Nylon-6, 10

Performer's Version

Safety Hazards

- Personal Protective Equipment:
  - Safety glasses/goggles
  - Nitrile gloves
  - Neoprene gloves
  - Chemical & flame retardant lab coat
- Physical Hazards
  - Sebacoyl chloride is corrosive to metals.
  - Hexanes is toxic to aquatic life with long lasting effects.
  - Hexanes is a highly flammable and volatile liquid and vapor.
- Chemical Hazards
  - 1,6-hexanediamine causes severe skin burns and eye damage, is harmful if swallowed or in contact with skin, and may cause respiratory irritation.
  - Sebacoyl chloride is harmful if swallowed, fatal in contact with skin, causes severe skin burns and eye damage, and may liberate toxic gas upon contact with water.
  - Hexanes causes skin irritation, may be fatal if swallowed or inhaled, may cause drowsiness or dizziness, may cause damage to organs (nervous system) through prolonged or repeated exposure if inhaled, and is suspected of damaging fertility or the unborn child.

Materials

- 50mL 0.5M 1,6-hexanediamine in water
- 2.14mL 97%+ Sebacoyl chloride
- 47.86mL Hexanes
- 250mL crystallization dish
- Fine point forceps/tweezers
- Winding stand
- Food coloring (optional)

Safety Data Sheet(s)

- 1,6-hexanediamine, 0.5M
- Sebacoyl chloride, 97%+
- Hexanes

Procedure

1. Pour the 50mL of aqueous 1,6-hexanediamine solution into the crystallization dish.
2. Slowly add the 50mL of sebacoyl chloride solution to the dish.
3. Using the forceps/tweezers to pull the nylon forming at the liquid interface. Pull the nylon up and gently wrap it around the glass stir rod on the winding apparatus.
4. Wind the stir rod until all of the reagent is used and all that is left is a large amount of nylon string winded around the stir rod.
5. Wash the string with ethanol, holding a waste beaker underneath to catch runoff.

Pedagogy & Supplemental Information

This demonstration showcases the synthesis of nylon-6,10, a synthetic polyamide, through an interfacial polymerization reaction. Two immiscible solutions are used: 50mL of 0.5M 1,6-hexanediamine in water (the aqueous layer) and 50mL of 0.5M sebacoyl chloride (a diacid chloride) in hexanes (the organic layer). When these two layers are carefully poured into a beaker, they form a distinct interface. At this boundary, a thin film of nylon-6,10 forms almost instantly and can be continuously pulled from the interface using tweezers, making the formation of the polymer dramatically visible in real time. This demonstration not only illustrates fundamental concepts in polymer and organic chemistry, such as nucleophilic acyl substitution and condensation polymerization, but also provides an opportunity to connect microscopic chemical changes to tangible, macroscopic materials.

The polymerization occurs via a step-growth condensation reaction, where the terminal amine group ($–NH_2$) on 1,6-hexanediamine acts as a nucleophile, attacking the electrophilic carbonyl carbon of sebacoyl chloride's acid chloride group (–COCl). This results in the formation of an amide bond (–CONH–) and the release of hydrochloric acid (HCl). The overall reaction is:

$$n\ H_2N\text{-}(CH_2)_6\text{-}NH_2 + n\ ClOC\text{-}(CH_2)_8\text{-}COCl \rightarrow [–NH\text{-}(CH_2)_6\text{-}NH–CO\text{-}(CH_2)_8\text{-}CO–]_n + 2n\ HCl$$

In this reaction, 1,6-hexanediamine contributes six carbon atoms per diamine unit, and sebacoyl chloride contributes ten carbon atoms per diacid unit, giving rise to the name nylon-6,10. The reaction occurs specifically at the liquid interface because the two monomers are soluble in their respective solvents but not in each other. As nylon forms at the boundary, pulling the polymer up exposes more monomers to react, allowing the strand to grow continuously.

Nylon-6,10 and related polymers have numerous real-world applications, including use in textiles, engineering plastics, automotive components, fishing lines, and electrical insulation. Interfacial polymerization is also a key process in membrane fabrication for water purification and selective separations, as well as in coatings and encapsulation technologies, making this demo both educational and industrially relevant.