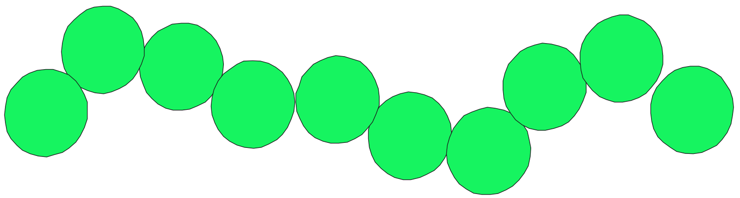
Diblock Copolymer Reinforced Interface



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Mentor: Jaso

Professor: E

Funding Source: Nation

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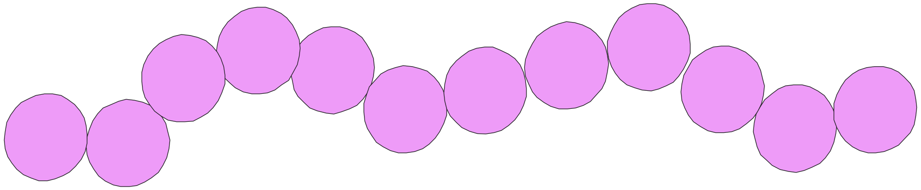

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Diblock Copolymer Reinforced Interfaces between Polystyrene and Polyethylene

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Funding Source: National Science Foundation

Abstract

The interface between Polystyrene (PS) and polyethylene (PE) normally has low fracture energy (G_c) on the order of 1 J/m^2. The strength of the interface can be improved by reinforcing them with PS-PE diblock copolymer. The areal chain density of the diblock copolymer was held constant for all tests. We measured G_c as a function of temperature using the asymmetric double cantilever beam test (ADCB). By observing the dependence of G_c on temperature, we can discuss whether or not the pullout of the PE block from bulk PE is a thermally activated process. Understanding PE fracture properties will help us improve the durability of polymers blends. Combining the two results in the properties shown below.

Polyethylene (PE):

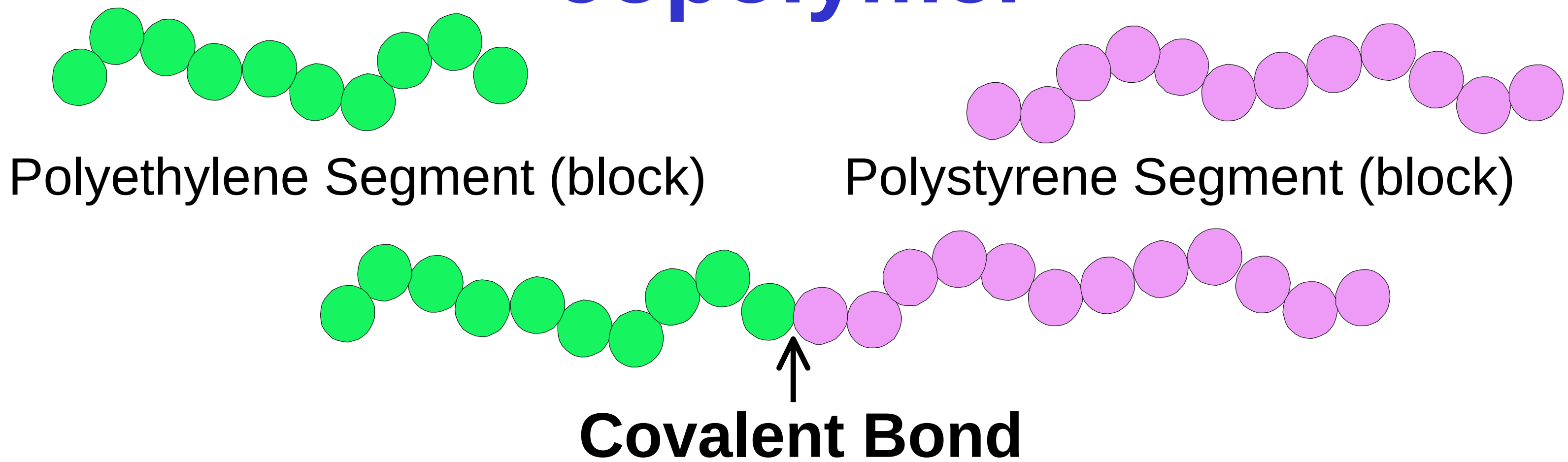
- Flexible, **Tough**
- Used for: Liners, Bullet Proof Vests, Food Packaging

Polystyrene (PS):

