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## 19CH201 ENGINEERING CHEMISTRY

### UNIT-4 HIGH POLYMERS

#### NYLON 6,6

##### Introduction

There are several polyamides, which have been developed as fibres. The generic word for these products is 'Nylon'. Nylon is defined as a generic term for any long chain synthetic polymeric amide which has recurring amide groups as an integral part of the main polymer chain and which is capable of being formed into a filament in which the structural elements are oriented in the direction of the axis.

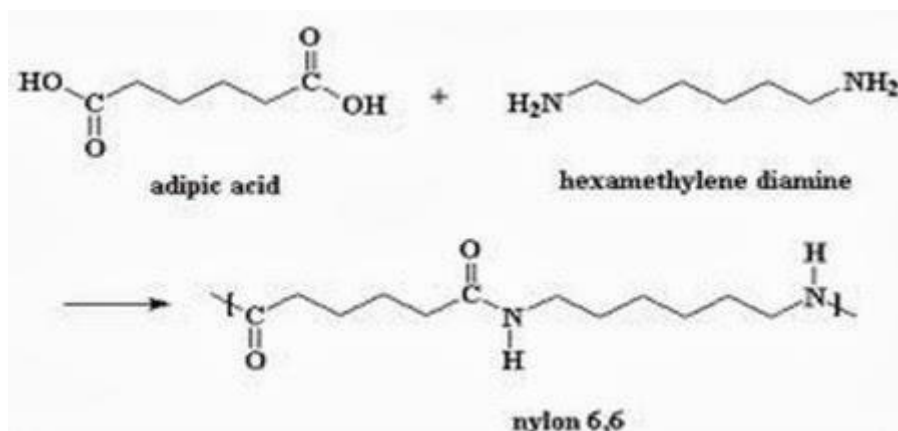
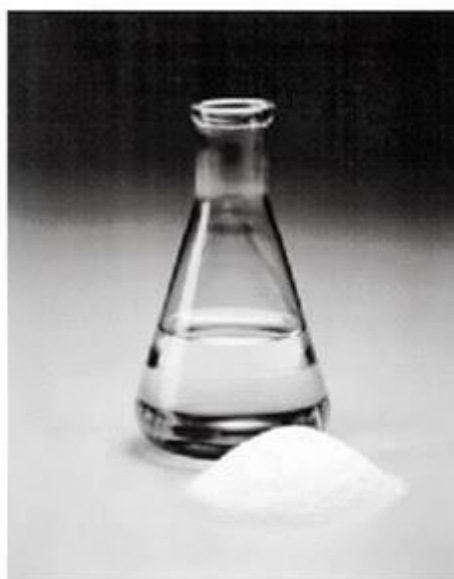
DuPont researchers led by Dr. Wallace Carothers, invented nylon-66 polymer in the 1930s. Nylon, the generic name for a group of synthetic fibers, was the first of the “miracle” yarns made entirely from chemical ingredients through the process of polymerization. Nylon 66 polymer chip can be extruded through spinnerets into fiber filaments or molded and formed into a variety of finished engineered structures. Nylon-66 fibre is a member of the large group of polycondensation products of dicarboxylic acids and diamines with fibre forming properties. The individual member refers to the number of carbon atoms respectively in the diamine and dicarboxylic acid chains.

Nylon-66 (polyhexamethylene diamine adipamide) is a polyamide made from adipic acid and hexamethylenediamine by polycondensation. The resulting polymer is extruded into a wide range of fiber types. The fibers are drawn, or stretched, in a process that increases their length and reorients the material's molecules parallel to one another to produce a strong, elastic filament. The thermo-plasticity of nylon permits permanent crimping or texturing of the fibers and provides bulk and stretch properties.

The nylon developed by Carothers at Du Pont was nylon 66. Because of the importance of



starting out with equal amounts of the two reactants, salts of the diamine and of the diacid are made and then used in the commercial synthesis of nylon 66.



## 2. HISTORY

The development of nylon was started from 1927 by means of many researchers, notably among them W.H.Carothers and P.Schlack. The research activities preceding the manufacture of nylon yarn can be divided into the following categories:

- (a) Fundamental research activities which provided the foundation for the development.



(b) Different types of polyamides, their synthesis, manufacture and their suitability for use as a new fibre. This includes all types of polyamides like aliphatic, aliphatic-aromatic and fully aromatic polyamides.

(c) Commercial production of the fibres.

(d) Development of the properties and serviceability of the fibres.

Polyamides are characterized according to the number of carbon atoms present in the structural unit of the molecule. These are:

(a) Nylon made from condensation of a diamine and a dicarboxylic acid is classified according to the number of carbon atoms present in the amine and acid respectively. Thus nylon formed by hexamethylene diamine ( $\text{NH}_2(\text{CH}_2)_6\text{-NH}_2$ ) having 6 carbon atoms and sebacic acid ( $\text{COOH}(\text{CH}_2)_8\text{-COOH}$ ) having 10 carbon atoms is generally referred to as nylon 6,10

(b) Nylon, made from amino acid, is classified according to the number of carbon atoms present in the acid. It will have only one number. For example, Nylon 6 can be made from amino acid having 6 carbon atoms i.e., amino caproic acid or its condense product caprolactum.

