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Polymerization: Synthesis of Polyamide-6,10
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Overview

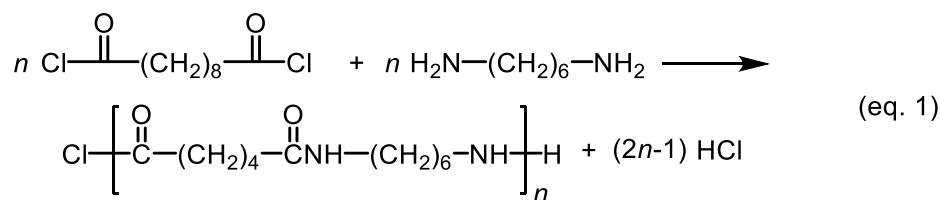
Polymers are made out of macromolecules, which are made out of repeating units, the so called monomeric units. In our modern world, polymers play an important role. One of the first important polymers was nylon, which is a polyamide. It found widespread application in tooth brushes and stockings.

Principles

There are two main ways of polymerization. The chain growth reaction is one of them, which can be differentiated into radical, cationic, anionic and coordinative polymerization. Step-growth polymerization is the other main way of making polymers. Bi-functional or multifunctional monomers react to ultimately form polymers. Step-growth polymerization can be further differentiated into condensation polymerization and addition polymerization.

In addition polymerization, monomers will add to another to form the polymer. Whereas in a condensation polymerization, two monomers will add in a condensation reaction under the release of water or another small molecule like hydrogen chloride.

In this synthesis of a polyamide, a dicarboxylic acid chloride condenses with a diamine to form a polyamide, under the release of hydrogen chloride. The notation 6,10 in the name of polyamide-6,10 reflects the number of carbons in the diamine monomer (six in this case) and the number of carbons in the dicarboxylic acid chloride monomer (ten in this case).



One characteristic of a step-growth polymerization is the dependence of the chain length and the conversion of the polymerization. At the beginning of the reaction most monomers will condense to mainly form dimers and trimers. With further progress, the dimers and trimers will combine to oligomers and only after high conversion rates, when most monomers have reacted, the oligomers will condense to form polymers with a high number of monomeric units. This phenomenon is illustrated in figure 1.

In this experiment the polyamide forms through a so called surface polymerization. In an inhomogeneous solution, consisting of an aqueous and organic solution, the polymerization will take place at the interface of the two layers. The diamine monomer is dissolved in water, while the dicarboxylic acid is dissolved in an organic solvent.

Procedure

- 1) Preparation
 - a) To a 250 ml beaker, add 3 ml (14 mmol) of sebacoyl chloride in 100 ml *n*-hexane.
 - b) To a 150 ml beaker, add 4.4 g (38 mmol) of 1,6-diaminohexane in 50 ml dist. water.
 - c) Add approx. five drops of a phenolphthalein solution to the 1,6-diaminohexane solution
- 2) Surface polymerization
 - a) Overlay carefully the aqueous solution with the sebacoyl chloride solution.
 - b) A thin layer will form at the interface of the aqueous solution and the organic solution
 - c) The added phenolphthalein will make the interface visible
- 3) Collecting the Polymer
 - a) Pull the formed polyamide film from the interface with tweezers and wrap it around a glass rod
 - b) Wind the polyamide on glass rod
 - c) Wash the polymer with acetone and then with copious amounts of water
 - d) Dry the polymer at 50 °C under reduced pressure

Representative Results

A hollow, long strand of polyamide is obtained.

Summary

This experiment showcases in a vivid way the synthesis of a polymer in a simple fashion. The condensation polymerization of 1,6-diaminohexane and sebacoyl chloride gives a polyamide-6,10, which polymerizes at the interface of two liquid layers. This surface polymerization will form a hollow strand of polyamide, after pulling the polymer from the interface and wrapping it around a glass rod to wind it.

Applications

Polymers and polyamide find a variety of different uses in our daily life. Initially used for toothbrushes and stockings. Today, polyamide is used in the production of textiles, like rain coats, outdoor clothes, lab coats and flight jackets. Due to its strength and toughness, polyamides are also used in parachutes, climbing ropes and sails. These applications make polyamides to one of the most important polymers we are using today.

Legend

Figure 1. Condensation Polymerization

Figure 1