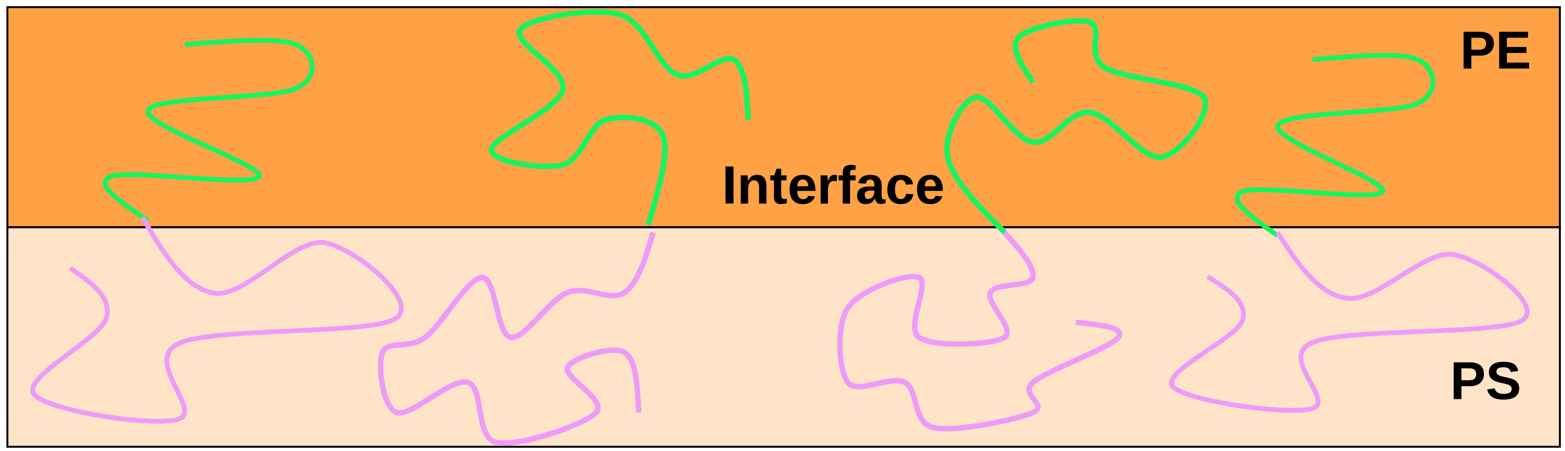
- **Hard**, brittle
- Used for: CD Cases, Disposables

