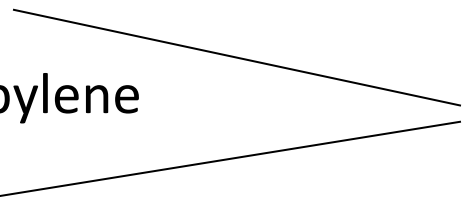
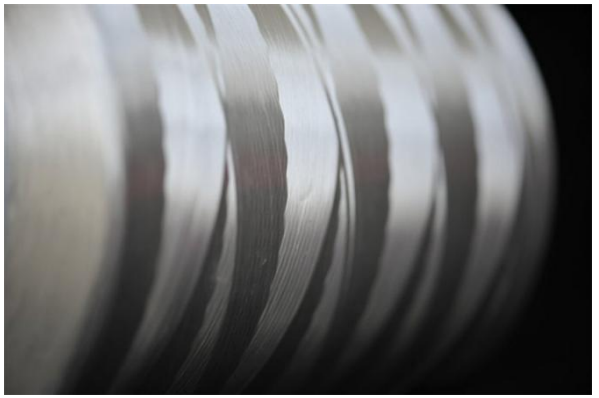
Synthetic fibers

- The first synthetic fiber synthesized by W.H.Carothers is Nylon 6-6.

- 1950>>>>>orlon >>>>>>>>>>(polyacrylonitrile)
- 1952 >>>>>Acrilan
- 1953>>>>>Dacron
- 1954>>>>polypropylene
- 1960>>>> Kodel
- 1965>>>>Vinylon



Poliamide fibers



Polyamide fibers contain –NH-(C=O)- groups in their main poymer chain.

High strength
high degree of solvent resistance
Toughness
High crystallinity
Resistance to the abrasion
Low shrinkage
Silk-like handling in the staple form
High resistance to the microorganisms

} suitable for fiber production

Low density
High dyeability
Long life

} Compared to natural and man-made fibers

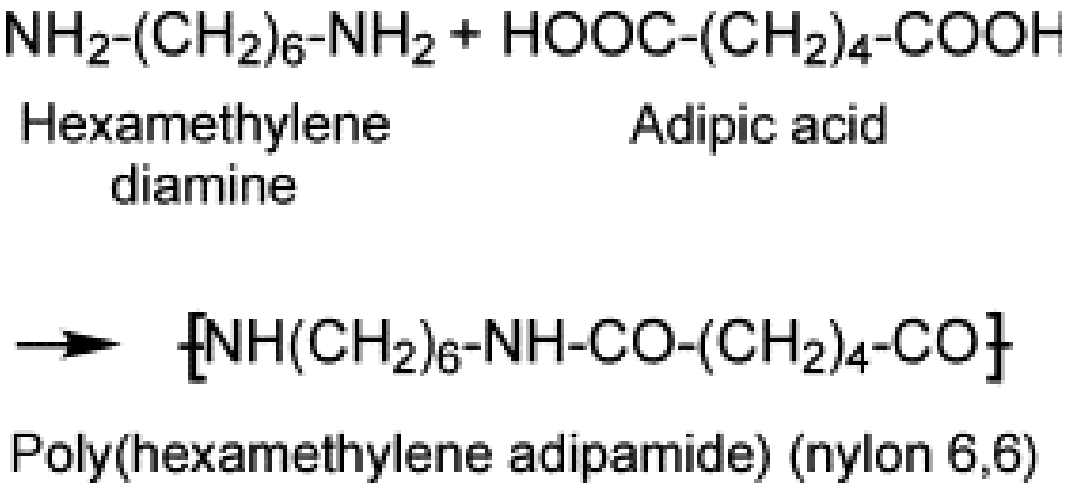
The properties of nylon are greatly affected by moisture.

- Nylon 2…….polyglycine
- Nylon 2-6….poly(ethylene adipamide)
- Nylon 6 …….polycaproamide
- Nylon 6-1…poly(hexamethylene carbonamide)
- Nylon 6-6…poly(hexamethylene adipamide)
- Nylon 6-T…poly(hexamethylene theraphthalamide)
- Nylon 2-T …poly(ethylene theraphthalamide)
- Nylon pP-T…poly(*p*-phenylene theraphthalamide) KEVLAR
- .
- .
- .
- .
- .

