Which plastics can easily/reasonably be replaced with biodegradable plastics?

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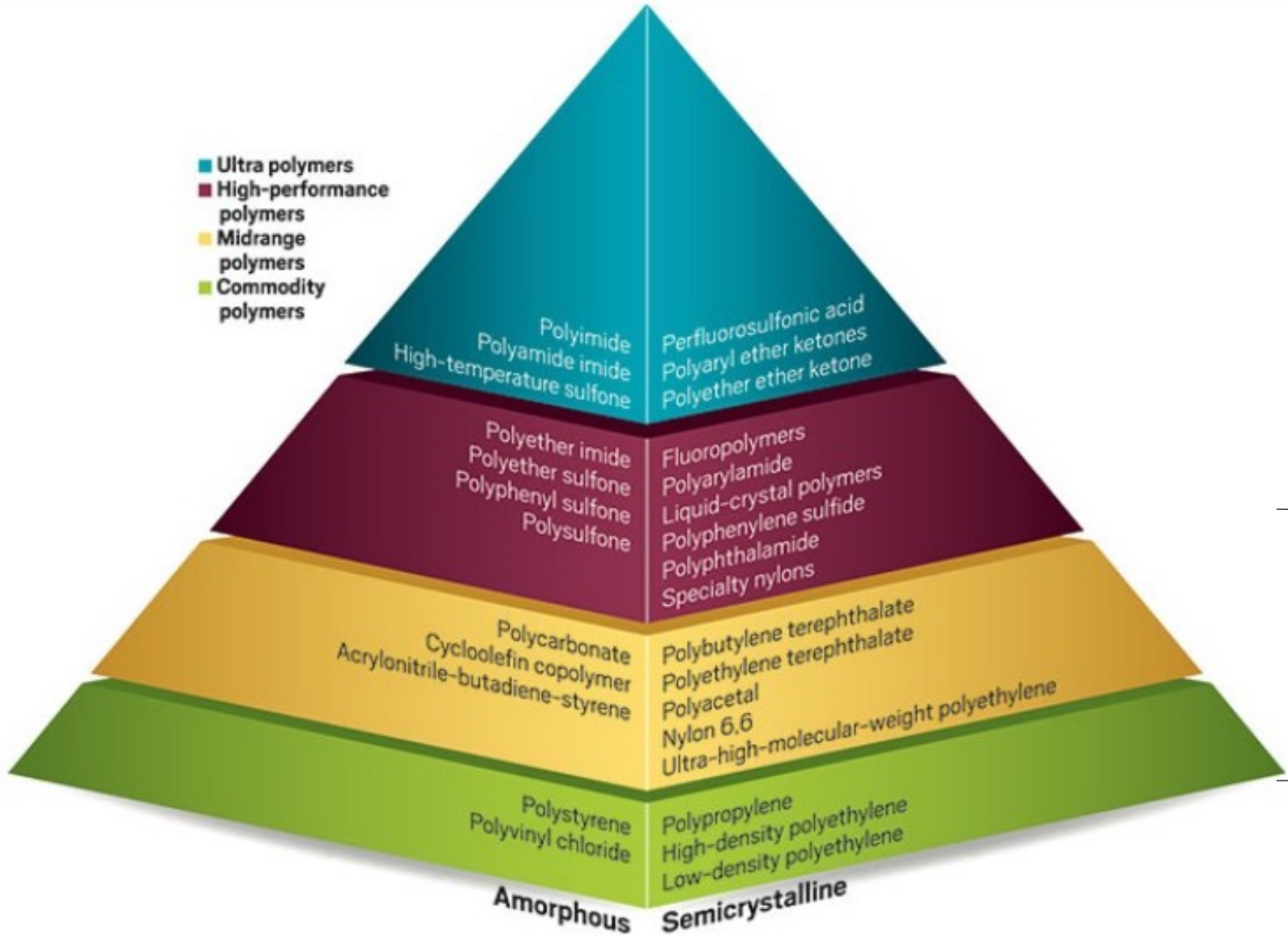
POLYMER PYRAMID



