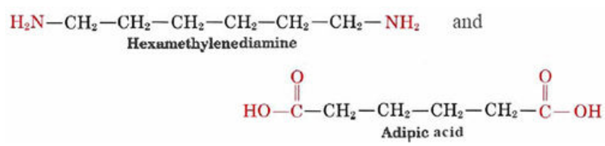
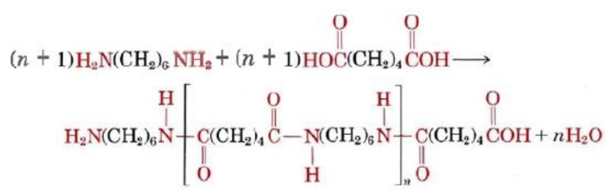
8.25: Condensation Polymers

When addition polymers are formed, no by-products result. Formation of a condensation polymer, on the other hand, produces H_2O, HCl, or some other simple molecule which escapes as a gas. A familiar example of a condensation polymer is *nylon*, which is obtained from the reaction of two monomers



Structure of hexamethylenediamine. Its "N" "H" 2 groups are highlighted in color. Structure of adipic acid is also shown with its "C" double bond "O" single bond "O" "H" highlighted in color.

These two molecules can link up with each other because each contains a reactive functional group, either an amine or a carboxylic acid which reacts to form an amide linkage. They combine as follows:



Equation shows the "N" "H" 2 functional group of an amine reacting with a "C" "O" "O" "H" group from a carboxylic acid. This forms a "N" "H" "C" double bond "O" group linkage between the two reactants. Water is a byproduct.

Below is a video of the reaction to form nylon. This reaction is slightly modified from the one described above, as adipoyl chloride, not adipic acid, is used as a reactant. Thus HCl, not H_2O is produced. This also means that the chain terminates in an acid chloride, rather than the carboxylic acid shown above. Note that an amide linkage is still formed.

A solution of adipoyl chloride in cyclohexane is poured on top of an aqueous solution of 1,6-diaminohexane in a beaker. Nylon (6,6) polyamide is formed at the interface of the two immiscible liquids and is carefully drawn from the solution and placed on a glass rod. The rod is then spun, and the Nylon (6,6) polyamide is spun onto the rod.

Well-known condensation polymers other than nylon are Dacron, Bakelite, melamine, and Mylar. Nylon makes extremely strong threads and fibers because its long-chain molecules have stronger intermolecular forces than the London forces of polyethylene. Each N—H group in a nylon chain can hydrogen bond to the O of a C=O group in a neighboring chain, as shown below. Therefore the chains cannot slide past one another easily.

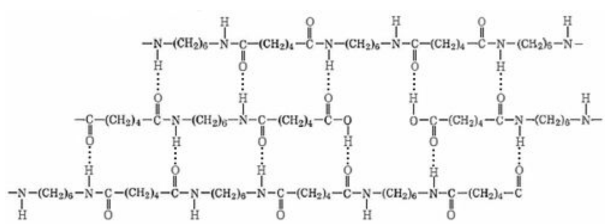


Figure 8.25.1: The three nylon molecules are held together by hydrogen bonding. The N-H group of one chain hydrogen bonds to the C=O group of another chain. This makes nylon quite strong and difficult to pull apart.

If you pull on both ends of a nylon thread, for example, it will only stretch slightly. After that it will strongly resist breaking because a large number of hydrogen bonds are holding overlapping chains together. The same is not true of a polyethylene thread in which only London forces attract overlapping chains together, and this is one reason that polyethylene is not used to make thread.