Hot Crossed “Many-mers”…. (Thermoset Polymers)

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Target Grade Levels: 10-12
Subject Areas: Chemistry
Time Required: 8-10 (90 minute blocks)

Lesson Objectives:
- Explain how important bio-molecules can be built by the polymerization of simpler molecules containing various functional groups.
- Develop an experiment to modify the properties of a thermoset polymer.
- Develop a model to describe why changing variables in their experiment changes the properties of the polymer produced.

Next Generation Science Standards:
- Refining, and evaluating empirically testable questions and design problems using models and simulations
- Develop and use models
- Plan and carry out investigations
- Analyze and interpret data

Lesson Summary

The purpose of this lesson is to have students engage in scientific process. Students will participate in valid scientific research with polymer to investigate how the polymerization process assembles the complex molecules necessary for life and industry from simpler building blocks. The role of hydrogen bonding in the creation of polymers will be discussed as well.

Students will do an authentic qualitative research project on the formation of a thermoset (polymer that has undergone curing). They will design an experiment to modify the properties of the thermoset material and will evaluate their product for hardness, toughness.

Students will then analyze the products and discuss what properties would be beneficial for different industrial applications and offer solutions for how they might change their product.

Materials Required:
- Chemicals (List on web)
- Oven or hot plate

Partners
Eric W. Cochran, PhD, Department of Chemical and Biological Engineering, Iowa State University

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The following is an overview of the order of skills and understanding the students will develop during this unit. The project is an extension activity that will allow students to explore factors that affect the development of thermoset polymers.

**Developing Prior Knowledge (4 blocks)**

1. Students will do comparative analysis of the boiling points of diatomic elements, polar molecules and hydrides to evaluate how the number of electrons influences the strength of attractions.
2. Students will infer the relative strength of the types of bonds based on their boiling points.
3. Students will examine examples of solvent-solute interactions as well as observe organic functional groups.
4. Students will understand how polymerization forms large molecules that are essential to life and how hydrogen bonding is important to the structure.

**Lesson (4 blocks)**

5. Students will understand how behavior of organic compounds is governed by functional groups.
6. Students will design and implement an experiment to determine what factors that will change thermoset properties. 
   
   *After the initial experiments are run, groups may be given 30 minute time periods to modify and rerun experiments.*

**Extensions**

Student groups may research factors that affect the properties of thermosets. They can then related that information to their product. (Possible factors may include number of crosslinks, length of polymer chains, etc.) Students will validate, based on their research, how their change may have affected the structure of their polymer. (e.g. temperature increased thus less chains were made resulting in a more brittle material)

**Teaching Tips**

Time will need to be allotted for students to redo and revisit their lab design and processes. While making thermosets can be a relatively quick process there is potential for errors that would cause students to have non results. It is important for student to have a chance to reproduce and modify their experiments as necessary.