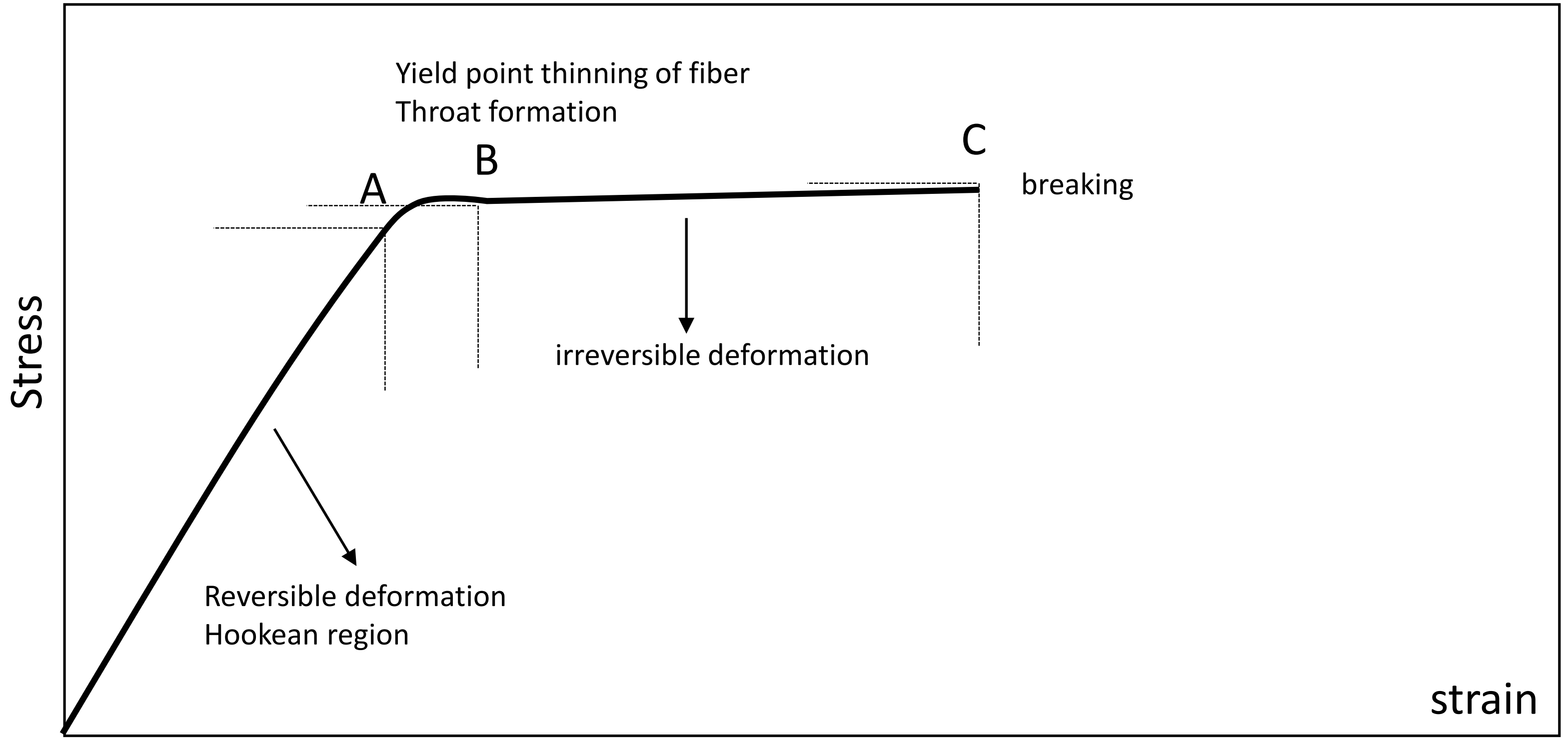
Properties of Fibers II

Mechanical and chemical properties

Mechanical properties

The mechanical properties are related with the behaviors of fibers against deforming external forces such as twisting, stretching, stress, and compressing.