So the numbers indicate the number of carbon atoms in the monomer taking part in the polymerisation. In general,

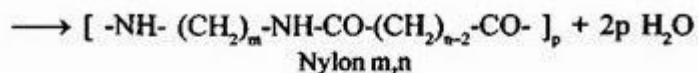
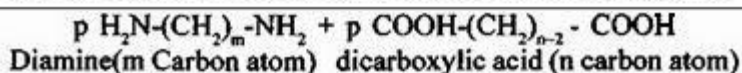


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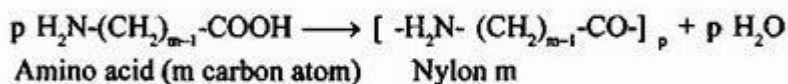
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p = no. of molecules and ultimately it is degree of polymerisation



Some of the polyamides and their raw materials are given in Table :

Table 1 Raw materials of different Nylons

<u>Nylon</u>		<u>Raw materials</u>
Nylon	4,6	1,4 diamino butane, Adipic acid
Nylon	6,6	Hexamethylene diamine, Adipic acid
Nylon	6, 10	Hexamethylene diamine, Sebacic acid
Nylon	6,12	Hexamethylenediamine, Dodecanedioic acid
Nylon	3	Acrylamide
Nylon	4	2-pyrrolidane
Nylon	7	Caprolactum
Nylon	11	Lactum of heptonoic acid
Nylon	12	W-amino-cendecanoic acid Dodelactum

### 3. The Nylon Fiber Design Advantage

In 1939, the introduction of nylon into sheer stockings revolutionized the women's hosiery



market. Silk and cotton were quickly replaced by this more durable and easy-care product. Nylon soon found its way into other end uses. In parachutes and fishing line, nylon provided a moisture- and mildew-resistant replacement for silk. In flak vests, nylon offered a strength and durability previously unattainable for protection against shell fragments. And, when used as aircraft tire reinforcement, nylon enabled heavy bombers to land safely on improvised air strips. Today, as the global leader in nylon polymer, DuPont offers a wide range of nylon-66 polymer types for use in industrial, textile, and furnishing/floor covering applications.

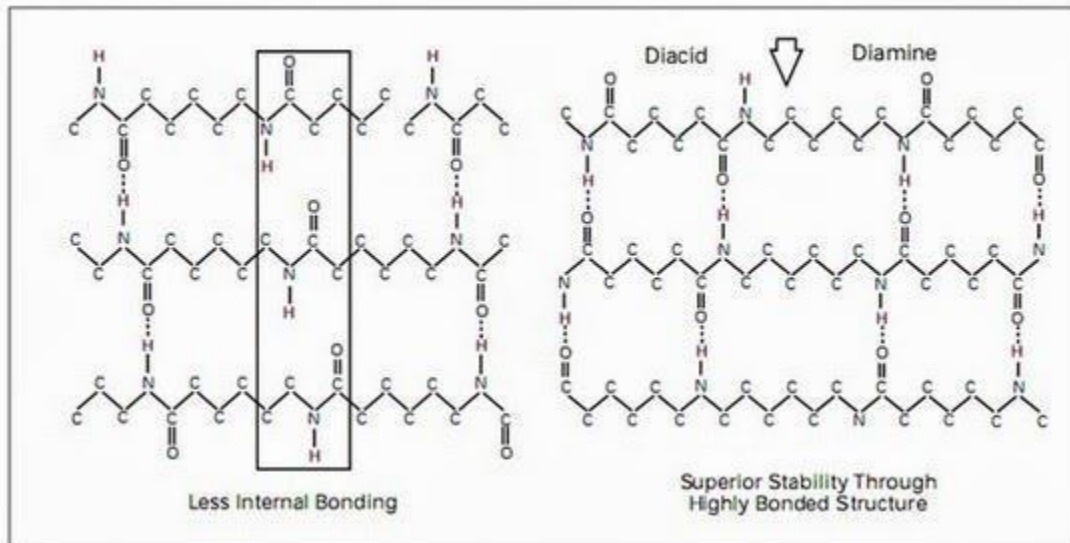
#### **4. Advantages of Nylon-66**

Nylon 66 is superior in many applications to nylon 6—the other large volume nylon—due to its outstanding dimensional stability, higher melting point, and more compact molecular structure (see Figure 1). Nylon 66 exhibits only about half the shrinkage of nylon 6 in steam, for instance. And, with a less open structure, the 66 fiber has good dye wash fastness and UV light-fastness, and excellent performance in high-speed spinning processes. Typical advantages of nylon 66 over nylon 6 are its

- Higher tensile strength in use,
- Excellent abrasion resistance, and
- Higher melting point.



Figure 1. The molecular structure of nylon 6 versus nylon 66 yields enhanced properties.



**Nylon 66 provides high tensile strength for**

- Tough fibers at fine deniers,
- Excellent performance for tyre applications, and
- High-speed mill processing.

**Excellent abrasion resistance makes nylon-66 polymer ideal for use in**

- Carpets,
- Upholstery, and
- Conveyor belts.

The rubber industry takes advantage of the higher melting point of nylon 66 in high-temperature tire curing. A high melting point also results in a fiber with

- High stretch and recovery in false-twist textured Yarns (e.g., hosiery and socks) and
- Thermal stability in high-temperature coating operations.

### **5. Use of Nylon-66 in Fiber Manufacturing**

The processing of nylon usually begins by conditioning the received chip, with or without an increase in the asreceived molecular weight. The chip is then melted, usually in a screw-type



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extruder, and spun into filament form. The filaments are then packaged in a process that may include drawing, bulking, or cutting into lengths of staple.



### Also Known As . . .

*Nylon 66 (pronounced "six-six") is known by many names. It is also called 6,6 (or 6/6) nylon, polyamide 66, N66, PA66, six-six polymer, and poly(hexamethylenediamine adipamide). All of these terms refer to the DuPont invention of over half a century ago.*