Title: Polymerization

Author(s): **Sandra Douglas**
Date Created: 2011
Subject: Chemistry
Grade Level: High School

Standards: New York State http://www.p12.nysed.gov/ciai/mst/sci/ls.html
Standard 1-**Analysis, Inquiry, and Design**
Standard 6- **Interconnectedness: Common Themes**
Standard 7-**Interdisciplinary Problem Solving**
Standard 4 Key Idea 3.2c: **Use atomic and molecular models to explain common chemical reactions**

Schedule: Two 45 minutes class periods (90 minutes)

Description:

Activity 1: The students will look at a model of a monomer using paperclips and try to determine the relationship between a monomer and a polymer.

Activity 2: Student will create nylon 66 from the reaction of adipoyl chloride and hexamethylenediamine.

Both activities will allow students to use inquiry to develop their understanding of polymers and their characteristics.

Objectives:

Students should be able to:

- differentiate between monomers and polymers
- differentiate between condensation and addition polymerization
- discuss the characteristics of polymers and relate them to their uses

Vocabulary:

- Monomer
- Polymer
- Condensation polymerization
- Addition polymerization
- Amine
- Amide

Materials:

- Beakers
- Stirring rod
- Graduated cylinders
- Hexamethylenediamine
- Adipoyl chloride
- Paperclips

Safety:

The experiment should be conducted in a fume hood as the adipoyl chloride is toxic. At the end of the activity follow the teacher's instructions for disposal of the chemicals.

Science Content for the Teacher:

Polymers are important in all aspects of life, starch, proteins, our nylon stockings that we wear, the soda bottle, the polystyrene cups and polyvinyl chloride (PVC) pipes are just a few of the polymers we encounter everyday. There are two ways to produce polymers; addition and condensation polymerization. **Addition polymerization** is the addition of simple molecules (**monomers**) to form long chain molecules (polymer). In **condensation polymerization**, **monomers** combine removing water to form **polymers**. In this lesson, we will manufacture nylon and see how the structure is related to its properties and uses. Nylon 66 contains an **amide** bond produced by condensation of two monomers, an **amine** and an acid derivative.

Classroom Procedure:

1. In Activity 1 students will create their own polymer using the paperclips in Model 1.

Model 1

MONOMER

?

Students will answer the following questions:

Essential Questions

A. If the single unit in the model is called a monomer, what would you call a chain of the units?
B. Describe the difference between a monomer of paperclips and the chain of paperclips that you made.
C. What is the relationship between a monomer and a polymer?

Adapted from: http://pogil.org/uploads/media_items/polymers.original.pdf

2. In Activity 2 students will prepare nylon 66 using the Model 2, do a lab write-up based on the scientific method: Purpose, Materials, Procedure, Observation, Summary Questions and Conclusion.

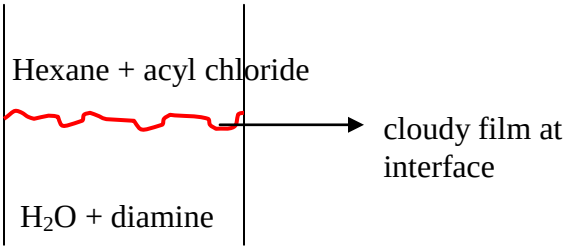
Model 2

Prepare nylon 66 by reacting hexamethylenediamine with adipoyl chloride.

$$n\ H_2N(CH_2)_6NH_2 + n\ Cl(O{=}C)(CH_2)_4(C{=}O)Cl \rightarrow \text{--}[\text{--}HN(O{=}C)(CH_2)_4(C{=}O)NH(CH_2)_6\text{--}]_n\text{--} + n\ HCl$$

Lab Procedure

- Pour 25 mL of aqueous solution of hexamethylenediamine (4% in 0.75M NaOH) into a 100 mL beaker.
- Carefully add 25 mL of a 4% solution of adipoyl chloride (dissolved in cyclohexane solvent) to the hexamethylenediamine by pouring it down the side of the tilted beaker such that it ends up floating on the top of the aqueous solution.
- At the interface between the two solutions you should see the nylon forming. (See diagram)
- Use the stirring rod to free the walls of any strands of nylon and push the material from the center. Lift the nylon, twisting as you pull (about a yard).
- Rinse the nylon several times with water.



Assessment:

- Teacher created laboratory report from Rubistar

Your Rubric Lab Report Nylon 66.htm

CATEGORY	4	3	2	1
Question/Purpose	The purpose of the lab or the question to be answered during the lab is clearly identified and stated.	The purpose of the lab or the question to be answered during the lab is identified, but is stated in a somewhat unclear manner.	The purpose of the lab or the question to be answered during the lab is partially identified, and is stated in a somewhat unclear manner.	The purpose of the lab or the question to be answered during the lab is erroneous or irrelevant.
Materials	All materials and setup used in the experiment are clearly and accurately described.	Almost all materials and the setupu used in the experiment are clearly and accurately described.	Most of the materials and the setup used in the experiment are accurately described.	Many materials are described inaccurately OR are not described at all.
Procedures	Procedures are listed in clear steps. Each step is numbered and is a complete sentence.	Procedures are listed in a logical order, but steps are not numbered and/or are not in complete sentences.	Procedures are listed but are not in a logical order or are difficult to follow.	Procedures do not accurately list the steps of the experiment.
Observation	Observations are clearly stated.	A few observations recorded.	Observations are somewhat unclear.	Observations are stated but very disorganized and unclear.
Conclusion	Conclusion includes whether the findings supported the hypothesis, possible sources of error, and what was learned from the experiment.	Conclusion includes whether the findings supported the hypothesis and what was learned from the experiment.	Conclusion includes what was learned from the experiment.	No conclusion was included in the report OR shows little effort and reflection.
Scientific Concepts	Report illustrates an accurate and thorough understanding of scientific concepts underlying the lab.	Report illustrates an accurate understanding of most scientific concepts underlying the lab.	Report illustrates a limited understanding of scientific concepts underlying the lab.	Report illustrates inaccurate understanding of scientific concepts underlying the lab.

Safety	Lab is carried out with full attention to relevant safety procedures. The set-up, experiment, and tear-down posed no safety threat to any individual.	Lab is generally carried out with attention to relevant safety procedures. The set-up, experiment, and tear-down posed no safety threat to any individual, but one safety procedure needs to be reviewed.	Lab is carried out with some attention to relevant safety procedures. The set-up, experiment, and tear-down posed no safety threat to any individual, but several safety procedures need to be reviewed.	Safety procedures were ignored and/or some aspect of the experiment posed a threat to the safety of the student or others.

- Homework (5 points)

Polyester contains many esters.

- How do we form esters? (2 points)
- Describe briefly how you would make polyesters. Your discussion must include the type of polymerization, the monomer and polymer. (2 points)
- While there are many man-made polymers, there are natural polymers. List two natural polymers. (1 point)

Acknowledgements:

High School Chemistry: *POGIL Activities for High School Chemistry*
http://pogil.org/uploads/media_items/polymers.original.pdf

Rubistar
http://rubistar.4teachers.org

CCMR- Polymer Characterization Facility (Experiment 7-Organic Polymers)
Anthony Condo, Facility Manager Polymer Characterization Facility

CCMR Education Staff