

**B.Sc. Semester-VI  
Organic Chemistry  
Paper-XIV**

**2. Synthetic Polymers**

**Coverage:**

**9. Polyamides**

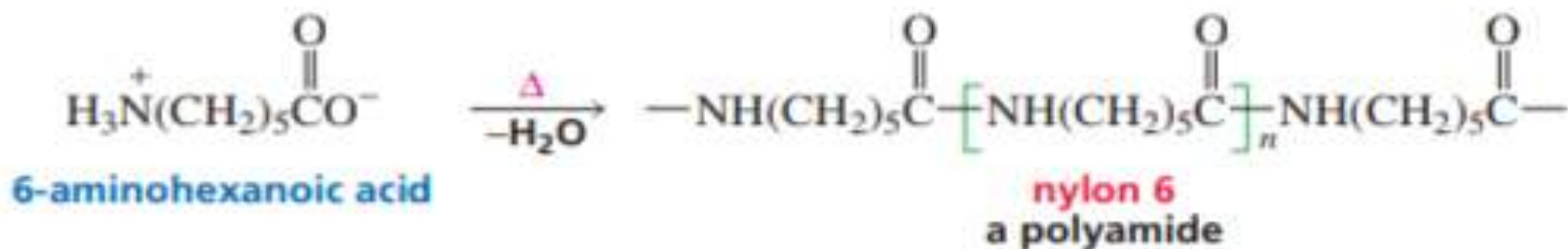
**10. Polyesters**



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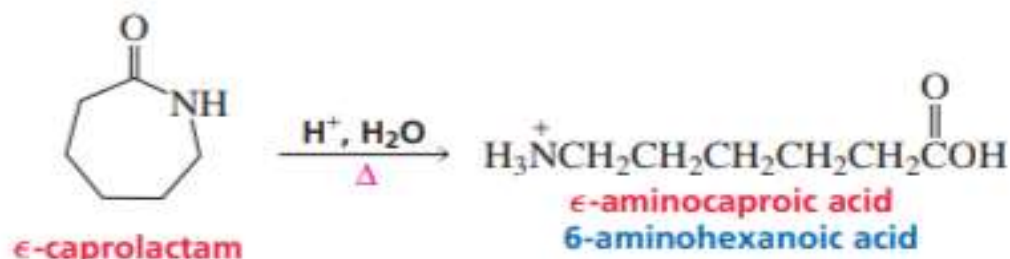
## 9. Polyamides

Nylon is the common name of a synthetic **polyamide**. Nylon 6 is an example of a step-growth polymer formed by a monomer with two different functional groups. The carboxylic acid group of one monomer reacts with the amino group of another monomer, resulting in the formation of amide groups. Structurally, the reaction is similar to the polymerization of  $\alpha$ -amino acids to form proteins (Section 23.7). This particular nylon is called nylon 6 because it is formed from the polymerization of 6-aminohexanoic acid, a compound that contains six carbons.

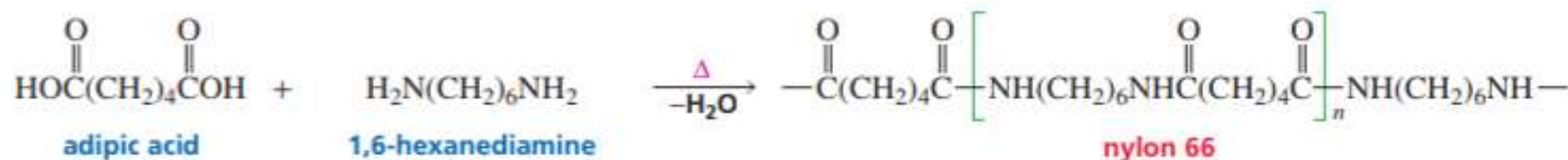


*Nylon was first synthesized in 1931 by **Wallace Carothers (1896–1937)**. He was born in Iowa and received a Ph.D. from the University of Illinois. He taught there and at Harvard before being hired by DuPont to head its program in basic science. Nylon was introduced to the public in 1939, but its widespread use was delayed until after World War II because all nylon produced during the war was used by the military. Carothers died unaware of the era of synthetic fibers that dawned after the war.*

The starting material for nylon 6 is  $\epsilon$ -caprolactam. The lactam is opened by hydrolysis.