PS + PE = Hard + Tough

The polyethylene and polystyrene diblock copolymer

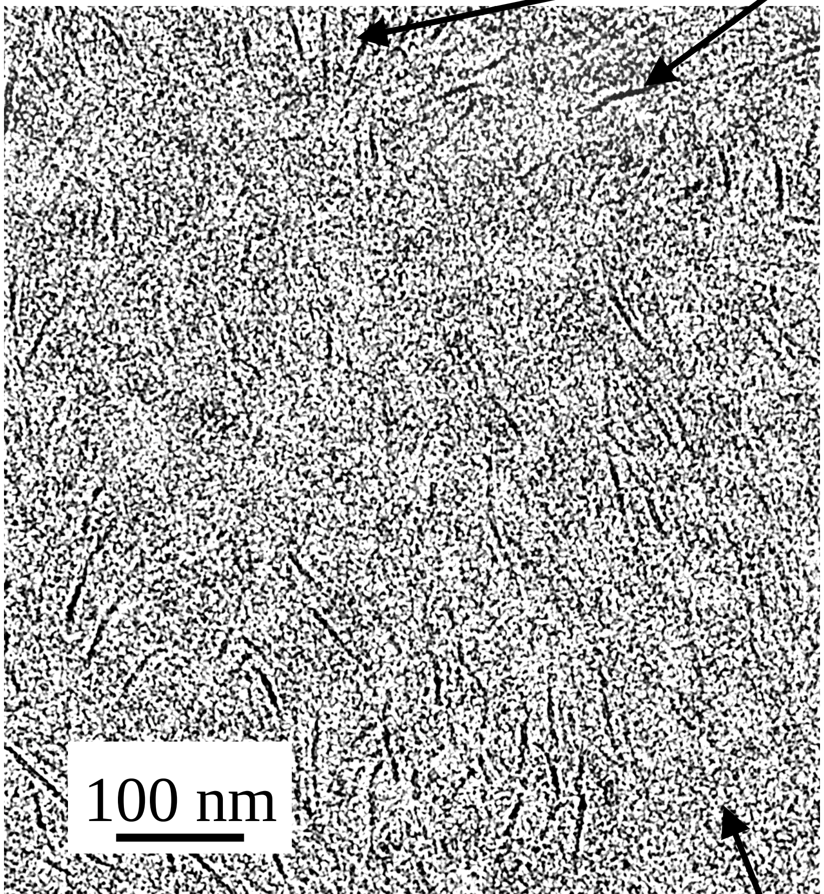


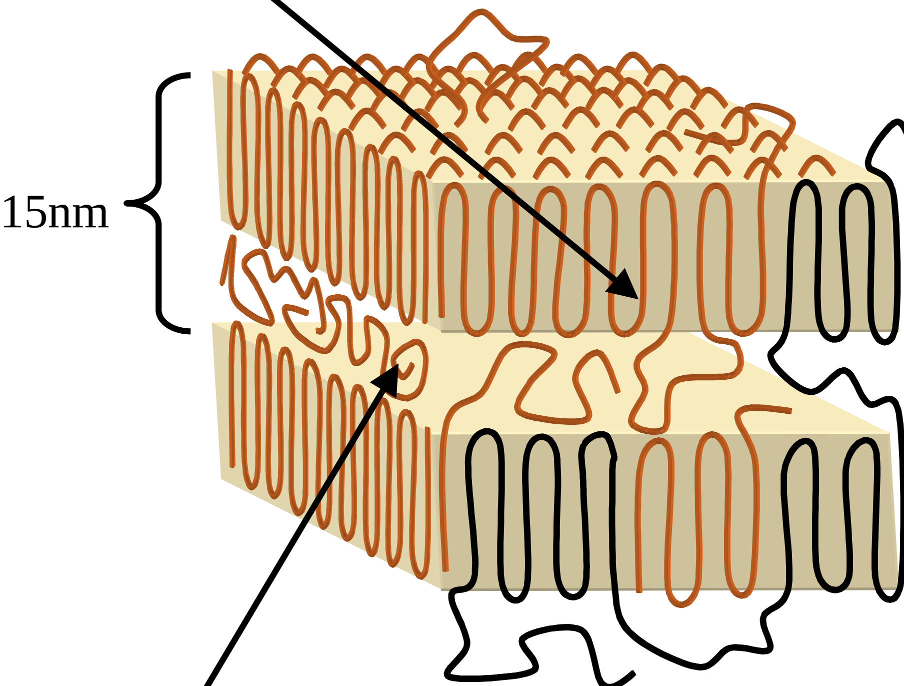
Diblock copolymer is placed in between polyethylene (PE) and polystyrene homopolymers (PS).



Semicrystalline Polymers

lamellae



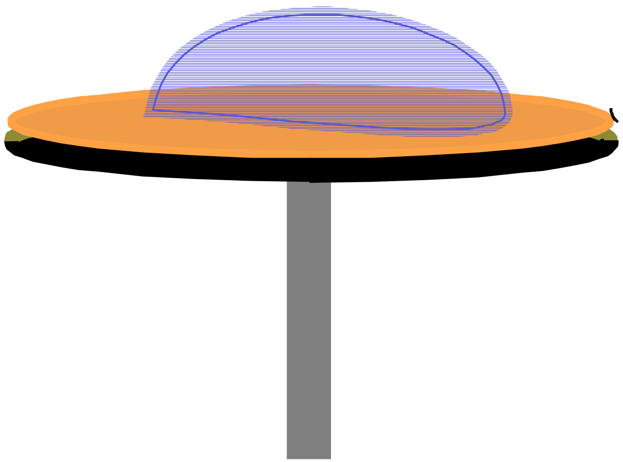


30% crystalline 70% amorphous

amorphou
s

Lamellae stack to form ribbon-like structures

Spin Coating Diblock Copolymer on top of the PE Film



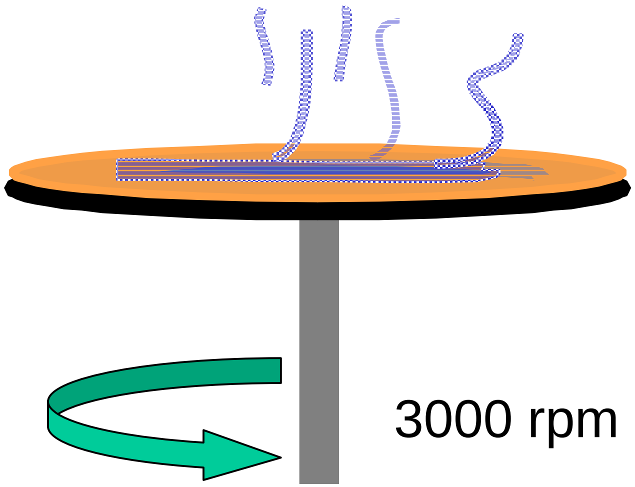
In the Solution:

- Toluene(solvent)
- Poly(styrene-b-ethylene)

The solvent evaporates leaving a thin coating on the PE.