Nylon 6-6

nylon 6,6 [poly(hexamethylene adipamide)] contain a hydrolyzable amide connecting group, as do proteins. Nylon 6,6 can absorb 9–11% water, by weight, at saturation.

Nylon 6,6 is synthesized from the reaction of hexamethylene diamine and adipic acid to form hexamethylene diammonium adipate, or "nylon salt." This is performed by reacting a 70% methanolic solution of the diamine and a 20% methanolic solution of the diacid. The nylon salt precipitates as it is formed. After isolation, a 60% aqueous solution of nylon salt is polymerized to form poly(hexamethylene adipamide) or nylon 6,6.



XUE-CHAO HU, H.H. YANG, 1.11 - Polyamide and Polyester Fibers,
Editor(s): Anthony Kelly, Carl Zweben, Comprehensive Composite Materials,
Pergamon, 2000, Pages 327-344,

- Mn ~around 12000 is more suitable to produce fiber from Nylon 6-6.
- The Tm of Nylon 6-6 is approx. 200^{o}C higher than that of its analogue polyester due to the dense H-bondings between its chains.
- Due to its high mechanical strength, nylon 6-6 is mainly used in the preparation of rope, cord, parachute cloth, upholstery, and belts.
- Since it has a high braking strength in the wet state, it can also be used in the fish lines.
- The monofilament nylon 6-6 fibers are generally used in the preparation of toothbrush, socks, dress and etc.



