How to Turn Rubber into Glass
Glass Transition

December 41, 2012
Vocabulary

- **Physical transition** – change in state of matter that does not alter chemical bonds
- **Glass transition temperature** ($T_g$) – temperature at which a polymer changes from rubber into glass (or glass into rubber)
- **Rubbery state** – temperature range at which a polymer is above its glass transition
- **Glassy state** – temperature range at which a polymer is below its glass transition
Name the physical transitions you have discussed in class so far.

- Melting/Freezing (solid/liquid transition)
- Evaporation/Condensation (liquid/gas transition)
- Sublimation (solid/gas transition)
- **Glass transition** (solid/solid transition)
What is the Glass Transition?

- Heat: material becomes flexible *(rubbery)*
- Cool: material becomes stiff *(glassy)*
- *Reversible*
What has a Glass Transition?

EVERYTHING!

- Water = -136°C (theoretically)
- Polyethylene = -90°C
- Poly(ethylene terephthalate) = 70°C
- Polystyrene = 95°C
- Poly(methyl methacrylate) = 100°C
- Polycarbonate = 150°C
Example: Dashboards

- Polymers in dashboards have $T_g$'s higher than “ambient temperature”
- HOW DO WE KEEP THE DASHBOARDS FROM CRACKING?!?
  - Answer: PLASTICIZERS
  - Plasticizers spread out the polymer chains, lowering $T_g$
  - They also produce that (amazing) “new-car smell”
How to Find the Glass Transition

- Old school: heat or cool polymer and try to bend it
- New school:
  - Dynamic mechanical analysis (DMA)
  - Thermomechanical analysis (TMA)
  - Differential scanning calorimetry (DSC)
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If you want more information on the glass transition, check these websites out:

http://pslc.ws/macrogcss/tg.html
This website has more info on what the glass transition is.

http://www.youtube.com/watch?v=om6YiaAwVLE
http://www.youtube.com/watch?v=mvdlBL7vDqo&feature=related
These videos show a rubber ball bouncing in slow motion. One is above its $T_g$, the other is below its $T_g$. 
Questions?