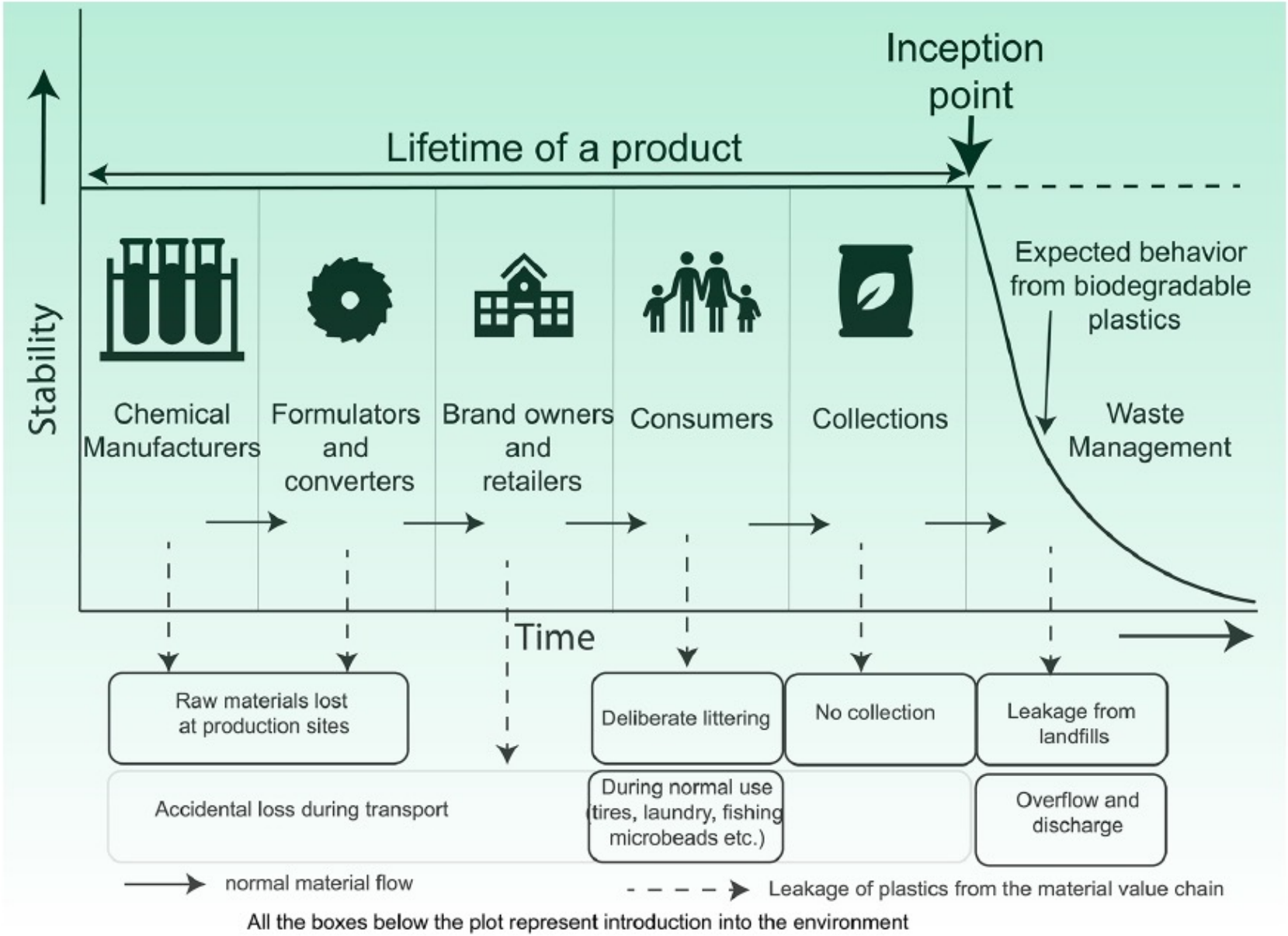
75%

Polyether ether ketone, with its envelope-pushing material properties and hefty price tag, sits at the top of the polymer world above cheaper and more popular plastics.
Sources: Solvay, C&EN

What makes a plastic biodegradable?