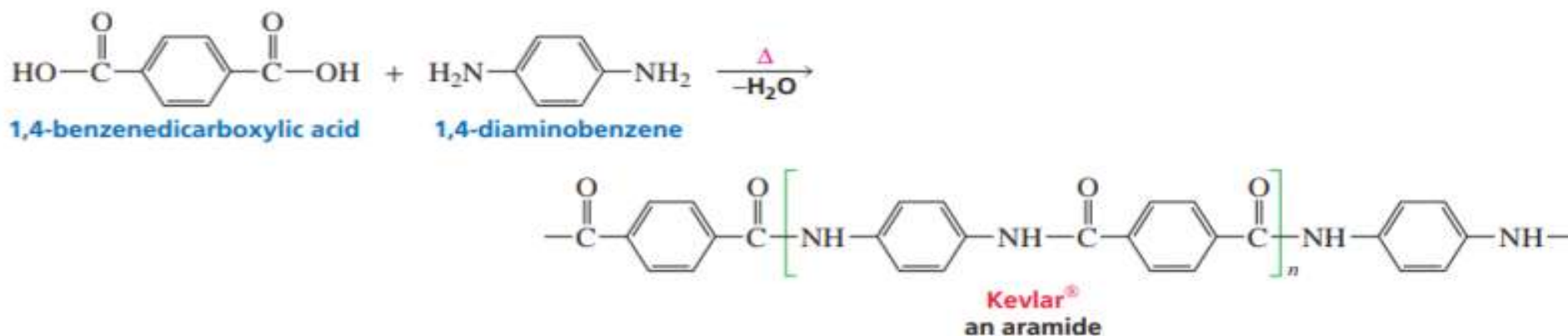


Nylon 66 is an example of a step-growth polymer formed by two different bifunctional monomers: adipic acid and 1,6-hexanediamine. It is called nylon 66 because it is a polyamide formed from a six-carbon diacid and a six-carbon diamine.



Nylon first found wide use in textiles and carpets. Because it is resistant to stress, it is now used in many other applications, such as mountaineering ropes, tire cords and fishing lines, and as a substitute for metal in bearings and gears. The extended applications of nylon precipitated a search for new “super fibers” with super strength and super heat resistance.

One super fiber is Kevlar<sup>®</sup>, a polymer of 1,4-benzenedicarboxylic acid and 1,4-diaminobenzene. The incorporation of aromatic rings into polymers has been found to result in polymers with great physical strength. Aromatic polyamides are called **aramides**. Kevlar<sup>®</sup> is an aramide with a tensile strength greater than that of steel. Army helmets are made of Kevlar<sup>®</sup>, which is also used for lightweight bullet-proof vests and high-performance skis. Because it is stable at very high temperatures, it is used in the protective clothing worn by firefighters.

