

The One That Got Away

Teacher Activity

Procedure

1. Weigh 8-10 g caprolactam and place into the test tube.
2. Weigh out 0.5 g polyoxyethylene and place in the test tube with the caprolactam.
3. Using a disposable pasteur pipette, add 20-25 drops of *N*-acetylcaprolactam to the mixture in the test tube.
4. Light your Bunsen burner. Holding your test tube with a pair of tongs, heat it gently in the flame. Move the tube about for even heating. **WARNING!** Do not point the open end of the tube toward anyone. The contents may splatter and cause burns!
5. When the mixture in the tube has melted, have your teacher add a very small amount (0.05 g or about a 5 × 5 mm square pinch at the end of your spatula) of sodium hydride to the solution in the tube. Make sure all the sodium hydride touches the solutions, and none stays stuck to the inside of the tube.
6. Heat the tube in the flame again for 2-4 minutes. Heat it just enough for the solution to come to a very gentle boil. The solution should become very thick (viscous).
7. Remove the tube from the flame. Allow it to cool slightly.
8. Insert a glass or wooden rod into the viscous liquid and draw it out again. This will draw out a thin filament of the material. One student should hold the tube, and another should hold the rod. Try to stretch the fiber out as far as you can.

Concept Development/Extension

Varying the amount of sodium hydride initiator will affect the average molecular mass of the polymer chains produced. Each molecule of NaH initiates one chain of nylon 6 polymer. Therefore, the less NaH there is in the reaction mixture, the fewer growing polymer chains there will be competing for caprolactam monomer molecules. Lowering the amount of NaH used will then increase the average molecular mass of polymer chains finally produced. Likewise, raising the amount of NaH will decrease the average molecular mass.

In general, the quality of the fibers increases with increasing molecular weight. Therefore, lowering the amount of NaH initiator will result in better fibers which can be drawn to longer lengths. Increasing the amount of NaH used in the reaction will result in poorer quality fibers which break at shorter elongations.

Safety

Because this activity uses sodium hydride and open flame, some school districts may not allow students to carry it out. So this activity can be carried out as a demonstration in such circumstances.

If you would still like your students to carry out a polymerization which is related to the story of Wallace Carothers, a very safe and easy to use activity kit called "Pull'n Polymers" is available from The Wild Goose Company. Students synthesize linear and crosslinked polyesters using only nontoxic starting materials. The company can be reached by telephone at 1-888-621-1040. This activity is relevant not

only because the chemistry of polyester synthesis is very similar to that of polyamide synthesis, but also because Carothers actually synthesized polyesters *before* polyamides.

Sodium hydride must be kept completely dry and away from water at all times. Fire may result when sodium hydride contacts water. Do not let the students handle sodium hydride themselves.

Although no special handling procedures are required for the other reagents in this procedure, remember to handle them with the same caution you would any other laboratory materials.

Make sure the students never point the open ends of test tubes at anyone when the tubes are hot. Splattering may cause burns if they do.

Post-Lab Questions

1. Describe your reaction mixture before heating.
2. Describe the reaction mixture after heating. How is it different? How is it the same?
3. If you notice any differences, how can you explain them?
4. Nylon 6 is made of long chain-like molecules. When you made the nylon 6, those chains were all tangled up in any old manner. What do you think happened to the tangled chains when you drew out a fiber?

Additional Teacher Resources

1. *The Macrogalleria* from the Polymer Science Learning Center at the University of Southern Mississippi
Nylon: <http://www.pslc.ws/macrog/nylon.htm>
Making Nylon 6: <http://www.pslc.ws/mactest/nysix.htm>
2. Making Nylon 6 and 6,10 (laboratory experiment), *The Macrolab*, from the Polymer Science Learning Center at the University of Southern Mississippi: <http://pslc.ws/macrog/lab/lab01.htm>

References

Mathias, Lon J., Vaida, Rajeev A. and Canteberry. J. B. "Nylon 6—A Simple, Safe Synthesis of a Tough Commercial Polymer," *Journal of Chemical Education*, 1985, 61(9), 805.