

Mystery Nylon Factory

Preparation of Polymers



Introduction

Two solutions are poured together in a beaker. A paper clip is inserted down into the solutions. As the paper clip is withdrawn, almost by magic a very long strand of nylon is pulled from the beaker. A super demonstration to discuss polymer concepts.

Concepts

- Polymerization
- Condensation polymer

Materials

Hexamethylenediamine/Sodium hydroxide solution, 7 mL

Beaker, 50-mL

Adipoyl chloride/hexane solution, 7 mL

Paper clip

Safety Precautions

Hexamethylenediamine/sodium hydroxide solution is toxic by ingestion and is corrosive. Adipoyl chloride/hexane solution is a flammable liquid and is toxic by ingestion and inhalation. Chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron should be worn. Perform this demonstration under a fume hood or in a well-ventilated room. Do not handle the nylon without wearing gloves unless it has been thoroughly washed. Please consult current Material Safety Data Sheets before beginning this activity.

Procedure

1. Add 7 mL of the hexamethylenediamine/sodium hydroxide solution to a small beaker.
2. Slowly add 7 mL of the adipoyl chloride/hexane solution down the side of the beaker. *Do not stir or mix the solutions.*
3. Note the formation of a white film at the interface of the two solutions.
4. Use a bent paper clip (opened to form a hook) to pull the film from the beaker. Pull slowly until there is no more nylon left. The nylon should be easily pulled from the beaker in the form of strands.
5. Wash the nylon strands by rinsing with water several times.
6. Lay the nylon strands on a paper towel to allow them to dry.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The nylon produced may be washed and dried. Dispose of it in the solid waste disposal according to Flinn Suggested Disposal Method #26.

Tips

- Let your students observe that the two solutions do not mix. They are immiscible.
- Observe the production of a film at the interface of the two solutions and the removal of the film as a long string of nylon.
- Make sure that the nylon is washed several times before it is handled.
- The hexamethylenediamine solution is slightly pink to make it more visible during the demonstration. If the pink has faded, add 1–2 drops of red food coloring.
- Sebacyl chloride can be used in place of adipoyl chloride to produce nylon 6/10.

Discussion

Nylon is a generic name for a family of polyamide polymers. W. H. Carothers at Dupont discovered nylon in 1935. It was quickly commercialized and played an important role in World War II in clothing and parachutes. Nylon is a condensation polymer since a molecule of water or HCl is formed for each extension of the polymer chain. A common nylon product is Nylon 6/6 which is produced from the reaction of two 6-carbon compounds, hexamethylenediamine and adipoyl chloride or adipic acid.

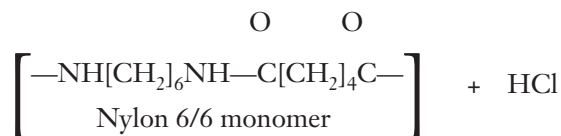


hexamethylenediamine



adipoyl chloride

excess diamine



Nylon is a thermoplastic and can be molded into shapes or extruded into a fiber. Nylon fibers are stronger and more elastic than silk and are relatively insensitive to moisture and mildew. Nylon is used in many commercial products such as hosiery, athletic apparel, bristles for toothbrushes, rugs and carpets, sails, parachutes, and some astroturfs.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12

Evidence, models, and explanation

Form and function

Content Standards: Grades 5–8

Content Standard B: Physical Science, properties and changes of properties in matter

Content Standards: Grades 9–12

Content Standard B: Physical Science, structure and properties of matter, chemical reactions

Answers to Worksheet Questions

1. Describe what happened in this demonstration. Include all observations you made about the substance produced.

A solution was poured on top of another solution in a beaker. The two solutions did not mix, but a white film began to form at the interface. When a paper clip was used to pull the film out, it came in thin, long strands. When the material dried, it was smooth, elastic, and relatively strong.

2. The polymer chains that make up nylon are randomly oriented when it is first produced. When the nylon is pulled like a thread, the chains line up into thin fibers, which increases the hydrogen bonding among the chains. What property do you think this bonding contributes to the nylon?

The large amount of hydrogen bonding among the chains strengthens the nylon fibers, so it contributes to the very strong, stable nature of nylon.

3. Why does the nylon form only at the interface of the two solutions?

Nylon only forms at the interface because the two solutions are immiscible. They do not mix, and neither is soluble in the other, so the only place the reaction can take place is right where the two solutions meet.

4. What are some commercial uses of nylon?

Commercial uses of nylon include hosiery, parachutes, and bristles for toothbrushes. It can be molded into many different shapes, or it can be extricated as fiber and used in that manner.

Acknowledgment

Special thanks to Jim and Julie Ealy, The Peddie School, Hightstown, NJ, who provided us with the instructions for this activity.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Mystery Nylon Factory* activity, presented by John Little, is available in *Preparation of Polymers*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Mystery Nylon Factory* are available from Flinn Scientific, Inc.

Materials required to perform this activity are available in the *Mystery Nylon Factory—Chemical Demonstration Kit* available from Flinn Scientific. Materials may also be purchased separately.

| Catalog No. | Description |
|-------------|--|
| AP2088 | Mystery Nylon Factory—Chemical Demonstration Kit |
| A0185 | Adipoyl Chloride/Hexane Solution |
| H0032 | Hexamethylenediamine/sodium hydroxide solution, 100 mL |
| S0260 | Sebacoyl chloride/hexane solution, 100 mL |

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.

Mystery Nylon Factory Demonstration Worksheet

Discussion Questions

1. Describe what happened in this demonstration. Include all observations you made about the substance produced.
2. The polymer chains that made up nylon are randomly oriented when it is first produced. When the nylon is pulled like a thread, the chains line up into thin fibers, which increases the hydrogen bonding among the chains. What property do you think this bonding contributes to the nylon?
3. Why does the nylon form only at the interface of the two solutions?
4. What are some commercial uses of nylon?