Lifecycle Analysis of Materials

How can we design materials that follow the 12 Principles of Green Chemistry?

What kinds of materials make up our world?

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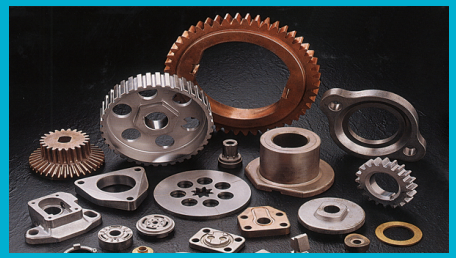
- Paper
- Plastics
- Metals
- Glass
- Ceramics
- Semiconductors
- Composites



How are these materials used?

- Paper - writing, packaging
- Plastics - containers, toys, medical instruments, clothing/footwear, electronics
- Metals - wire, foil, car parts, building materials, cooking utensils
- Glass - lenses, windows
- Ceramics - dishes, building materials, toilets, bone/tooth replacements
- Semiconductors - electronics
- Composites - athletic equipment, spacecraft, insulation, car parts




What are some problems with these materials?

- Paper - large amounts of wood pulp and water are used in manufacturing
- Plastics - involves potentially toxic solvents and starting materials
- Metals - require high temperatures and harmful chemicals to purify
- Glass and Ceramics - need high temperatures and occasionally use heavy metals for coloring
- Semiconductors - can contain toxic heavy metals
- Composites - can involve toxic substances and high temperatures

What is “Materials Science”?

- The study of materials!
- Materials scientists…
  - Analyze the structure and properties of materials
  - Study how materials are manufactured and how well they perform
  - Design new materials
  - Decide which materials to use in certain products and how to make those materials

What makes a material sustainable/green?

- Made from renewable/biological resources
- Requires little energy to make
- Produces little waste when it is made
- Recyclable/biodegradable

Cradle to Cradle Design

https://www.youtube.com/watch?v=fP8PRA-OajU&t=6s

Polystyrene vs. Ecovative

POLYSTYRENE

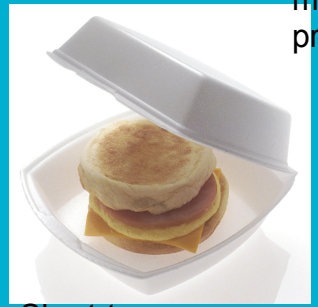
- Derived from petroleum
- Non-biodegradable
- Made from styrene
  - Flammable liquid with a strong odor
  - Iron oxide catalyst and steam are needed to synthesize it
  - Short-term exposure can cause skin/eye irritation and nausea/vomiting
  - Long-term exposure can cause headaches and fatigue
  - Toxic if inhaled or swallowed
  - May affect reproductive system
  - May be linked to increased risk of some cancers

Lifecycle of Polystyrene

Open Loop

Landfill

Non-biodegrable and Limited recycling



Short-term use consumer product

Multi-step manufacturing process

Non-renewable Feedstock (petroleum)

How does polystyrene's lifecycle connect with green chemistry principles?

- Does NOT follow…
  - Principle 1: waste prevention → used styrofoam gets dumped in a landfill!
  - Principle 2: atom economy → waste products during manufacturing are discarded
  - Principle 3: minimize toxicity → styrene monomer is toxic
  - Principle 5: safer solvents → manufacturing process uses toxic solvents
  - Principle 6: energy efficiency → manufacturing process uses high heat
  - Principle 7: renewable feedstocks → petroleum is non-renewable!
  - Principle 10: design for degradation → styrofoam is non-biodegradable

Polystyrene vs. Ecovative

ECOVATIVE

- Nontoxic
- Made from mycelium and agricultural waste
    - Mycelium = organic material found in mushrooms
    - Can be composted to help more crops grow → renewable resource
- Same applications as traditional polystyrene

Lifecycle of Ecovative Materials

Closed Loop

Renewable Feedstock from agricultural waste

Ecovative production process

Short-term use consumer product

Post-use Composting

Compost used to fertilize and grow renewable feedstock

How does the ecovative material's lifecycle connect with green chemistry principles?

- DOES follow…
  - Principle 1: waste prevention → discarded materials get composted
  - Principle 2: atom economy → starting materials fully incorporated into final product
  - Principle 3: minimize toxicity → materials are food-based!
  - Principle 4: designing safer chemicals → same applications as polystyrene with minimal toxicity
  - Principle 5: safer solvents → manufacturing process uses water
  - Principle 6: energy efficiency → manufacturing is done at room temp
  - Principle 7: renewable feedstocks → agricultural waste
  - Principle 10: design for degradation → completely compostable

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