The beneficial information related to the mechanical properties of fibers can be obtained from the stress-strain (load-deformation) curves. In this graphs, an increasing force is applied to the fibers and the elongation amounts per unit length of a fiber is plotted.



A stress-strain curve for an ideal fiber

The behaviors of real fibers under loads can be practically defined under two topics:

A) wool-type fibers (polyacrylonitrile, viscose, wool, acetate)

B) silk-type fibers (linen, PET, cotton, nylon 6, silk)

The silk type fibers have relatively higher elastic (young module) module values

? *Elastic module* is calculated by the ratio of stress to strain (force/elongation). In the other words, it corresponds the slope of the line in the Hookean region.

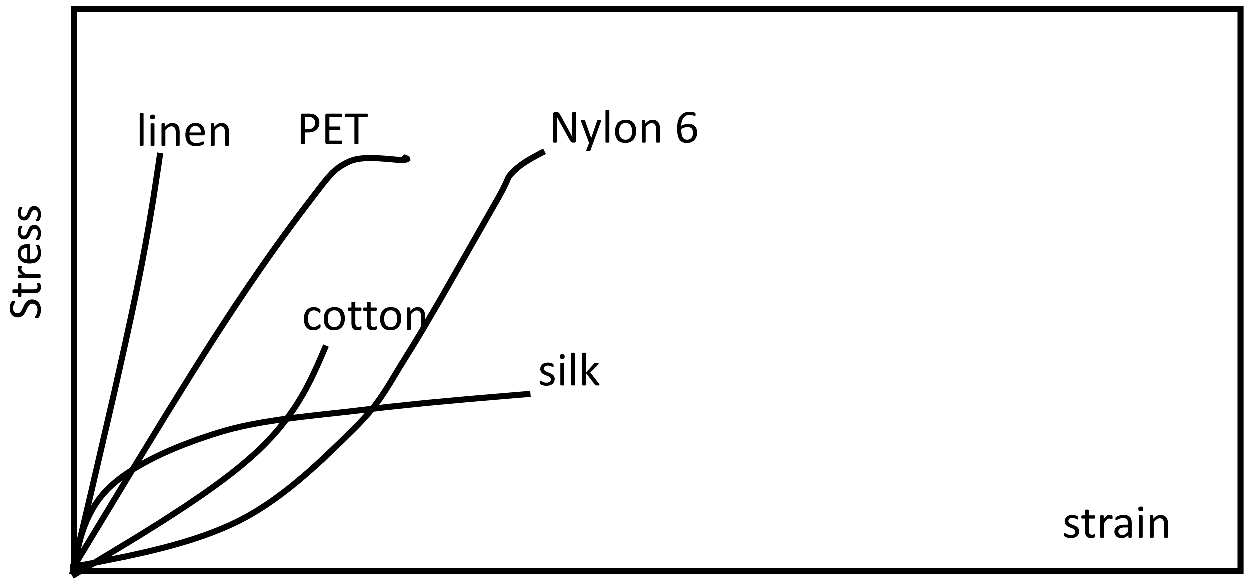
In the wool-type fibers, a sharp decrease is observed in the elastic module value at low strain values. Under a constant load, the elongation of the fiber continues.

