Bouncy Ball Polymerization Reaction

Basic Experimental Procedure

1. Mix 2 Tablespoons of warm water with ½ tsp of borax and stir to dissolve. Label this "Borax solution". (This step can be done ahead of time and the mixture can be scaled up)

2. Place 1 Tablespoon of Elmer's glue into a container. Dixie cups work well as the container.

3. Add ½ tsp of the Borax solution and 1 Tablespoon of cornstarch to the container with glue. Wait 15 seconds and then stir. You want as uniform a mixture as possible.

4. When you are unable to keep stirring, remove the mixture from the cup and mold it with your hands until it becomes solid.

5. Record observations about the appearance and size of the bouncy ball in your lab notebook.

6. Test the bouncy ball and record your observations.

Background Chemistry

Polymers can be thought of as long strings of units. The units can all be the same or can differ and they can repeat or appear in a random order. For example, Nylon, Kevlar, and PVC (polyvinyl chloride) are well known synthetic polymers, while DNA is a natural polymer made of a series of base pairs connected by a phosphate backbone. In this experiment, we focus on a polymerization reaction where Borax (Na2B4O7) is used to form connections between the polyvinylacetate molecules in Elmer's glue. The process of cross-linking the polyvinylacetate changes the physical properties of the glue. Students should be encouraged to make observations about how the bouncy ball is different from the glue they started with.

Scientists design polymers for specific applications. The ability to change the units with a polymer and how they are connected, allows scientists to control what properties their polymer will have. Some polymers are stiff and some are stretchy, some can be torn by hand and others like Kevlar are hard to damage. Although most people think of plastics like plastic water bottles or Ziploc bags when considering the uses of polymers in everyday life, polymers (and plastics) are also used as coatings and incorporated into many items. Plastics are used to make contact lens, are incorporated into athletic clothing, and used to create playground structures. Polymers are even incorporated into paper money and cosmetics. The use of polymers is ubiquitous in society, because they can be made at low cost. However, pollution from plastics has become a problem for the environment. This means we need to develop new polymers that have the

properties we need and that are biodegradable or can be recycled. This is a new challenge for scientists and engineers to design better materials.

Variations and Additional Experiments

After making the first bouncy ball, students should hypothesize how they can adjust the procedure to make a "better" bouncy ball. They can start with a Borax solution with a different concentration or add more or less of one of the ingredients. When forming a hypothesis, students should be encouraged to not only predict a change will occur, but to predict the change they expect and why they expect that change. They can then test their hypothesis and continue to refine their understanding of this chemical reaction.

Additional Resources

The Bouncy Balls were made by a polymerization reaction, this is similar to the reactions that occur for making the plastic materials that surround us. Plastics (aka polymers) are incorporated into toys, car parts, cell phone cases, cosmetics, money, and even in clothing. The materials below provide resources to help you make connections between the Bouncy Ball chemistry and real-world applications. In the experiment, students performed a polymerization reaction and modified the recipe in order to change the properties of their final product. Chemists do this when designing polymers for use in all sorts of applications. This experiment can be related to the development of plastics for specific applications or to the development of biodegradable plastics.

- The Compound Chemistry website: https://www.compoundchem.com/ is a great resource for infographics about chemistry and its applications. The site is Andy Brunning who is a chemistry educator in Cambridge, UK. The infographics can be downloaded for free for use in classrooms as they fall under educational use.
    - "The Chemistry of Silly Putty"
    - https://www.compoundchem.com/2015/11/10/sillyputty/
    - "A Guide to Common Household Plastics"
    - https://www.compoundchem.com/2015/04/30/plastics/
    - "What's your biodegradable coffee cup made of – and how biodegradable is it?" https://www.compoundchem.com/2019/06/26/biodegradable-plastics/
    - "The Chemistry of Nail Polish – Polymers, Plasticizers and Pigments" https://www.compoundchem.com/2017/04/06/nail-polish/
    - "Developing Cheaper Lab-on-a-chip Devices with 3D Printing"
    - https://www.compoundchem.com/2016/11/02/rtcweek-labonachip/
    - Kevlar: https://www.compoundchem.com/2014/06/22/kevlar/
    - "The Materials Science of Athletics Tracks"
    - https://www.compoundchem.com/2021/08/07/athletics-track/
    - "What are Lego Bricks Made of?"

- https://www.compoundchem.com/2018/04/09/lego/
- “The Chemistry of Paper and Polymer Banknotes”
- https://www.compoundchem.com/2016/09/20/banknotes/
- “The Chemistry of Football (Soccer) Shirts”
- https://www.compoundchem.com/2018/07/15/football-shirt-2018/
- “The Chemistry of Contact Lenses”
- https://www.compoundchem.com/2015/10/13/contactlenses/
- Chemistry of Teflon for Non-Stick Pans
- https://www.compoundchem.com/2016/02/04/teflon/
- “The Chemistry of Superglue”
- https://www.compoundchem.com/2015/10/15/superglue/
- “The Chemistry of the Euro 2016 Ball”
- https://www.compoundchem.com/2016/06/14/euro2016ball/