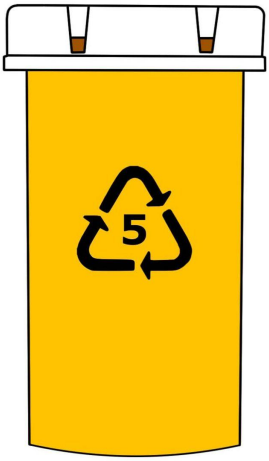
Medical Bottles

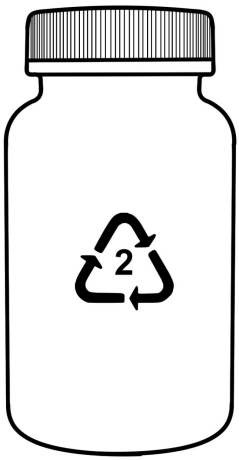
Shirin Kuppusamy
Jadelin Kirkvold
Aissa Conde
Dre Hilton

Bottle Types



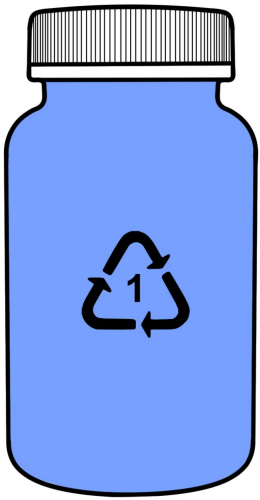
Polypropylene (PP)

- Translucent (orange tinted) bottle
- White opaque top (also PP)
- Prescription medication



High-Density Polyethylene (HDPE)

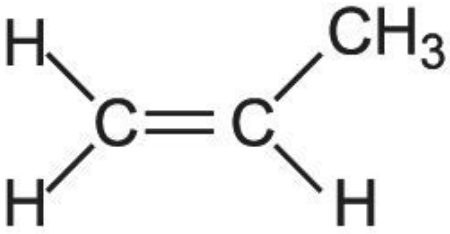
- Opaque (white) bottle and lid
- Over-the-counter medication



Polyethylene Terephthalate (PET)

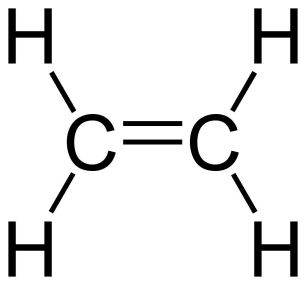
- Transparent or tinted color
- Over-the-counter medication
    - Sometimes liquids

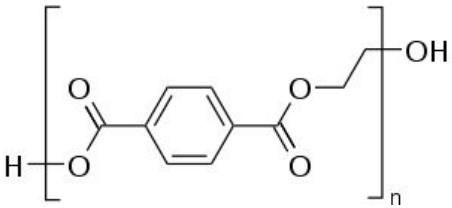
Chemical Structure



Propylene, the monomer unit of polypropylene, has a rigid carbon-carbon covalent double bond. The hydrogens are also covalently single bonded to the carbons. The monomer units have van der waals interactions between them to form the polymer.

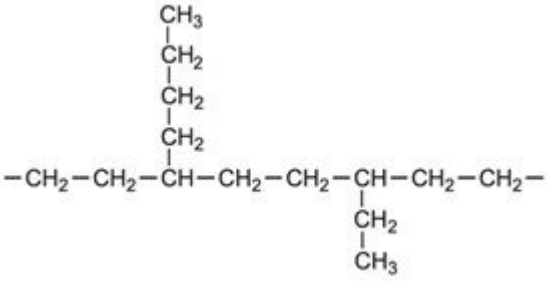
Ethylene, the monomer unit of high-density polyethylene, has a rigid carbon-carbon covalent double bond. The hydrogens are also covalently single bonded to the carbons. The main interactions between monomer units is still van der waals forces, but because there are no branches in the structure, the molecules can pack together tightly to form a high-density, more crystalline polymer.



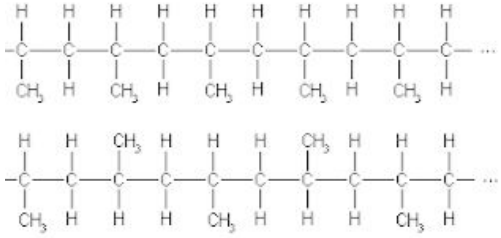


ethylene terephthalate, the monomer unit of polyethylene terephthalate (aka polyester), has multiple components to it. There is a carbon ring with 3 double bonds. There are two oxygens covalently double bonded to the carbons and two oxygens covalently single bonded to the carbons. One single bonded oxygen has a hydrogen bonded to it, and the other has a hydroxyl group bonded to it. There are strong intermolecular forces because the molecule is polar.