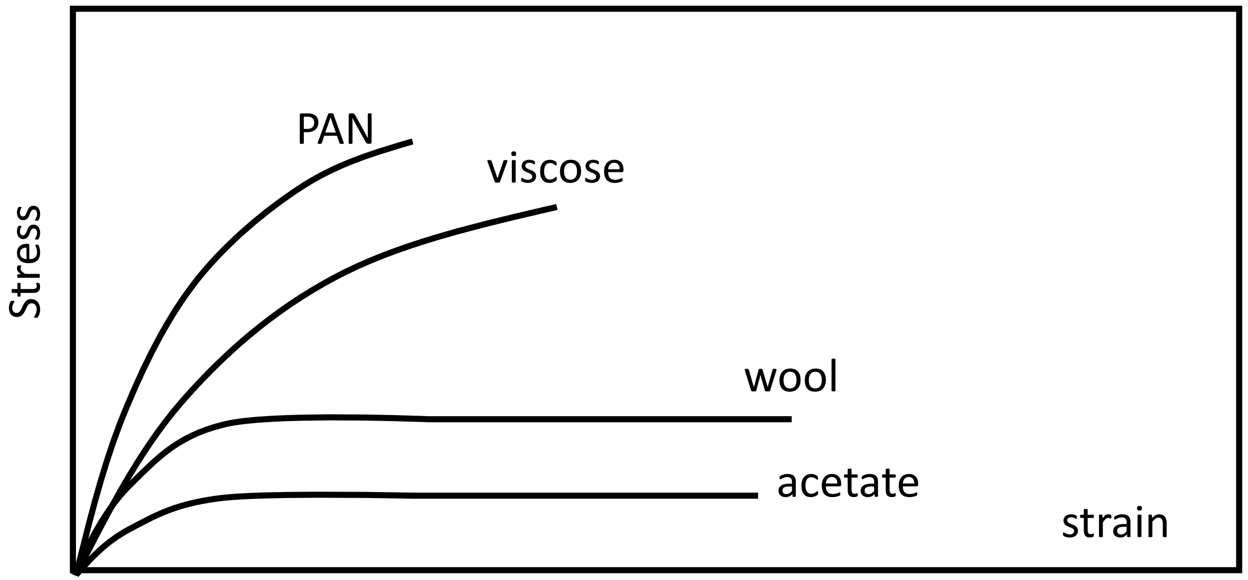
Elongation at break

This value is calculated considering the elongation amount of the fiber length at the rupture(breaking) time.

If a fiber in 100 cm length elongates to 110 cm before the breaking, the elongation at break value is then calculated as 10%.

This value varies between 10-20% for the fibers to be used as textile purposes.


Stress
linen
PET
Nylon 6
cotton
silk
strain


Stress
PAN
viscose
wool
acetate
strain

Breaking strength

It is the measure of a resistance ability of a fiber against stress applied to the fiber. The breaking strentgh of a fiber can be increased with orientation.

Elasticity

It is the ability of a fiber to reach its initial length when the applied force is removed on the fiber.

e.g.

100 cm…….> stress applied……..>110 cm…….>stress removed…..100 cm (100% elasticity)

100 cm…….> stress applied……..>110 cm…….>stress removed…..105 cm (50 % elasticity)

Chemical properties

Moisture absorption

$$\text{Moisture absorption (\%)} = \frac{m_{after\ moist} - m_{dry}}{m_{dry}} * 100$$

Related with the chemical structure of the fiber.
Hygroscopic fibers easily absorp moist from the environment.

?Homework: give an example for hygroscopic and non-hygroscopic fibers. Justify the reasons.

Dyeability

To dye the fibers, a functional group should be present in the fiber-forming polymer that will give a chemical interaction with any type of dye molecule.

Basic functional groups containing fibers can be dyed with acidic dyes and acidic groups containing fibers also dyed with basic dyes.

? Homework: give examples for the functional groups of the fiber forming polymer?

Which possible functional groups have acidic and basic characters?

Swelling

Fibers can swell in the liquids. The swelling of fibers is also anisotropic similar to double refractive index behavior. Due to the anisotropy, the diameter of the fibers imregnated into a liquid increases more than those of length. The reason underlying the anisotropic swelling is the orientation. The polymer chains that are paralelly assembled and become closer after the orientation expand with the introduction of liquid molecules between them. Consequently, the increase in the expanding (increase in the diameter) is higher than the elongation in the fiber length.