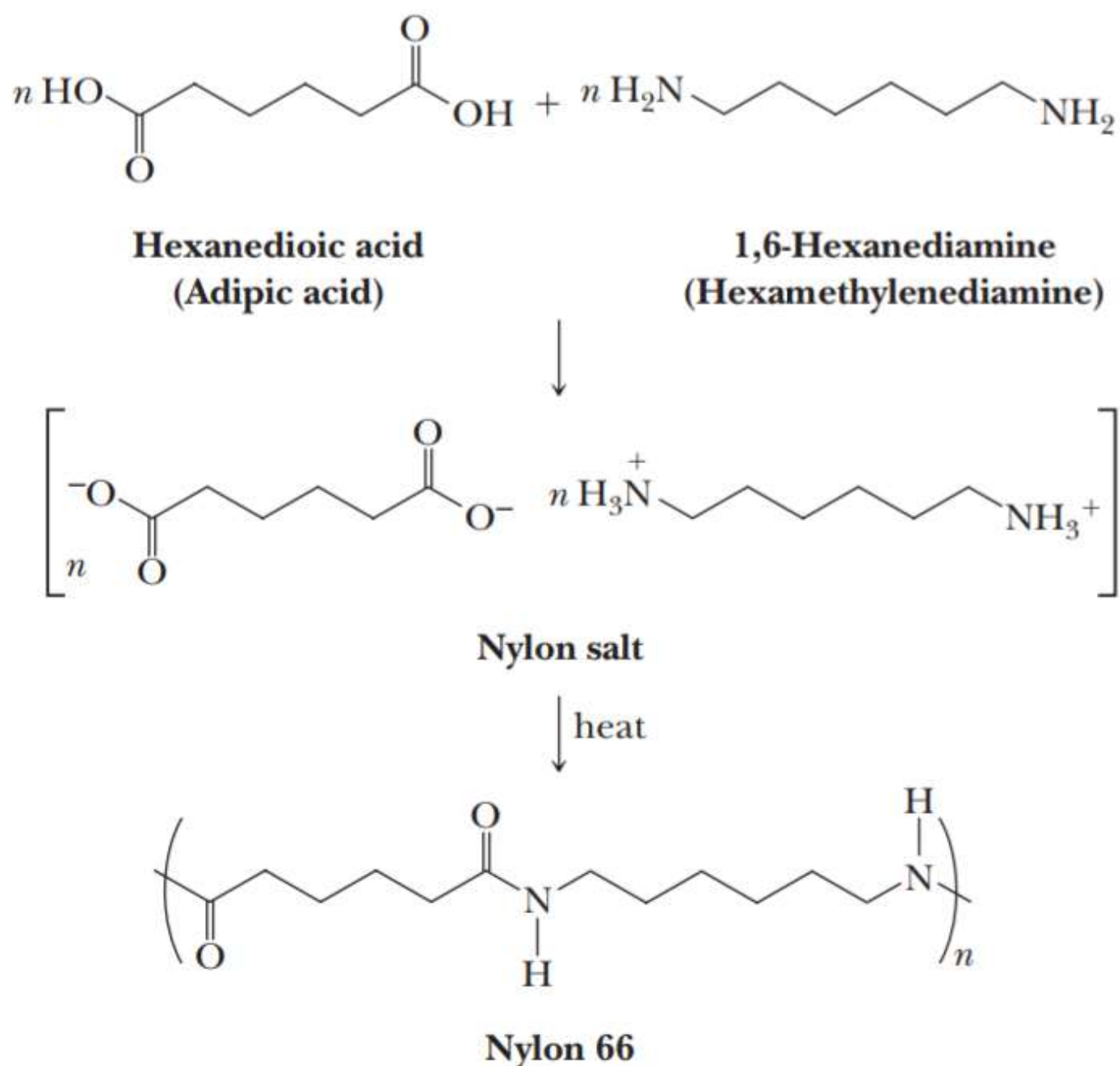


Kevlar<sup>®</sup> owes its strength to the way in which the individual polymer chains interact with each other. The chains are hydrogen bonded, causing them to form a sheetlike structure.



