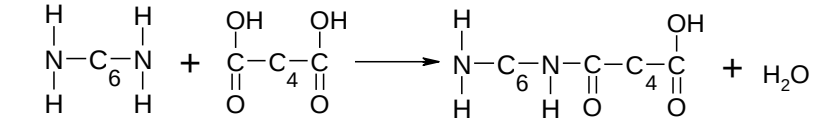
Polyamides (Nylons)

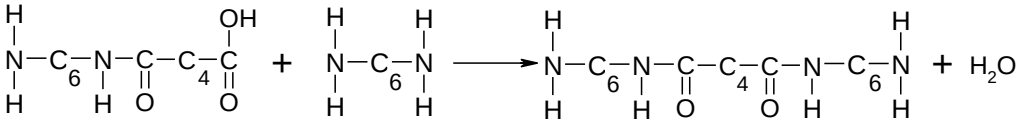
Polyamides (PA), or Nylons, are semi-crystalline polymers with high impact strength, abrasion resistance, tensile strength, and chemical resistivity[1]. PA was developed in the 1930's by DuPont through the work of W.H. Carothers. PA is formed via step-growth polymerization of diamine and amino acids. Below are the steps to form a polyamide (nylon 6/6):



Hexamethylene diamine (Monomer A)

Adipic Acid (Monomer B)

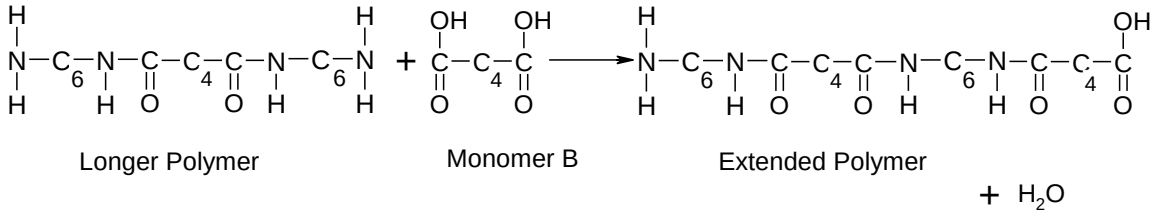
Beginning polymer



Beginning Polymer

Monomer A

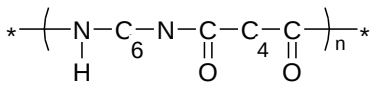
Longer Polymer



Longer Polymer

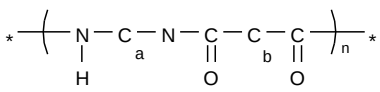
Monomer B

Extended Polymer



Polymer (nylon 66)

The structure of nylon is quite polar, which induces the formation of secondary bonds between the polymer chains. The secondary bonds facilitate close packing resulting in high crystallinity. This crystallinity leads to high strength, high stiffness, good toughness, translucency, good fatigue life, good abrasion resistance, low gas and vapor permeability. Nylons' mechanical and physical properties are considerably affected by the amount of crystallization.



Polymer (nylon ab)

The variation in the number of carbons, subscripts *a* and *b* above, are the principle difference between the different types of nylons[2]. The properties of the various PA grades differ only slightly. Yet, as a rule, the lower values of *a* and *b* [i.e. shorter distances between the amide groups (N-H)] give higher density, higher melting temperature, higher water absorption, higher tensile strength, stiffness, hardness and creep resistance[3]. In general, PAs should not be used in applications where water is present. This is due to its high water absorption (~2.5% by weight).

There are additives and fillers to improve properties of PAs. Filler levels of up to 50% are available in many grades of PA[4]. Metal powders can be added to improve electrical properties. Slip and abrasion resistance are improved with the addition of MoS_2, PTFE, HDPE and graphite. PA can be grafted with acrylate elastomoer or coupled with polyethylene to improve its impact strength.

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[1] Campo, E. Alfredo, *The Complete Part Design Handbook*, Hanser, 2006.
[2] Strong, A. Brent, *Plastics: Materials and Processing*, Prentice Hall, 2000.
[3] Brydson, J. A., *Plastics Materials*, Butterworths, 1989.
[4] Osswald, et al, *International Plastics Handbook*, Hanser, 2006.