**Creating and testing durability of biodegradable polymers with different amounts of catalyst and initiator**

**Abstract:**This lab was conducted to explore the relationship between monomer, initiator and catalyst ratios and polymer strength. After they were made and had hardened, the polymers were tested for strength through two different tests, the drop weight test and the rod hanging weight test. We expected to have seen that the polymers with the smaller amount of initiator and catalyst are stronger. Polymers with fewer initiators and catalysts will be stronger because they will have longer chains and stronger intermolecular attraction. On the other hand, polymers with more initiator will be weaker. The results from the first test show that the strength of the polymer is greater when there are smaller amounts of initiator and catalyst. The second test proved inconclusive but we should have seen the same thing, as the initiator and catalyst goes up the durability goes down. This inaccuracy could have been caused because of an inaccurate testing apparatus or discrepancies during mold creation.

**Introduction:**The purpose of this lab was to polymerize monomers into different length polymers by controlling the amount of catalyst and initiator, to design testing methods to assess the physical properties of the polymers created, and to demonstrate and explain the differences in physical properties based on structure.   
Polymers made up of long chains of molecules. They are made through a process called polymerization. This process includes linking the smaller molecules called monomers together to form a long chain. The word polymer translates to many monomers. In this lab, polymers were created through the chain-growth polymerization. This means that the polymerization happened through sequentially adding one monomer at a time to the end of a polymer chain. An initiator causes the monomer, caprolactone, to unwind and change structure, which is the start of the polymerization process. This now unwound caprolactone will influence the next molecule to unwind just the same and then the two unwound molecules will bond together. This process will repeat itself, lengthening the molecule as it goes. The catalyst then comes in to lower the energy that this reaction requires which makes the reaction happen at a lower temperature and faster speed.  
The microstructure of the polymer often can dictate the properties of that polymer. For example: polymers with longer chains will be stronger with a higher destruction point and a higher melting point because the longer chains have a higher intermolecular attraction. The opposite goes for shorter chains.

**Methods:  
Creating the Molds:**In this lab, multiple molds were made for the making of the polymers: two rods, a puck, and a spoon. The rod mold was made out of scoopulas. To make these, two scoopulas, preferably of slightly different sizes were taped securely together with metal-backed tape. Then, with test tube brushes the scoopulas were thoroughly greased and then plugged from the flat side. Then an additional piece of tape was added to the bottom to prevent leakage.

**Creating the Polymer:  
*Safety Concerns:*** *while conducting this lab be sure to wear eye protection, a lab apron, and disposable gloves. Some of the materials in this experiment, such as: the monomer, the catalyst, and the initiator are irritants as well as flammable. All chemicals used in this experiment are harmful if inhaled or ingested. All work must be conducted under a fume hood.*

The first step was to place a magnetic stir bar in a 125ml Erlenmeyer flask. Then, with a 100ml graduated cylinder, 85ml of caprolactone was added to the flask Next 1-ocanol was added using a 1ml syringe. Then, the instructors in the supply room gave each group a specific amount of stannous octoate. Next, using the provided stands and clamps in the fume hood, students arranged the hot plates, the Erlenmeyer flask and the thermometer in a way so that the bulb of the thermometer was fully submerged in the flask. Then, students were to record how much time it took the reaction to heat up to 120°C. The viscosity of the mixture was monitored throughout the heating. The goal is for it to reach the consistency of syrup. Now it was time to turn off the hot plate and remove the flask with a hot mitt. While still holding the flask with a hot mitt, as it is extremely hot, students poured the reaction into the molds over a surface lined with wax paper to prevent spills. They were to first, fill the puck mold, then the spoon/Santa Clause, and the scoopula mold last. When filling the scoopula mold, student had to use test tube clamps and pour the mixture slowly to eliminate the possibility of any air bubbles. Then, all of the molds were taken to the oven to solidify.

To determine the properties of these polymers two tests were conducted. First, to test the pucks, the class made a hammer drop test. The puck of each type of polymer A-G was placed on a platform and the hammer was dropped from increasing heights starting at 15°. *(see Table 1 for test results).* The second was a suspended weight test for the rods. Two tables were separated and a rod was placed in between the tables. A string was tied to the rod and weights were added until the rod broke. *(see Table 2 for test results).*

**Results:**

***Table 1: Drop hammer test.***

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Group Letter** | **Test 1** | **Test 2** | **Test 3** | **Test 4** | **Test 5** | **Test 6** |
| A | 15° | n/a | n/a | n/a | n/a | n/a |
| B | 60° | 15° | 30° | n/a | n/a | n/a |
| **C** | 30° | 15° | 45° | n/a | n/a | n/a |
| D | 60° | 90° | 30° | 30° | 15° | 75° |
| E | 15° | 30° | n/a | n/a | n/a | n/a |
| F | 15° | 30° | n/a | n/a | n/a | n/a |
| G | 34° | n/a | n/a | n/a | n/a | n/a |

***Table 2: Rod hanging weight test.***

|  |  |  |  |
| --- | --- | --- | --- |
| **Group Letter1** | **Test 1 (grams)** | **Test 2 (grams)** | **Average breaking point (grams)** |
| **A** | 650 | 550 | 600 |
| **B** | 800 |  | 800 |
| **D** | 1032 |  | 1032 |
| **E** | 982 |  | 982 |

The first test suggests that with less initiator the polymer has longer chains. The longer the chain the stronger the intermolecular forces within the polymer. A polymer with stronger intermolecular forces will be more durable. The results from the second test were inconclusive but should have proved the same thing.

**Discussion:**This lab was conducted in order to create biodegradable polymers with different amounts of catalyst and initiator, and then to test their durability and discover which polymer- the one with more or less catalyst and initiator- is more durable. This was tested through the drop weight test and the hanging weight test. The polymers were made with caprolactone, 1-octanol and catalyst all heated to 120°C, this mixture was then poured into molds and left to harden. Then, the polymers went through the drop weight test and the hanging weight test and their results were recorded into tables. The results from the drop weight test proved that polymers with more initiator and catalyst are stronger because they have longer chains and stronger intermolecular forces. The hanging weight test was inconclusive with ranging results.