CHEM FAX!

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Polyurethane Foam System

The Preparation of Polyurethane Foam

Introduction

Try this amazing demonstration! Simply mix two liquids together and watch as the mixture expands to about 30 times its original volume. The result is a hardened, lightweight polyurethane foam.

Concepts

- Polymers
- Catalysis

Materials

Polyurethane Foam System (Part A and Part B)*
Acetone (optional)
Disposable cups (clear plastic, if available), 2
**Materials included in kit.*
Disposable glove, clear (optional)
Food coloring (optional)
Paper towels or newspaper
Tongue depressor or stirring rod

Safety Precautions

This activity should only be performed in a fume hood or well ventilated area. Avoid breathing any vapors produced and avoid skin contact, as both Part A and Part B may contain skin and tissue irritants. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Please review current Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. In a fume hood or well ventilated area, pour approximately 20 mL of liquid Part A in a disposable cup. *Note:* The exact volume is not critical. *Do not use glassware!* It is almost impossible to remove the hardened foam. Please use only disposable materials for the handling and mixing of the chemicals.
2. Place approximately 20 mL of liquid Part B in a second disposable cup. *Note:* The volume of Part B should be approximately equal to that of Part A.
3. If desired, add several drops of food coloring to one of the cups and stir thoroughly to mix.
4. Spread a paper towel or newspaper flat on the table and place one of the cups in the center of the paper towel.
5. Pour the contents from the second cup into the cup on the paper towel and stir thoroughly until you see the foam beginning to expand. Remove the stirring rod. *Note:* Use a disposable stirring rod, such as a tongue depressor, to stir the contents.
6. Observe the foam as it expands to about 30 times its original volume. The cup will get warm, indicating an exothermic reaction. Do not touch the foam until it is completely hardened.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. The disposable cups may be thrown in the trash. Any leftover liquids should be mixed together, allowed to react, and then the solidified polymer may be disposed of in the trash according to Flinn Suggested Disposal Method #26a. Please consult your current *Flinn Scientific Catalog/Reference Manual* for proper disposal procedures.

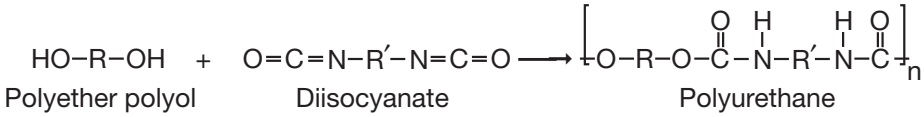
Tips

- For a fun alternative, place about 35 mL of Part A and Part B in a paper cup, mix, and then pour the mixture into a latex glove. Make sure some of the mixture is in each finger of the glove. Now watch the foam expand and fill the glove. When completely hardened, the glove can be removed (probably not in one piece), if desired. You will have made a "hand" out of the polyurethane foam. The liquid may also be placed in plastic molds.
- Any 50/50 mixture of Part A and Part B may be used, but take into consideration the amount of expansion when measuring out the liquids.
- Acetone may be used to remove any hardened polymer on the table.
- Do not touch the foam. It will take about 15 minutes for the surface to firmly set and may contain unreacted material for up to 24 hours. Some people will have allergic reactions to unreacted monomers.

Discussion

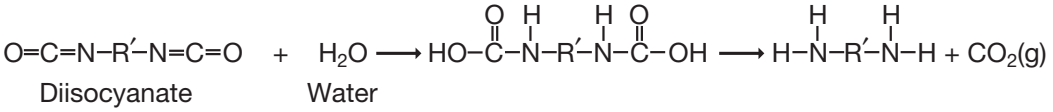
There are many forms of polyurethane such as fibers, coatings, elastomers, flexible foams, and rigid foams. The foam in this system is a rigid foam that is used in furniture, packaging, insulation, flotation devices, and many other items. Here, a rigid polyurethane foam is produced by mixing equal parts of two liquids, called Part A and Part B. This lightweight foam expands to about thirty times its original liquid volume and will become rigid in about five minutes.

Part A is a viscous cream-colored liquid containing a polyether polyol, a silicone surfactant, and a catalyst. The polyether polyol may be a substance such as polypropylene glycol [$HO(C_3H_6O)_nH$]. The hydroxyl (–OH) end of the polymer is the reactive site. The silicone surfactant reduces the surface tension between the liquids. The catalyst is a tertiary amine which aids in speeding up the reaction without being chemically changed itself. Part B is a dark brown viscous liquid containing diphenylmethane diisocyanate [$(C_6H_5)_2C(NCO)_2$] and higher oligomers (dimers, trimers or tetramers) of diisocyanate. When the polyether polyol (Part A) is mixed with the diisocyanate (Part B), an exothermic polymerization reaction occurs, producing polyurethane (see Equation 1).



Equation 1

During the course of the polymerization reaction, a small amount of water reacts with some of the diisocyanate. A decomposition reaction occurs and produces carbon dioxide gas, thus causing the solution to foam and expand in volume. Pores in the mixture are created from the gas; these pores are visible when looking at the rigid substance. The multifunctionality of both reactants leads to a high degree of crosslinking in the polymer, causing it to become rigid within minutes. (See Equation 2.)



Equation 2

Connecting to the National Standards

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

Unifying Concepts and Processes: Grades K–12
Constancy, change, and measurement

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

References

Rosato, D. V. *Rosato's Plastics Encyclopedia and Dictionary;* Hanser: New York, 1993; pp 318–320, 572.

Shakashiri, B. Z. *Chemical Demonstrations: A Handbook for Teachers of Chemistry;* University of Wisconsin: Madison, 1983; Vol. 1, pp 216–218.

Materials for the *Polyurethane Foam System* are available from Flinn Scientific, Inc.

Catalog No.	Description
C0335	Polyurethane Foam System
A0009	Acetone
V0003	Vegetable Dyes (food coloring), set/4

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