Material Properties: Molecular Weight & Structure

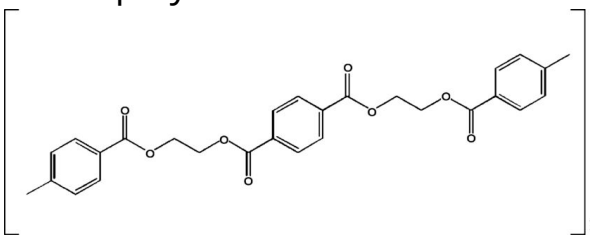


Isotactic polypropylene, the most common form of the plastic used, is mainly a linear polymer.



The polymer structure of polypropylene is semi-crystalline (about 30-60%) and has a molecular weight of 42.1 g/mol. It is one of the most widely used commercial polymers due to high melt point, low density, rigidity, toughness and chemical resistance

The polymer structure of HDPE is highly crystalline and has a molecular weight range of about 100,000 to 250,000 g/mol. High density polyethylene is mainly linear polymers.

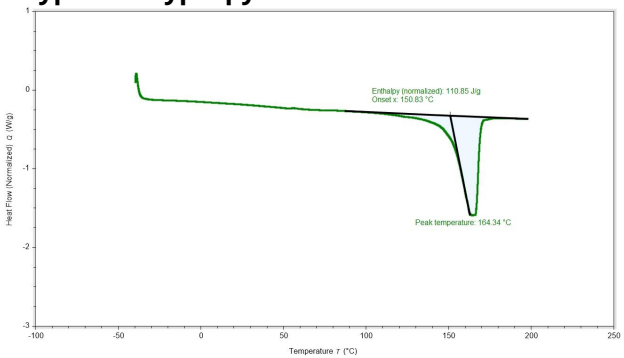


The polymer structure of polyethylene terephthalate is highly crystalline, up to 60%.

It has a molecular weight range 8,000-31,000 g/mol.

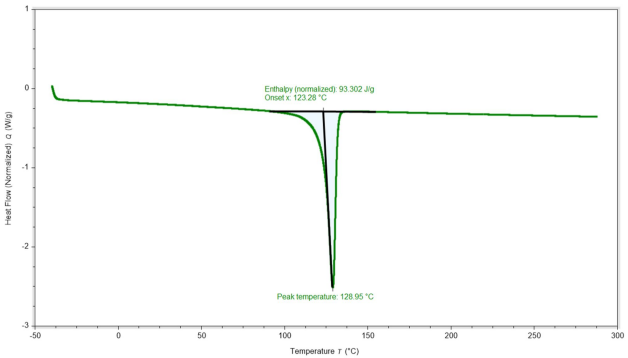
Material Properties: Melting Point

Type 5: Polypropylene



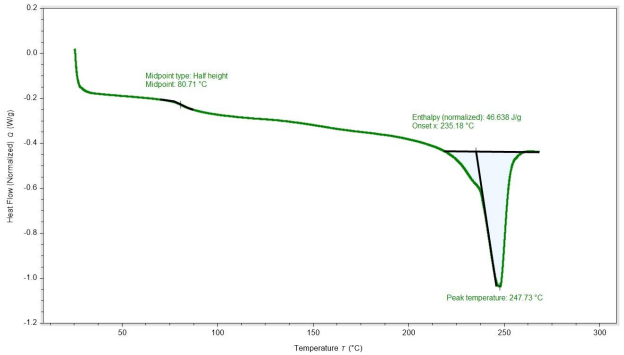
Our type 5 DSC scan presented some interesting results. The melting point of around 164.64 degrees Celsius was standard to that of PP but there was a small oxidation occur at around 50 degrees Celsius. We believe this to be some sort of additive that was put into the plastic that had a much lower melting point.

Type 2: High Density Polyethylene



HDPE is a polymer with a relatively low melting point in comparison to other polymers. It melts at around 129 degrees Celsius. Within the FTIR scan of this plastic however, we get an idea of how the adhesive used for the label interacts with the bottle. Of the 3 bottles, this bottle was the hardest to get the adhesive off. Because of this, the scan revealed all of the additives within the adhesive.

Type 1: Polyethylene Terephthalate

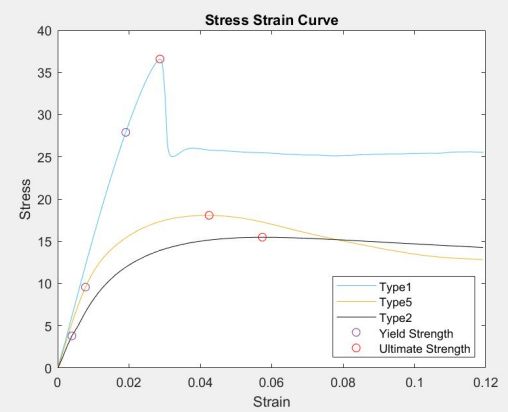


PETE is a polymer that has a higher glass transition rate than a lot of other polymers, because of this, we can observe a glass transition within. It is characterized by a step in the graph which we can see around 80 degrees Celsius. The melting point for our particular strain of PETE was about 247 degrees Celsius. We can indeed confirm it is PETE after conducting an FTIR scan on the bottle and receiving the results we expected.