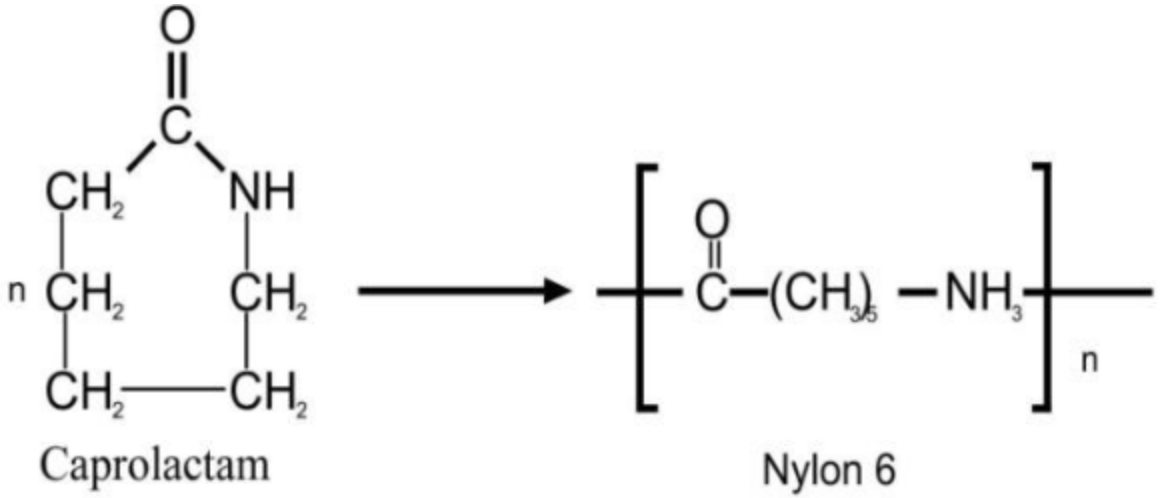

Sewing Threads

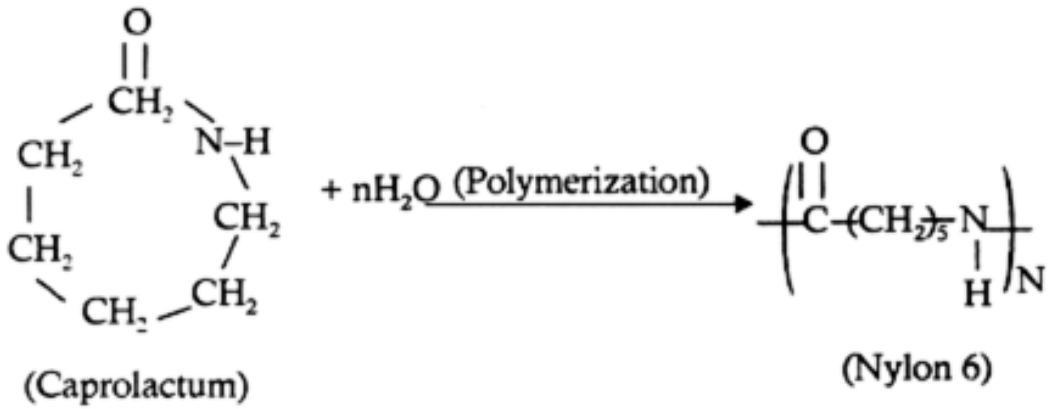

Backpack


Raincoat


Umbrella

Nylon 6, or polycaprolactam (perlon), is prepared by the polymerization of caprolactam.



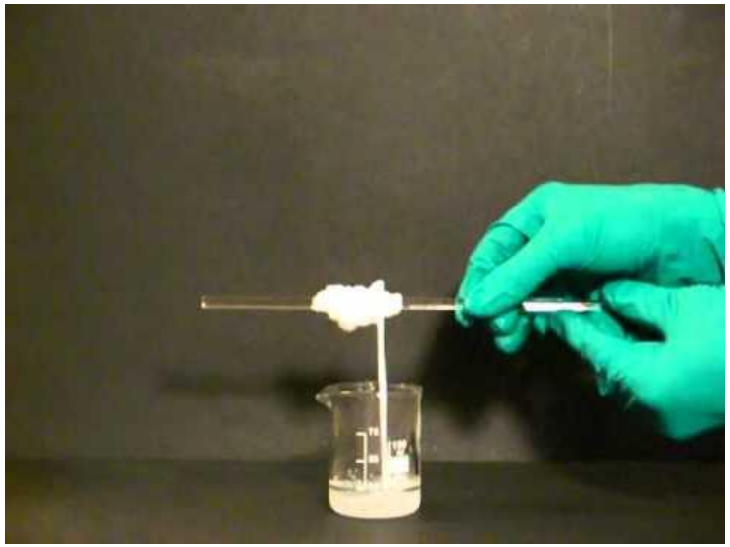


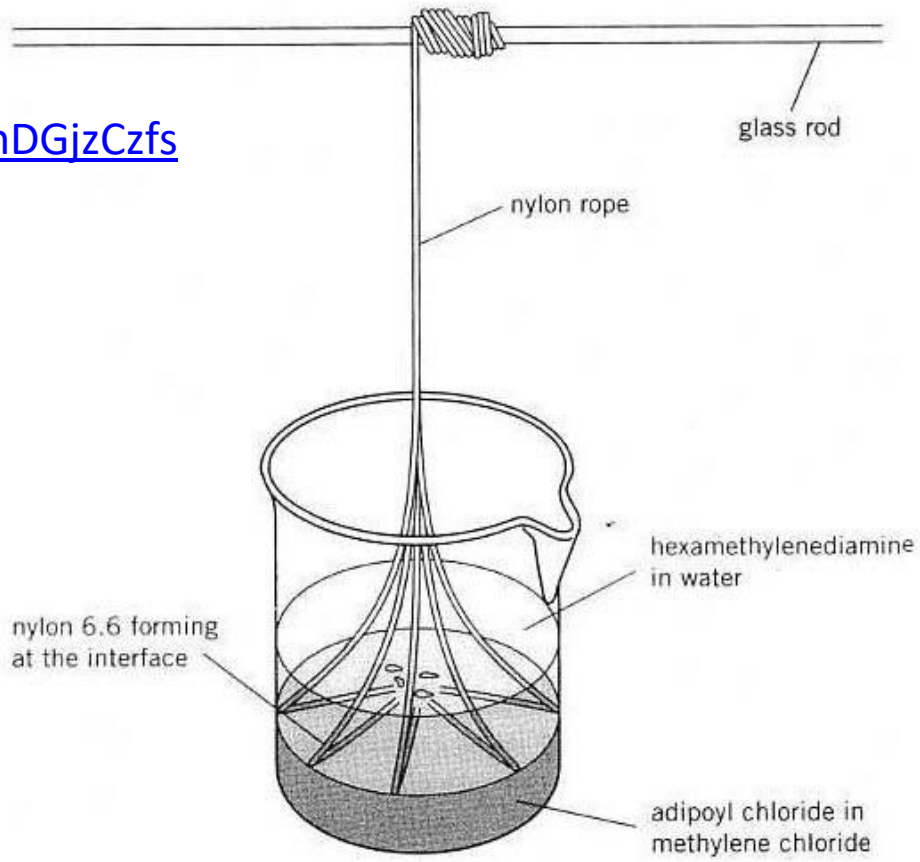
Adegbola, Bolaji. “System Identification of Nylon-6 Caprolactam Polymerization Process.” (2014).

