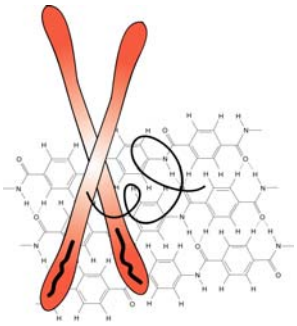
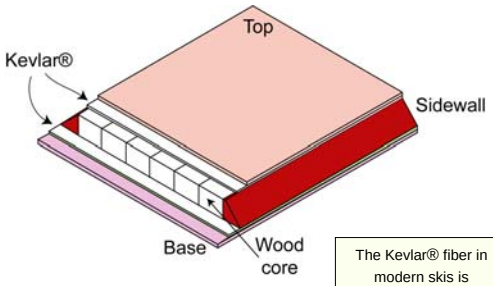
Class 1: Introduction to Polymers Used for Skis and Snowboards



PRIME Modules
Project-based Resources for Introduction to Materials Engineering

Polymers and polymer composites are the key elements in skis and snowboards.



http://www.skibuilders.com/howto/skicon/materials.shtml

The Kevlar® fiber in modern skis is sometimes replaced with fiberglass.

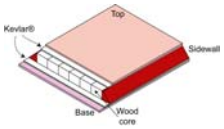
The core of the skis are made up of composites.

Wood, a natural composite, is used as the inner core of a lot of skis and snowboards.

The wood is layered with a polymer based composites (fiberglass, Kevlar® fiber sheets, carbon fiber sheets) that provide extra support.

The composite is strongest in the direction of the fiber so multiple layers of the composite sheets are used.

Epoxy, another polymer, is used to fix the layers all together.



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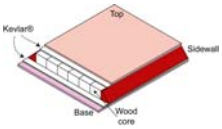
Polymers are used to protect the composite core.

A polymer coating such as polyethylene is put on the, the top-sheet material. It's main purpose is to protect the epoxy from UV radiation.

The bottom base material is a thin sheet of plastic made from UHMWPE (ultra-high molecular weight polyethylene).

Sidewalls and tip spacers are strips to protect the wood core from moisture. A common sidewall and tip spacer is a co-polymer, ABS.

Polymers are also used in rubber strips on the edges of the skis that minimize vibrations and prevent delamination .



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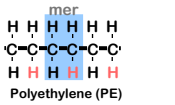
A polymer is a long, C based chain made up of repeatable sub-units (monomers)

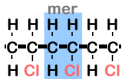
A polymer is a long C based chain.

It is made up of individual units, monomers.

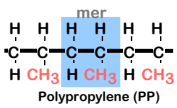
The monomers are tailor-able, we can easily change the side groups. This is what gives polymers the range of properties including mechanical, aesthetic, and electrical.



Polyethylene (PE)



Polyvinyl chloride (PVC)

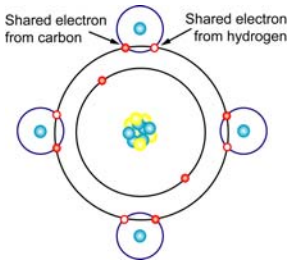


Polypropylene (PP)

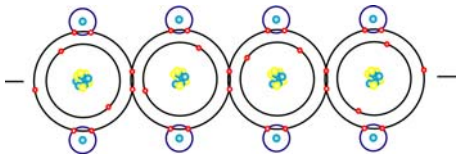
Adapted from Fig. 14.2, *Callister 6e.*

A building block of a polymer is a hydrocarbon.

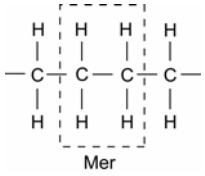
If we remove two of the hydrogen atoms and replace them with carbons we can start linking more carbon atoms to form a polymer.



A long polymer chain is made by connecting monomers (hydrocarbon sub-units).



Polymer molecules can be very large, extending over hundreds or thousands of carbon atoms.



The polymer is defined by the average molecular weight

The chain length varies between chains in a sample.

The polymer sample is defined by either the number- average molecular weight

$$\overline{M}_n = \sum x_i M_i$$

Fraction of the total number of chains that have that MW

Or the weight average molecular weight

$$\overline{M}_w = \sum w_i M_i$$

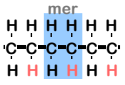
Fraction of the total weight that have that MW

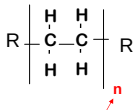
Figure from Callister overheads

The degree of polymerization is how many monomers are in a chain.

n, the degree of polymerization, tells how many monomers are in a chain

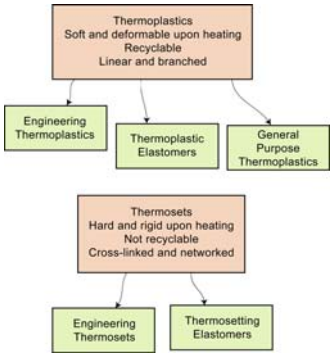
$$n_w = \frac{M_w(\text{chain})}{A_{\text{monomer}}}$$





Degree of polymerization

Polymers can be divided up into thermoplastics or thermosets.

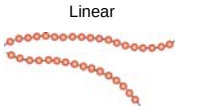


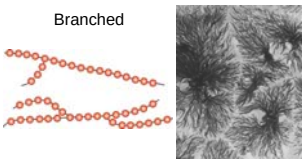
Thermoplastic polymers can be linear or branched.

Linear polymers are long straight chains with secondary bonding forces between the chains

Branched chains form when monomers attach in different directions. There is a reduced density and a reduced interaction between the chains.

HDPE (high density polyethylene) is liner LDPE is branched





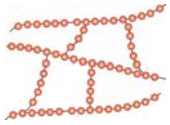
Branched Polyethylene

Figure from Callister overheads

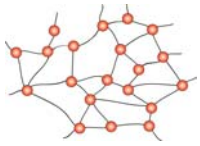
Thermoset polymers are cross linked or netwroked.

Cross-linked is when chains connect in a 3-D nature. The chains become locked together.

Networked is a chemical connection forms between chains as part of the polymerization process.



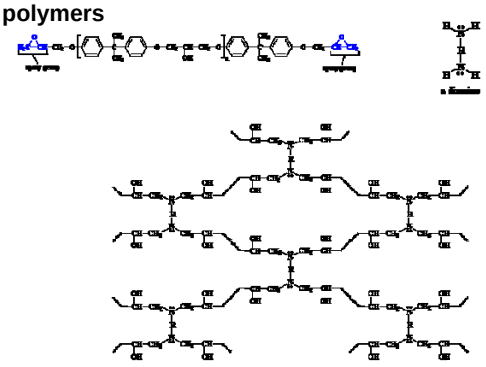
Crosslinked



Network

- W.D. Callister, Materials Science and Engineering An Introduction, 5/e, (John Wiley and Sons, New York, 2000).
- http://www.lbl.gov/MicroWorlds/Kevlar/

Epoxies are examples of networked polymers



In summary, a polymer is a long C based chain with tailor-able properties

- Polymers and composites are used to make up the many layers of skis and snowbaords.
- Monomers with double or triple C bonds link up when a catalyst breaks the bond.
- The length of the chains in a polymer sample vary.
- The lengths are controlled by the rate of initiation, propagation, and termination.
- Polymers are classified by how the chains interact (linear, branched, cross-linked, and networked).