Spin coating both sides of the film:

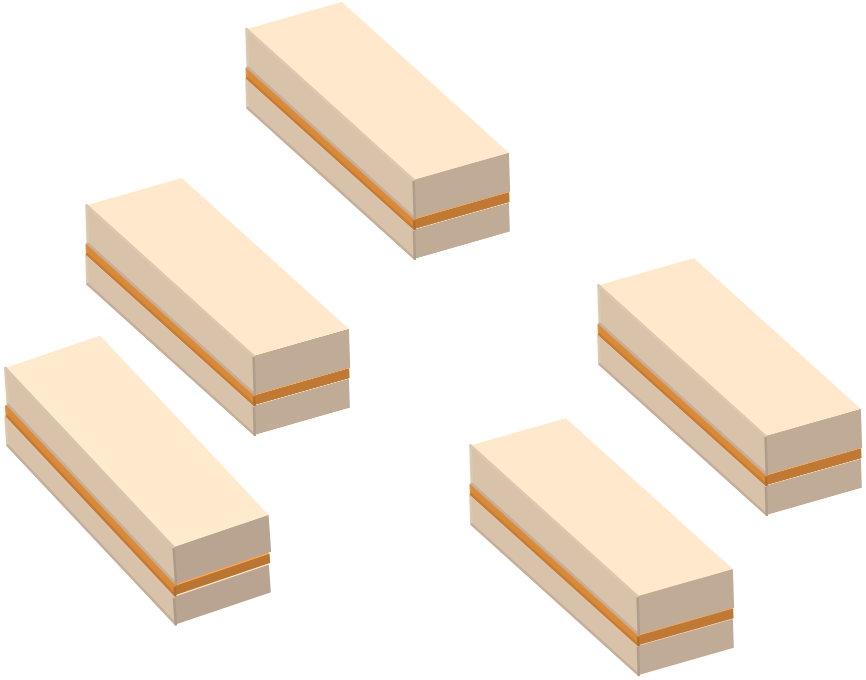
- PS-PE (40,000g/mol-30,000g/mol)
- PS-PE (40,000g/mol-100,000g/mol)
- Areal chain density of 0.2 chains/nm^2

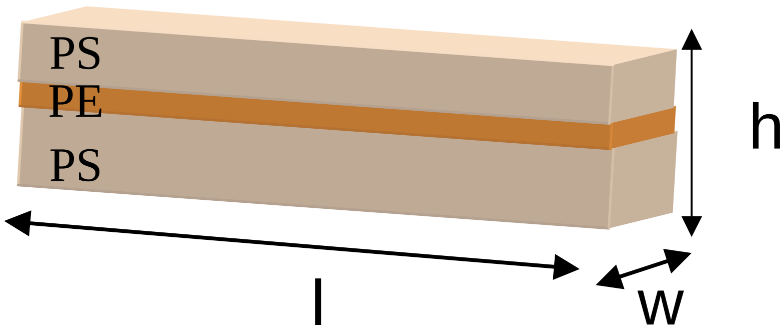


Dimensions of Samples

1. Polymers are annealed at 160ºC for two hours.
2. Cooled to room temperature in 3 minutes and cut into samples

- PE film is 70 μm thick
- Top PS beam is 2 mm
- Bottom PS beam is 2.5 mm





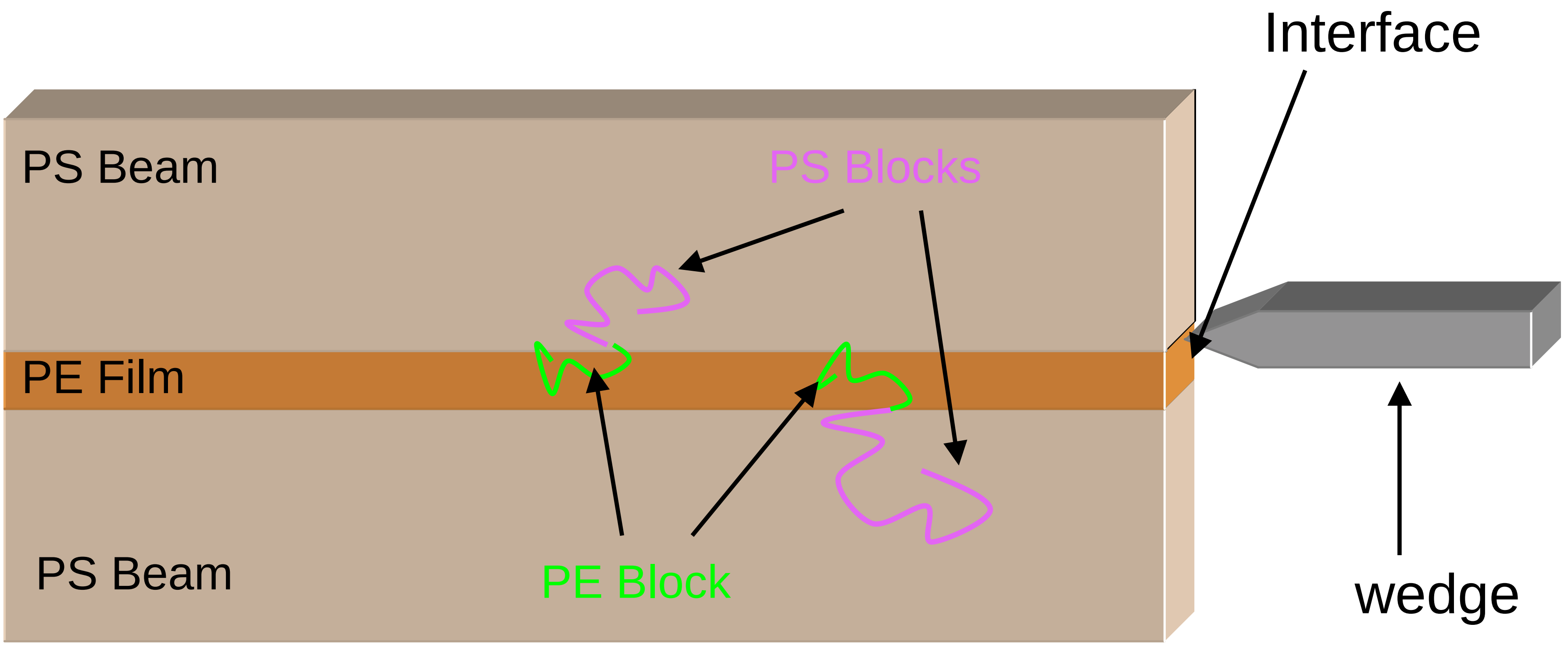
- Width (w) = 8 mm
- Length (l) = 40 mm
- Height (h) = 4.5 mm