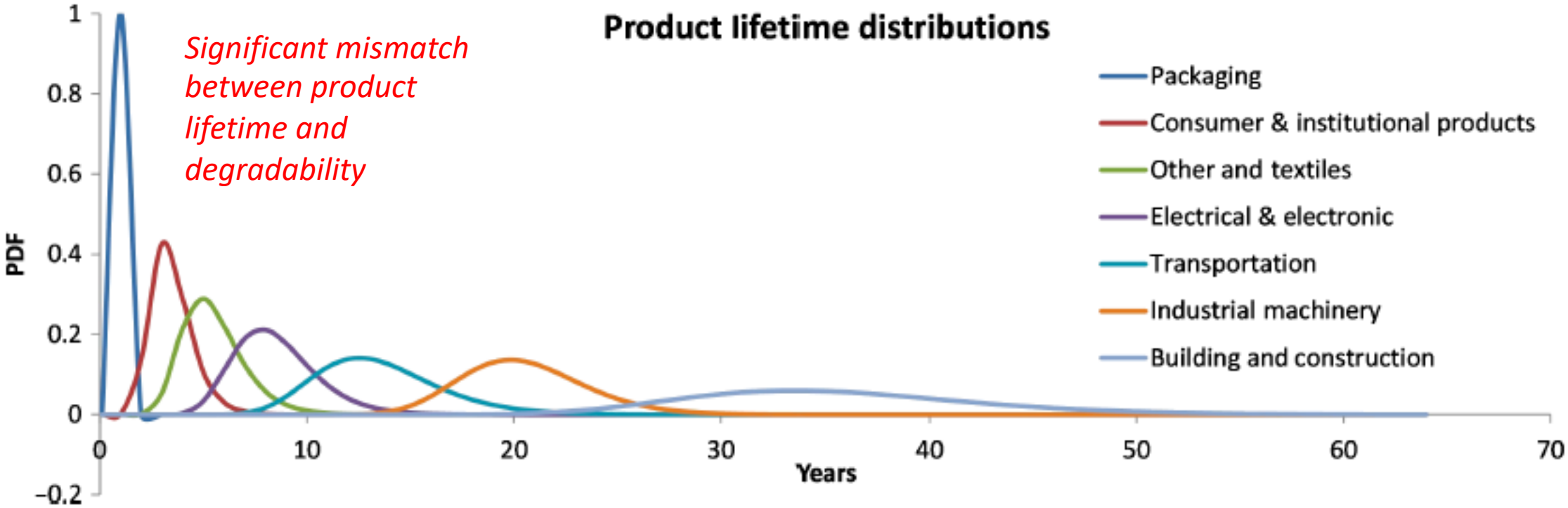
- Biodegradation is traditionally thought to utilize enzymatically accessible backbones that can be cleaved, forming small molecules, by microbes and their enzymes
- Compostability is biodegradation in a specific environment
- Also consider environmentally degradable plastics? Engineered degradation? Are microbes or enzymes always needed?

- Heteroatoms in the backbone (O, N and sometimes S) *can* make plastics biodegradable/compostable
- Greater degradability usually means lower thermal stability
- Waste management pathways?
- Requirements for degradation often in conflict with performance requirements



K. Ghosh and B.H. Jones "Roadmap to Biodegradable Plastics – Current State and research Needs" *ACS Sus. Chem. Eng.* **2021**, *9*, 6170-6187

Product lifetimes vary significantly



R. Geyer, J.R. Jambeck and K.L. Law "Production, use and fate of all plastics ever made" *Sci. Adv.* **2017,** 3:e1700782

When is biodegradation (composting) most desirable?

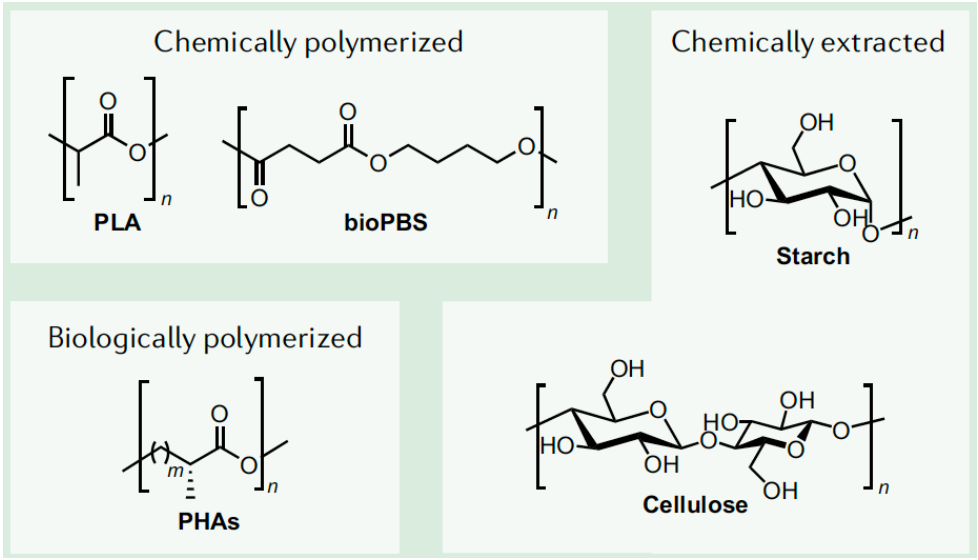
- Contamination with food waste
- Likely to end up in organic waste collection and unlikely to be effectively mechanically recycled in the plastic recycling stream
- Potential to reduce non-biodegradable plastics contamination of bio-waste collection
- No efficient re-design possible in order to move to reusable solutions