- Relatively lower Tm compared to Nylon 6-6.
- Cheaper reactants.
- High chemical resistance
- Better dyeing with acidic dyes

Nylon 6-10

https://www.youtube.com/watch?v=RRnDGjzCzfs

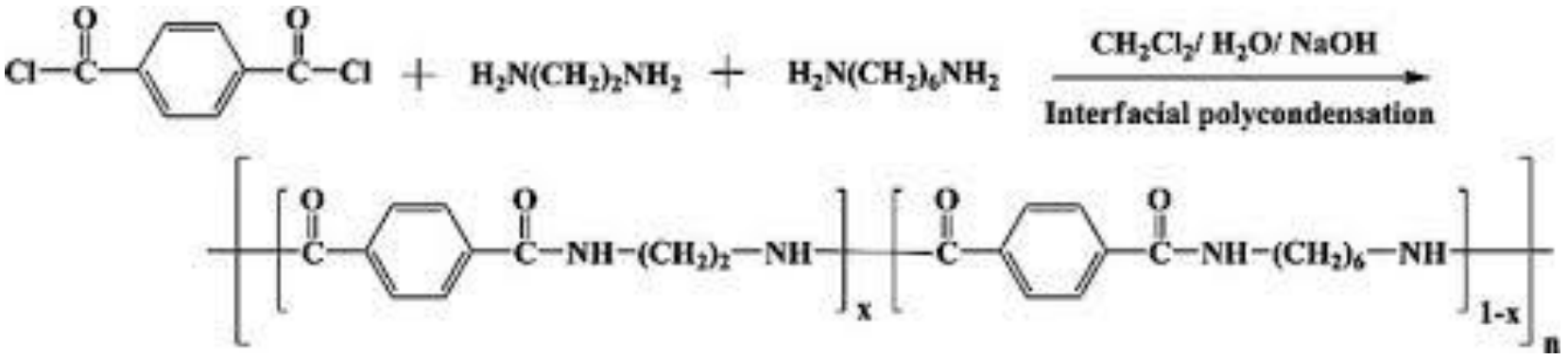




? Homework: write the reactants for the synthesis of Nylon 6-10.

Aramides
(aromatic polyamides)

- If a polyamide main chain consists of an aromatic group containing reactant, then it is called aromatic polyamide.
- Aromatic polyamides are relatively more strength at the applications at the higher temperatures (>150^{o}C).
- The presence of an aroatic group in the main polyamide chian increase the Tg and Tm values of the polyamides