Asymmetric Double Cantilever Technique

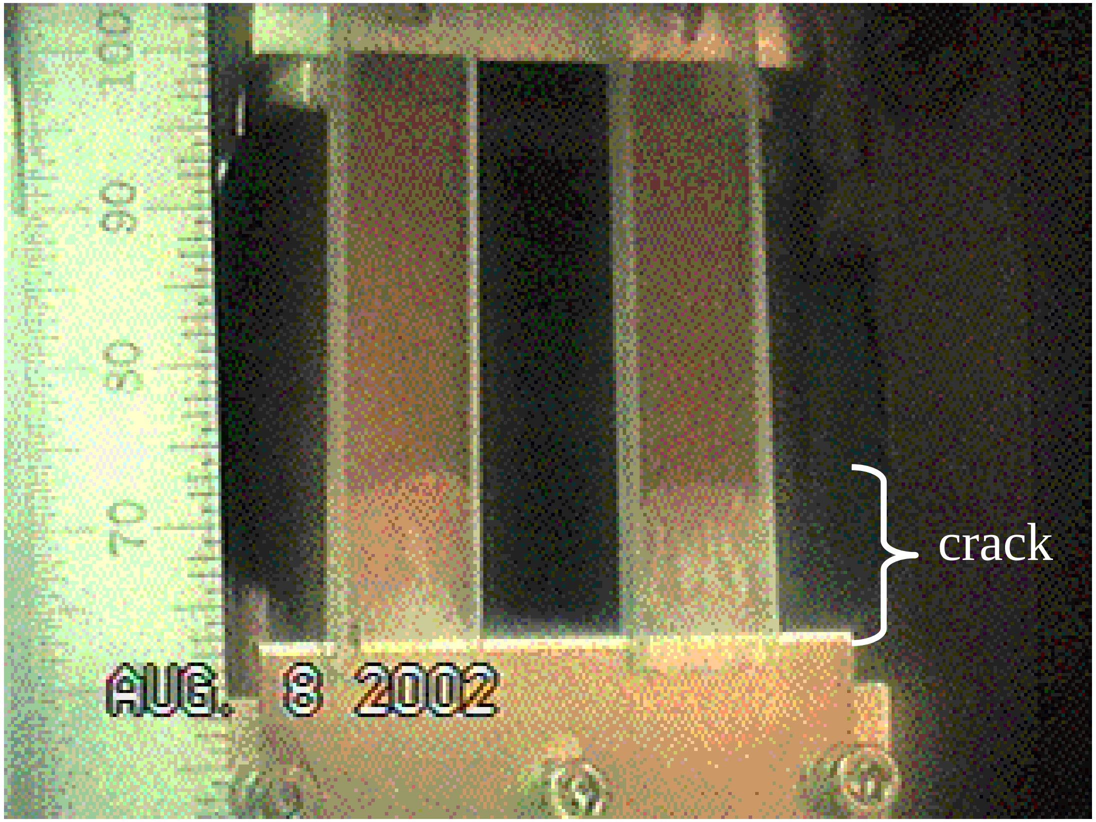
1. 2.7 mm wedge moves through the interface at constant speed.