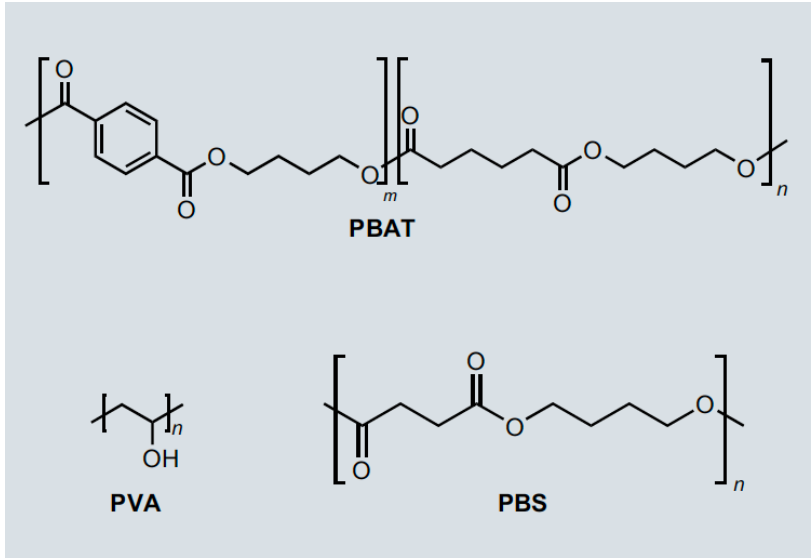
- Potential targets: bio-waste bags; very think plastic bags/fruit and vegetable bags; tea bags; coffee capsules/pods/filters; produce stickers; cling film; catering items; paper towels (wet-strength); multi-material flexible packaging for perishable food

https://www.european-bioplastics.org/eubp-proposes-criteria-and-product-examples-for-preferable-use-of-compostable-plastics/

Many current biodegradable plastics are sourced from or inspired by natural materials

- PLA
- Starch
- PHA
- Cellulose
- PCL and PGA
- PBS
- PBAT

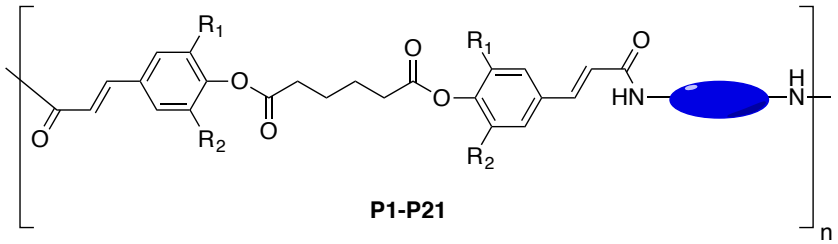




J-G Rosenboom, R. Langer and G. Traverso “Bioplastics for a circular economy” *Nat. Rev. Mat.* **2022**, **7**, 117-137

Lignin is underutilized as a source for monomers and materials

- 50 million tons of lignin isolated from pulping in 2010 – only 2% used in specialty products
- Great source of aromatic carbon, can be used to produce a number of bio-based monomers



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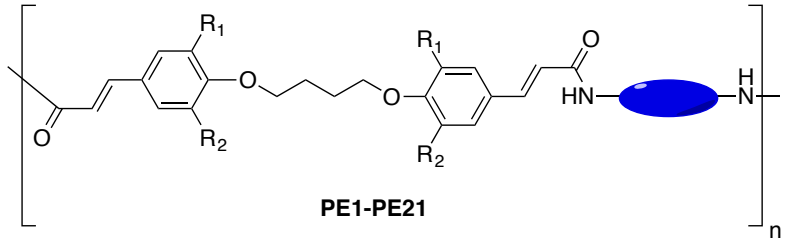

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