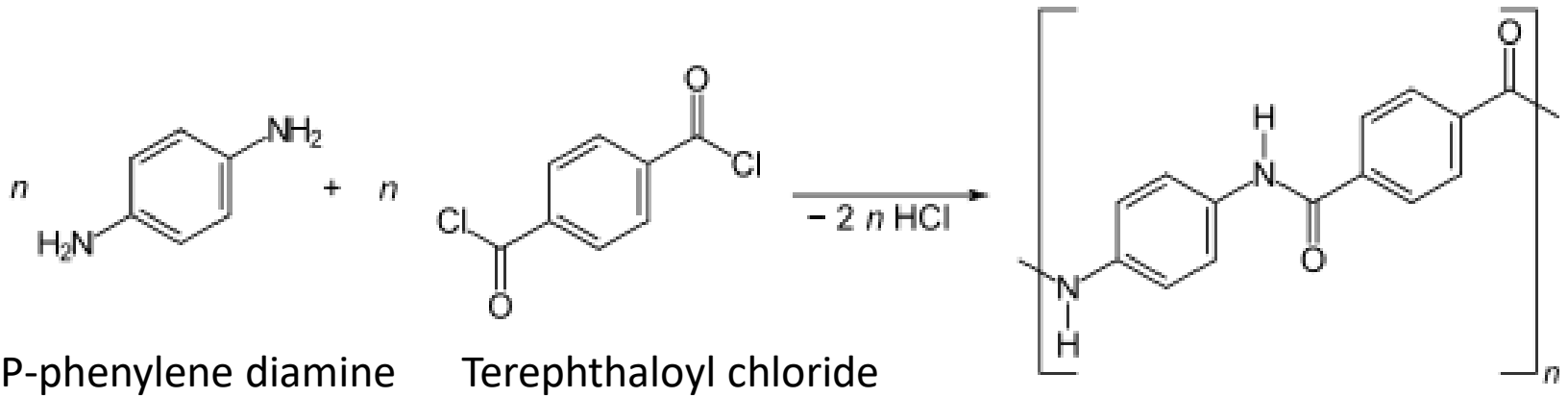
Lan Qu, Sheng-Ru Long, Mei-Lin Zhang, Gang Zhang, Xiao-Jun Wang & Jie Yang (2012) Synthesis and Characterization of Poly(ethylene terephthalamide/hexamethylene terephthalamide), Journal of Macromolecular Science, Part A, 49:1, 67-72, DOI: 10.1080/10601325.2012.630950

? Homework: write the polycondensation reaction for Nomex.

Trick: it's repeating unit contains two aromatic groups. (fully aramide)

- The aramides could preserve thier physical and mechanical properties at higher temperature (200-300^{o}C)
- Low flame temperatures
- Resistance to the ionization radiation
- Resistance to chemicals such as solvents.
- Long life at higher temperatures

KEVLAR



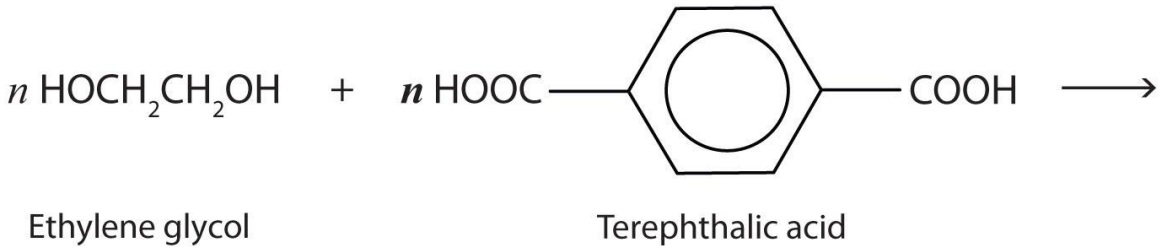
P-phenylene diamine Terephthaloyl chloride KEVLAR

High thermal stability
Tough chains
Good chain packacking/high crystallinity
Good materials to prepare bulletproof vest

Polyester fibers

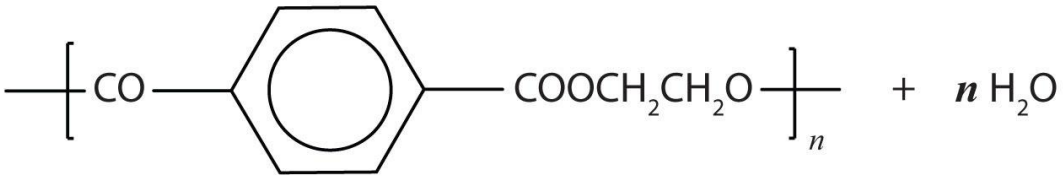
- The most well known polyester is PET
- 1941>>>terylene
- 1953 >>>dacron

Same structure? What is the difference?