2. Images are captured every 3 minutes to a computer.

3. Crack lengths are measure using the NIH Image program.



Fracture Energy Measurements



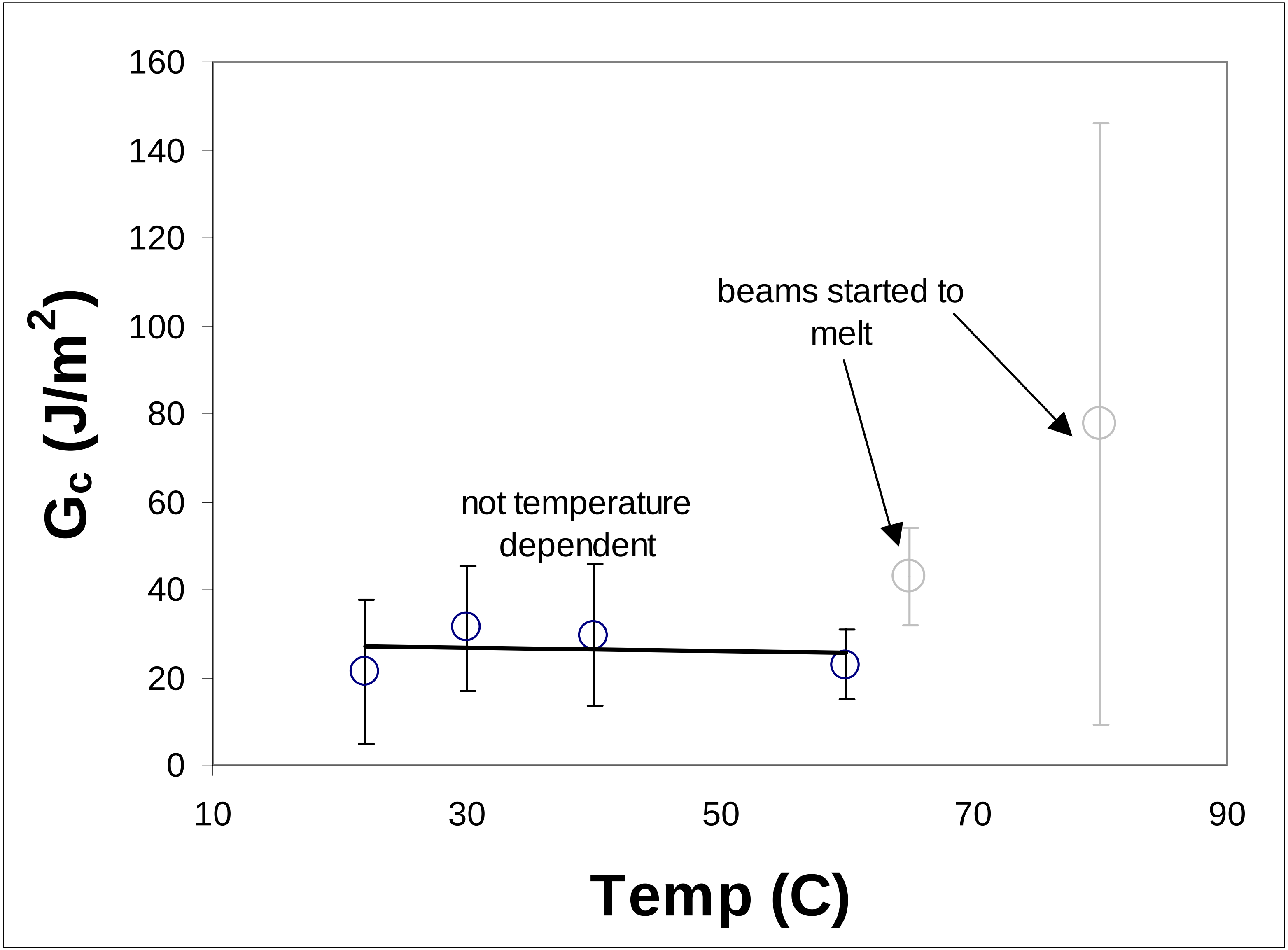
•3 measurements per picture

•30 pictures per sample

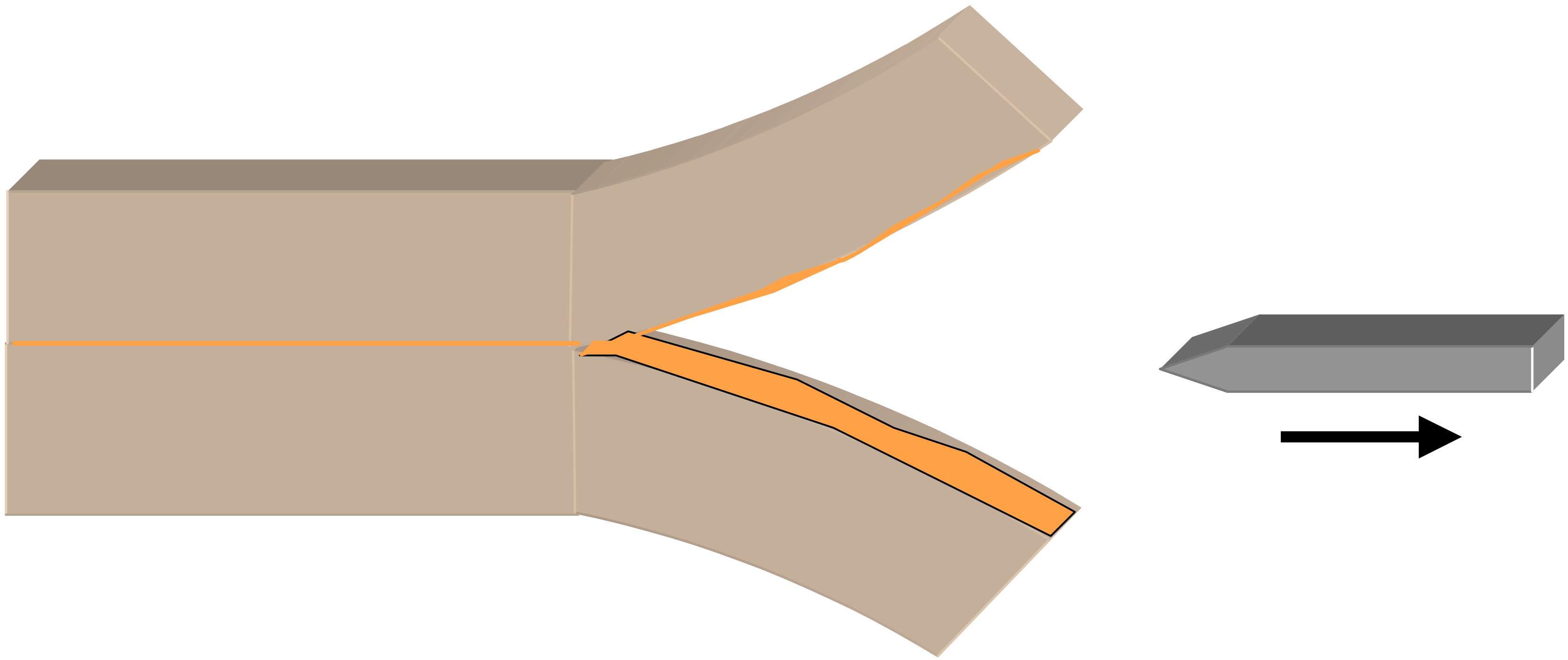
•6 samples

•540 measurements per data point

