Lab 1: Making Plastic from Potato and Corn Starch

Objective

To understand how the glass transition temperature of polymeric materials are impacted by plasticizers.

Background

Society predominately uses three categories of materials: metals, ceramics and glasses, and polymers. What about natural materials such as wood, cotton, and silk? These materials are composed of polymers as well. In fact, starch from different plant sources is a polymeric material that our body breaks down into monomers (glucose) for energy. However, starch in its polymeric form can be transformed into "thermoplastic" starch that can serve many applications. In this laboratory exercise we will modify starch and investigate its viscoelastic properties.

Q: Do you think the starch from one plant will be different than another plant? Explain.

Laboratory format

The lab will take place over two lab sessions. The first week the lab groups will modify potato and corn starch and then "solvent-cast" films. During the following week the class will qualitatively measure the mechanical properties of the films.

Data Analysis

For the first week, there is no data to collect. The following week the class will mechanically test the films and record observations. How much can the film be deformed prior to breaking (approximate elongation at break (EAB))? This will be a ratio of the original length to the length at break, measured with a ruler. Additionally, take pictures of the broken samples, put them in the report, and describe and analyze the images (see below in the report section). Each group will report the elongation at break observations at the end of the lab session.

EAB (slow deformation rate): Potato, Potato(Gly), Corn , Corn(Gly)

EAB = (Total length at break- original length) / original length * 100%

For each sample type, the data must be averaged together, the standard deviation reported, along with the coefficient of variation (COV) and T-Tests to compare the means of the plasticized potato starch vs. the plasticized corn starch film.

Lab 1, Part 1: Film Preparation

Procedure (adapted from RSC Advances "Making a Plastic from Potato Starch")

In this activity you will make plastic films from potato and corn starch. You will use hydrochloric acid to break down the polymers in starch (the high molecular weight starch is not very soluble).

This changes the polymers' structure and properties. Starch comes as micron size packets of starch polymer chains assembled in a specific pattern within a granule. Placed in water these particles form a *dispersion* of particles. The polymer chains that make up the granule are not real soluble because of their size-- the acid will break these chains until they are soluble. You will make two different batches of the potato/corn plastics from acid treated starch. In one you will add some propan-1,2,3-triol (also known as glycerol), which will act as a plasticizer. In the other batch, you will leave the propan-1,2,3-triol out.

To prepare these batches, put 35 ml distilled water into a 50 ml tube and add 3.5 g potato starch, 4 ml 0.1M hydrochloric acid, and 3 ml propan-1,2,3-triol. Cover the test tube with foil and heat in boiling water. Boil gently for 15 minutes, stir occasionally with a glass rod and check periodically that it does not boil dry – if it looks like it might, then stop heating. Carefully remove the tube from the boiling water and dip a glass rod into the mixture and using pH indicator paper, measure the pH. Add enough 0.1M sodium hydroxide solution to neutralize the mixture, mixing well before testing. You will probably need to add about the same amount of sodium hydroxide as you did acid at the beginning (4 ml). Test pH after each addition of sodium hydroxide solution.

If you wish you can add a drop of food coloring (careful not to spill as it stains) and mix thoroughly. Pour the mixture onto a labelled petri dish and push the mixture around with the glass rod until you have an even covering. Place Petri dishes on the side bench to dry. Petri dishes will be dried in 40°C oven.

Repeat process substituting corn starch instead of potato starch. Repeat the steps described above, but leave out the propan-1,2,3-triol for the third and fourth batch. Make sure you label your mixtures so that you know which one contains propan-1,2,3-triol and which does not.

At the end of this lab session, each group will have 4 petri dishes containing mixtures which will be tested during the following lab session.

Lab 1, Part 2: Testing

Remove film from petri dish. Take scissors and cut the film into approximately 0.5 cm wide strips (8 strips). These will be your test samples. Take a few pictures of your samples and measure each sample (length).

Practice strips: Take a sheet of paper and cut 2 to 6 strips similar in size to your test strips. These paper strips are your calibration samples to practice deforming the samples and data will not be reported.

Hold the film strips near the measuring device (ruler) and pull on the ends. Have a second person watch and check if any deformation is observable. It is very challenging to observe any deformation with these strips, so you must estimate the amount of deformation (0.1mm would be suitable for no observable deformation). If a group chooses, one person can use a camera phone to record the deformation process and then use the movie to analyze for deformation. This is an extremely qualitative test so pay close attention! Take pictures of your failed films for your report.

Additionally, take some left-over film strips and devise another simple test, such as how much can the sample bend before it breaks? Or if the film is held on the edge of the desk, and a pressure is applied, does it feel rigid/stiff or relatively soft? This secondary data will not be shared with the class, but must be used in your discussion section in your report.

Laboratory report

Follow the guidelines for general lab reports included in the laboratory handout. For your results section, insert a photo of your samples. Describe what the photo shows in your results section and annotate (place arrows or boxes, etc. to call the reader's attention to details in the image) as required. Some questions that could be answered by the description: What does the fracture surface look like, is it flat and square, and is it deformed such as stretched and necked down? What observations did you make about the film, such as was one film type easier to deform than the other? Additionally, report the elongation at break values for the different films in a tabular form that lists average, standard deviation, and COV. Make comments about the difference in averages and note if the COV is larger for any of the particular film types. If so, describe why you think this is so. Also in your results section describe the properties of the films as determined by the other simple test your group devised. In your discussion section, discuss the film properties and use these following terms: plasticizer, viscoelasticity, modulus of elasticity, glass transition temperature, toughness, and brittle behavior. It would be excellent to research what are the different properties of potato starch vs. corn starch and use this information in your discussion why you did or did not observe differences. Finally, describe a potential application for the non-plasticized starch, based on its behavior.