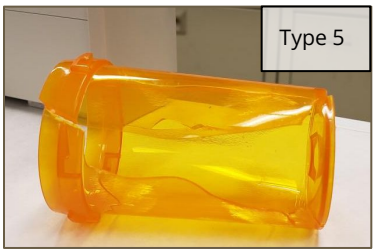
Why These Materials?

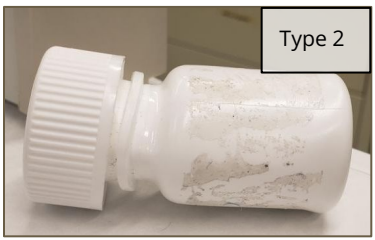
Goal: **get a better understanding of what kind of forces these plastics can undergo and why that maps to medical bottles use cases.**

The stress strain curve is developed from a tensile test that recorded load and extension of a t-bone shaped sample of a Type 1, Type 5, and Type 2 plastic medical bottle. The graph shows the yield strength and ultimate strength of each bottle type, and the table shows the exact values along with the Young's modulus.



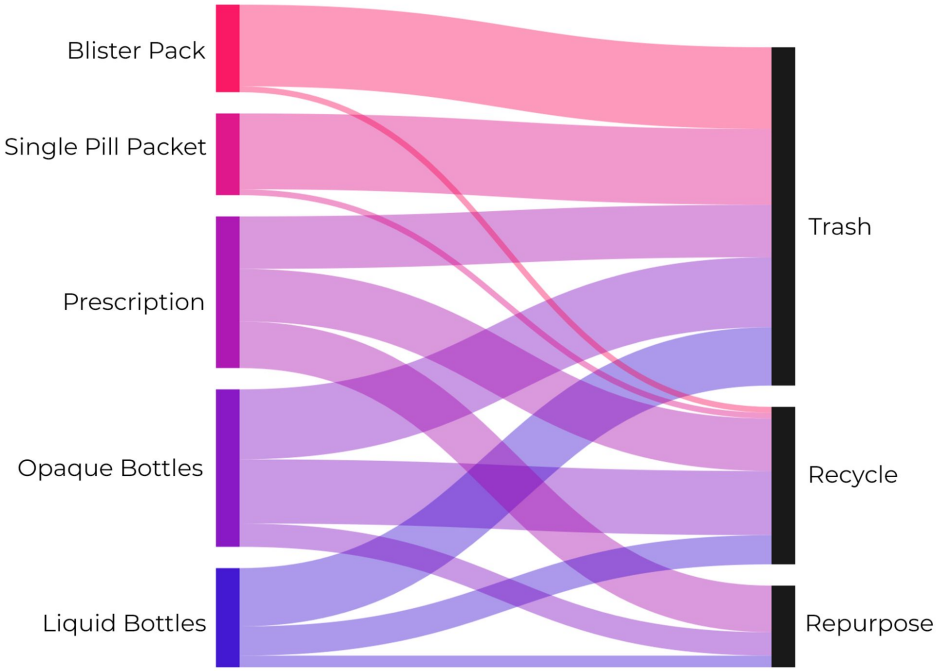
	Young's Modulus	Yield Strength	Ultimate Strength
Type 1 Plastic	1486.3771	27.9069	36.5872
Type 5 Plastic	1260.1292	9.56952	18.0809
Type 2 Plastic	981.73015	3.80431	15.4824





The pictures depict the results of a compression test on bottles of the same type of plastic respectively. Looking at the results in conjunction, we can note which bottles are more likely to fracture and which need higher forces applied to them before breaking. For example, the type 1 bottle can withstand a higher stress than the type 5 bottle, so it's less likely to break and forego it's elastic properties, but it may also require more strength to open - which could pose challenges for elderly patients or those with arthritis as an example.

What do Oliners do with their Medical Bottles?



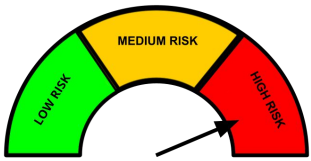
From our survey results, we see that the final destination for prescription and opaque OTC medical bottles is split almost evenly with the trash and recycling, with a smaller percentage being repurposed. We notice that prescription bottles are most likely to be repurposed by a significant margin, and that pill packets are more likely to be thrown away by a significant amount.

End of Life & Recyclability

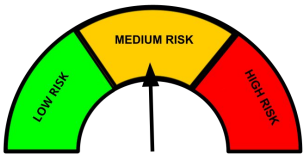
	Type 5 PP	Type 2 HDPE	Type 1 PETE
Curbside Recycling	✗	✓	✓
Mechanically Recyclable	✗	✓	✓
Chemically Recyclable	✓	✓	✓

Vulnerability to UV degradation

Type 5 PP



Type 2 HDPE



Type 1 PETE