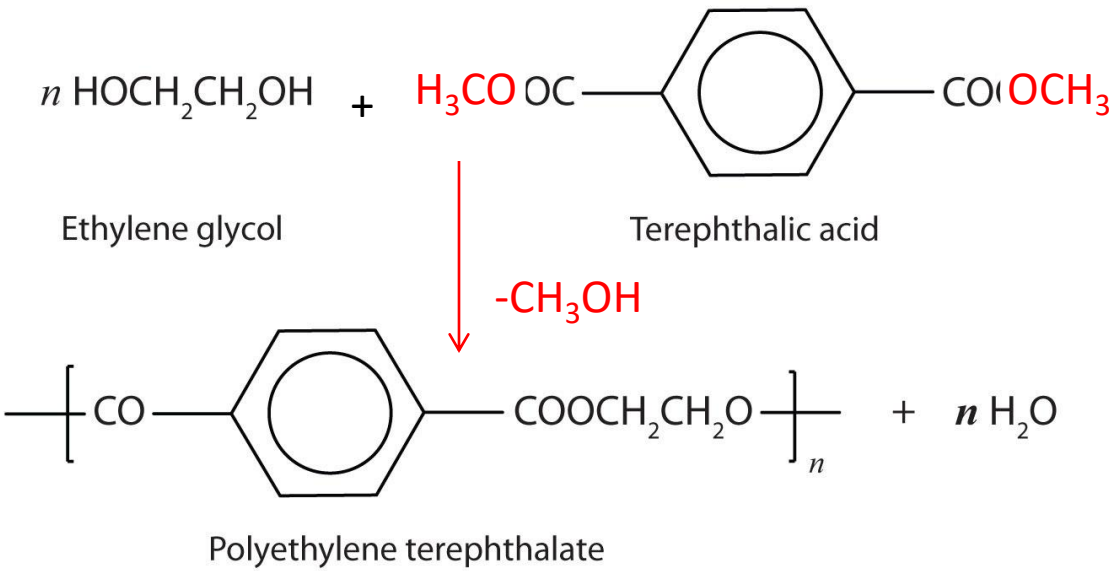


Ethylene glycol

Terephthalic acid



Polyethylene terephthalate dacron


n HOCH2CH2OH
+
H3CO OC
CO OCH3
Ethylene glycol
Terephthalic acid
-CH3OH
CO
COOCH2CH2O
n
+ n H2O
Polyethylene terephthalate

terylene

pros

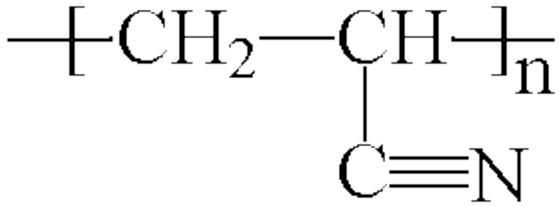
- High resistance to the weak acids at thier boiling temperatures
- Resistance to strong acids at RT
- Low resistance to tha bases (tend to alkaline hydrolize)
- High uv resistance >>>suitable to prepare curtains (low yellowing compared to nylons)
- Siutable to produce textile materials such as swimsuits, thin underwears, ropei upholstery, and etc.
- Can be blendable with natural cotton fabrics to decrease the shrinkage >>>>such as shirts
- Cotton is for moist absorption and supply opacity, polyester is for improving physical appearence/properties

Cons

- Low dyeability due to the absence of any functional groups that will have interactions with dye molecules.
- Expensive disperse dyeing is suitable for polyester dyeing. (at higher temperatures/pressures with additive chemicals)

Acrylic fibers

- Acrylonitrile is a monomer that can give high molecular weighted-polymer (a desired property for fiber production)
- Lineer polymer chains but strong polar interactions between the chains.
- High crystallinty
- Relatively high Tg value (~ 100-110 ^{o}C)
- If a polymer consists of polyacrylonitrile over the value of 85% (by weight), it's called acrylic fibers. Pure polyacrylonitrile is not suitable for directly producing fibers and used as copolymers with a ratio of 85-94%.
- If the polyacrylonitrile content in the copolymer composition is between 35-85 %, it's called modacrylic fibers.



- Olefin fibers (>85% polyethylene, polypropylene)
- Vinyl and vinylidene chloride fibers (PVC, PVA, TEFLON)
- Elastomeric fibers (PU fibers, spandex)

- Anorganic synthetic fibers
- Glass fibers
- Carbon fibers