Polystyrene (PS)

- Aromatic polymer made from styrene monomers
- Cheap relatively easy to manufacture and process
- Thermoplastic commonly extruded or molded
• Clear polymer
• Low-cost applications
• Low impact strength
• Rigid (easy to fracture)
• Poor Weatherability
• Poor Chem. Resistance
• Processed
  – Sheet
  – Molded
  – Foams

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
<td>1.05 g/cm³</td>
</tr>
<tr>
<td>Young’s Modulus</td>
<td>3000-3600 Mpa</td>
</tr>
<tr>
<td>Tensile Strength</td>
<td>46-600 Mpa</td>
</tr>
<tr>
<td>Elongation at Break</td>
<td>3-4%</td>
</tr>
<tr>
<td>Electrical Conductivity</td>
<td>10-16 S/m</td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>0.08 W/(m·K)</td>
</tr>
<tr>
<td>Glass Temp.</td>
<td>95°C</td>
</tr>
<tr>
<td>Melting Temp.</td>
<td>240°C</td>
</tr>
<tr>
<td>Decomposition</td>
<td>50-1000 years</td>
</tr>
</tbody>
</table>
Polystyrene Products

- Sheet or Molded
  - Disposable Cutlery
  - CD “Jewel” Cases
- Foams
  - Insulation (Thermal & Acoustic)
- Extruded Polystyrene Foam (XPS)
  - Packaging
  - Shock Absorption
Do YOU Have a Waste Polystyrene Problem?
Polymer Myth:

Polystyrene can not be recycled
Polystyrene Disposal

• Burial (Landfill)
  – Stable to bury (without contamination)
  – Without UV and oxygen long degradation times
• Incineration
  – Requires high temperatures to combust properly
  – High energy content (good fuel)
• Discarded (*Thrown away into the environment*)
• Reduce / Reuse / Recycle
Environmental Impact

• Hazardous if improperly burnt
  – When burnt below 900°C up to 90 dangerous compounds can be released. 
    \( \text{(ex: alkyl benzene, carbon monoxide, and benzo[ghi]perylene)} \)
• Takes up large volumes and occupies landfills
  – Foams decompose slow taking space longer
• Slow to degrade which poses danger to wildlife
  – Products improperly disposed of can hurt wildlife 
    \( \text{(ie: styrofoam cups, disposable cutlery)} \)
Polystyrene Recycling

• Like other polymers it can be recycled
  (majority of Polystyrene is not recycled)

• Expanded Polystyrene Scrap (EPS)
  – Chopped into building materials
  – Filler for structures (park benches, lamp posts)
  – Remolded & using in casting industry
    (25% of recycled foam)

• PS sheet and molded components
  – Chop filler for non PS materials
  – Reground into PS materials (if near virgin)
PS Recycling Problems

• Bulky Foams take up large amounts of space requiring multiple trips to hall away relatively little waste. *Increased expenses and costs*

• Light polymer structure makes regrinding and molding into PS components difficult without degradation.

• Additives and fillers prevent direct recycling

• PS is the most comely contaminated resin *(food contact, toxins and organics)*
Incineration Solution

- Polystyrene can be burned cleanly and efficiently
- Maintain burn temperature over 1000°C
- Burned with excess oxygen to break down chemicals

Byproducts
- \( CO^2 \) (As exhaust gas)
- Water Vapor
- Soot (Biochar- easily biodegradable)
- Heat
Burial Solution

Melting technology to reduce bulk before burial

- EPS is subjected to low heat to release entrapped foaming agents and reduce bulk

Before

After
Reduce/Reuse Solutions

• Make foam packaging components generic shapes which can be used repeatedly.

(No mold to fit components)
Reduce/Reuse Solutions cont.

• Reuse “disposable” products. PS is nonporous and easy to clean/serialize
  (Cutlery and Jewel Cases)

• Redesign disposable products to be used multiple times before being disposed.
  - Add stronger liners
  - Reinforcing fillers
  (ex. Cups and Containers)
Recycle Solutions

• Sterilizers: Decontaminate straight PS
  – Allows PS to be reground and used in new PS products. (With use of colorant)
  – Chemicals, UV or Heat is applied to break down or kill off contaminants from PS

• Pyrolysis: Breaks down PS in the absence of $O^2$
  – Creates base monomers for reprocessing
  – Light crude oil for fuel or virgin stock reprocessing
Recycling Solutions Cont.

• Condensers: Compact unusable EPS
  – Used to allow more PS to be carried away decreasing the costs associated with PS recycle
  – Mechanically applies pressure and some heat to crush foams into a dense block.
  – Works best on open cell foams
  – Allows for 2-5 times the amount of PS foam to be shipped for recycling

  *(reducing transportation costs)*
Any Questions?