II- Examples of condensation polymerization

1-Nylon 6,6 Synthesis

Background

Nylon 6,6 is the polymer used to help show how step-growth polymerization works in this lab. Step-growth polymerization can have any polymer or monomer react, so the monomers disappear quickly. The molecular weight increases slowly because the monomers react, but the molecular weight increases quickly towards the end of the polymerization because small chains are forming larger chains. There is also another product besides the polymer after polymerization. For example, after Nylon 6,6 forms, the leftover product was water. Step-growth polymerization often requires two different monomers to form one polymer. Step-growth polymerization occurs when monomers start to join together. Any monomer can star forming chains, so the molecular weight is low. Towards the end of the process, the small chains start to form larger chains, so the molecular weight increases dramatically.

Procedure

Materials

1) 10mL - 0.35 M aqueous hexamethylenediamine

2- 10mL – 5 vol% adipoyl chloride in cyclohexane solvent

(3) 10 Drops – 20wt% aqueous sodium hydroxide

We prepared 25mL of the first component, 0.35M aqueous hexamethylenediamine, using 1 gram of 1,6 hexanediamine and 25mL of water. 10mL were poured into a 50mL beaker and then set aside for later. 20mL of the second component, 5 vol% adipoyl chloride, was made from 1mL of adipoyl chloride and 19mL of cyclohexane. 10mL were set aside and covered in order to prevent evaporation. Finally, the last component (20wt% aqueous sodium hydroxide) was made from 5g of sodium hydroxide pellets and 20mL of water.

Synthesis

10 drops of the sodium hydroxide solution was added to the 50mL beaker containing 10mL the hexamethylenediamine solution. The beaker was tilted at a 45° angle and the 10mL of adipoyl chloride was slowly poured down the side of the beaker to slowly add it to the solution. A polymer film formed immediately at the liquid-liquid interface and stuck to the outside of the beaker.

Shows the liquid-liquid interface with Nylon 6,6 forming in between.

We used a copper wire with a hook on the end to break the nylon free and then gently pulled the wire up out of the solution in the middle of the beaker. A rope formed on the end of the wire; we pulled it for a few feet, broke the rope and placed it on a paper towel to dry out. The rest of the solution was stirred and a

ball of polymer was formed on the end of the wire hook. This was also dried by squishing the ball between sheets of paper towels. The rope and the ball were placed in a glass jar and labeled with our group number, the date, and the contents of the vial. All waste was disposed of in either the aqueous or organic waste containers.

Nylon Rope video

تابعى هذا الفيديو لتوضيح بلمرة النايلون

https://www.youtube.com/watch?v=uKwr2-qtG4Y

This video shows the pulling of our rope of Nylon 6,6. It is clear that the rope is thin, white, and opaque, and pulls easily from the solution.

Results & Discussion

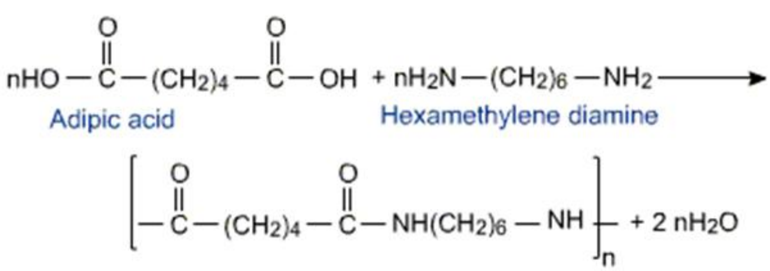
Nylon 6,6

During the synthesis of Nylon 6,6, the solution started to become foggy with a white precipitate. There was also a distinct inter-facial area between the two solutions. This area was clouded, whereas the separate solutions were clear. After the rope and bulk polymer were created, they appeared to be white and very fragile. They both seemed to contain a lot of the solution they were created from, especially the nylon bulk. Both forms of the nylon were flexible, but the nylon bulk seemed to be a lot more resistant to tearing than the nylon rope. This is because the chains in the bulk are randomly oriented, which makes its properties more isotropic. The nylon fiber was strong in the direction of orientation, but its transverse properties were much weaker.

These pictures show the before and after "squishing" pictures of the Nylon rope and bulk polymer. The bulk polymer contained much more water initially.

Nylon was synthesized in an interfacial polymerization in this lab. If this step-growth reaction were run in a bulk polymerization similar to that of the synthesis of polystyrene, the molecular weight would have increased. When there is more initiator and monomer in the reaction, the total molecular weight of the final product will be increased.

The name Nylon 6,6 is derived from the fact that both the diamine and diacid used in the reaction donate 6 carbons to the polymer chain during synthesis. The chemical structure of the repeat unit in Nylon 2,2 would be the same, except each diamine and diacid would have 4 less CH2 groups. Aside from that difference, the chemical structures would be the same.



Sodium hydroxide (NaOH) was added to the hexamethylenediamine solution in order to react with the hydrochloric acid (HCl) produced when the hexamethylenediamene reacts with the adiptic acid. The NaOH maintains the

pH of the solution by reacting with the HCl to form NaCl and water. This removes HCl from the solution and pushes the reaction towards the products.