## Nylon 66

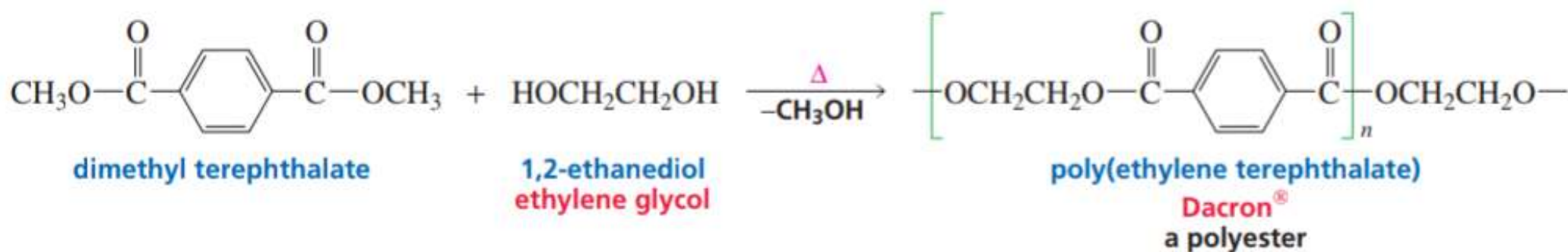
In the synthesis of nylon 66, hexanedioic acid (adipic acid) and 1,6-hexanediamine (hexamethylenediamine) are dissolved in aqueous ethanol where they react to form a one-to-one salt called nylon salt. Nylon salt is then heated in an autoclave to 250°C where the internal pressure rises to about 15 atm. Under these conditions,  $\text{—COO}^-$  groups from adipic acid and  $\text{—NH}_3^+$  groups from hexamethylenediamine react with loss of  $\text{H}_2\text{O}$  to form amide groups.



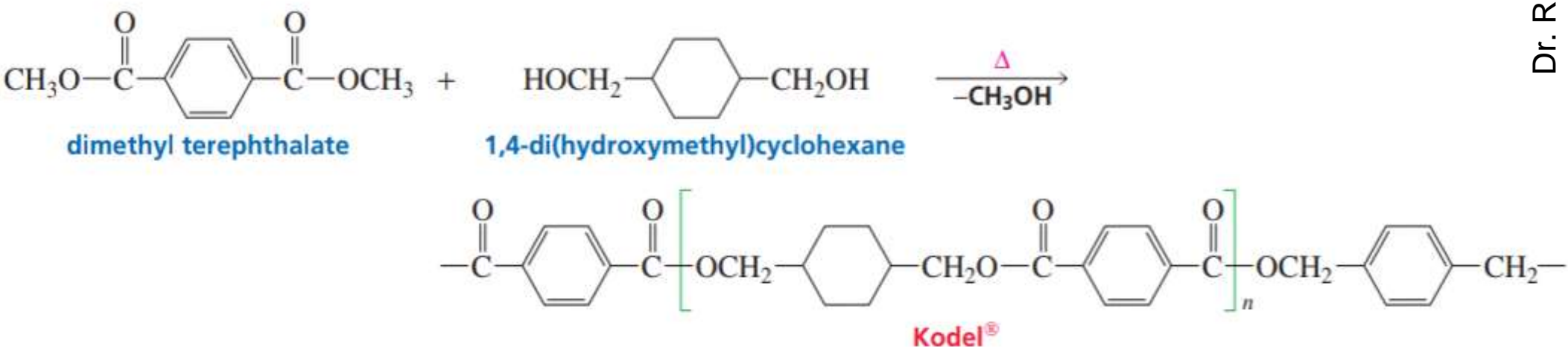
Nylon 66 formed under these conditions has a  $T_m$  of 250–260°C and has a molecular-weight range of 10,000 to 20,000 g/mol.

## 10. Polyesters

**Polyesters** are step-growth polymers in which the monomer units are joined together by ester groups. They have found wide commercial use as fibers, plastics, and coatings. The most common polyester is known by the trade name Dacron<sup>®</sup> and is made by the transesterification (Section 17.10) of dimethyl terephthalate with ethylene glycol. High resilience, durability, and moisture resistance are the properties of this polymer that contribute to its “wash-and-wear” characteristics.



Kodel<sup>®</sup> polyester is formed by the transesterification of dimethyl terephthalate with 1,4-di(hydroxymethyl)cyclohexane. The stiff polyester chain causes the fiber to have a harsh feel that can be softened by blending it with wool or cotton.



Polyesters with two ester groups bonded to the same carbon are known as **polycarbonates**. Lexan<sup>®</sup> is produced by the reaction of phosgene with bisphenol A. Lexan<sup>®</sup> is a strong, transparent polymer used for bulletproof windows and traffic-light lenses. In recent years, polycarbonates have become important polymers in the automobile industry as well as in the manufacture of compact discs.