Fracture Energy vs. Temperature



Plastic Deformation Above 60ºC

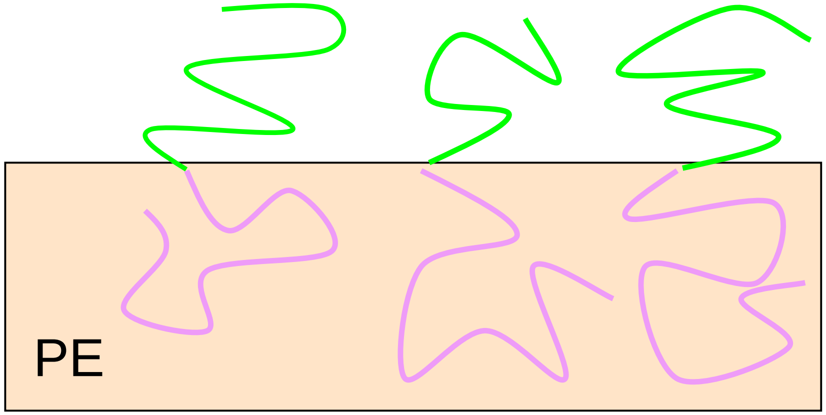


•Beams remained bent after blade was removed.

•Too close to T_g for polystyrene beams

Fracture Failure

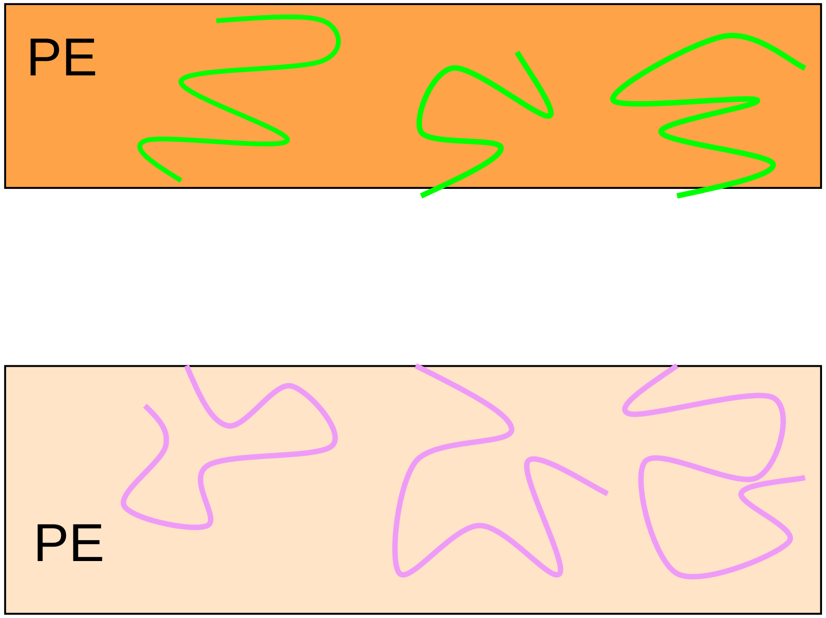
Pullout



Occurs when one block is pulled out from its parent homopolymer during fracture.

