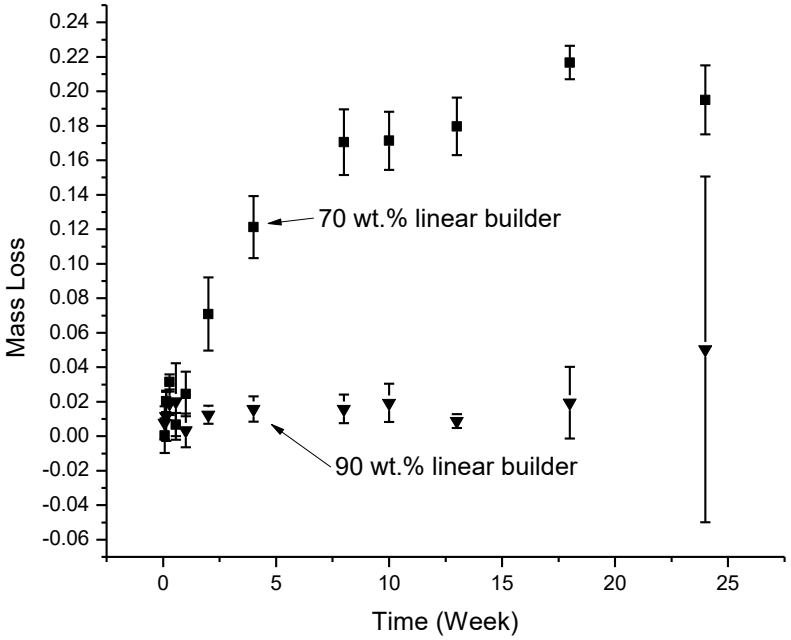
# Mechanical Behavior

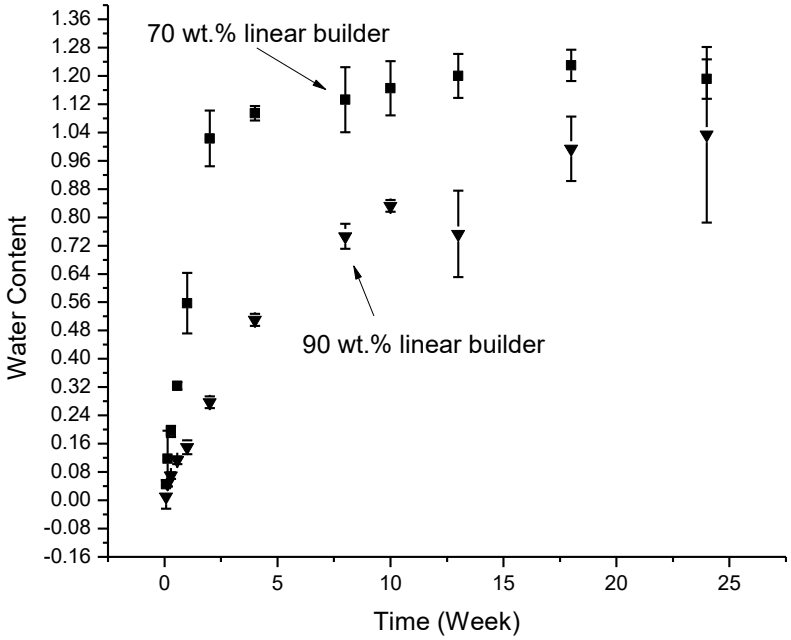
- Glassy region (10°C)
  - Plastic behavior
- Rubbery region (60°C)
  - Elastic behavior



# Degradation Characteristics

- Samples placed in saline solution 37°C



# References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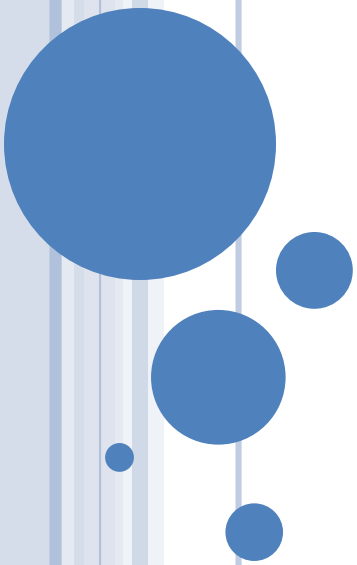

# Questions