This is what we see for our system.

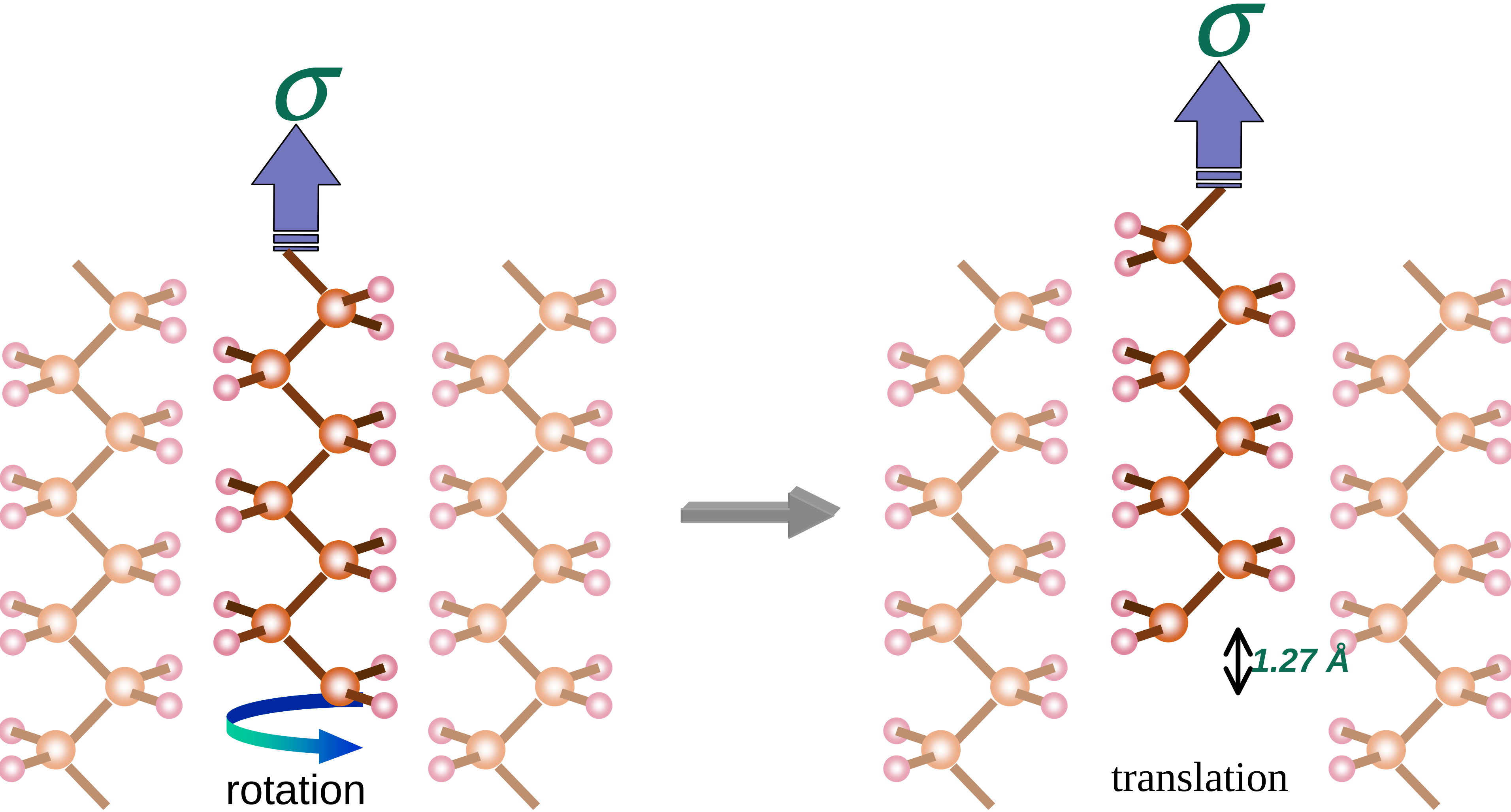
Scission



Occurs when the diblock copolymer breaks somewhere along its length.

Only at higher molecular weights

Thermally Activated (Diffusion) Process



Does pullout involve stress-assisted diffusion?

Conclusions

- The pullout of PE blocks do not appear to be thermally activated
  - G_c does not change with temperature
  - Temperature range may be too small
- Cannot make measurements above 60^{o}C
  - Beams plastically deform
  - Too close to T_g