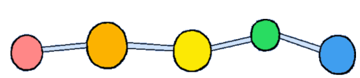
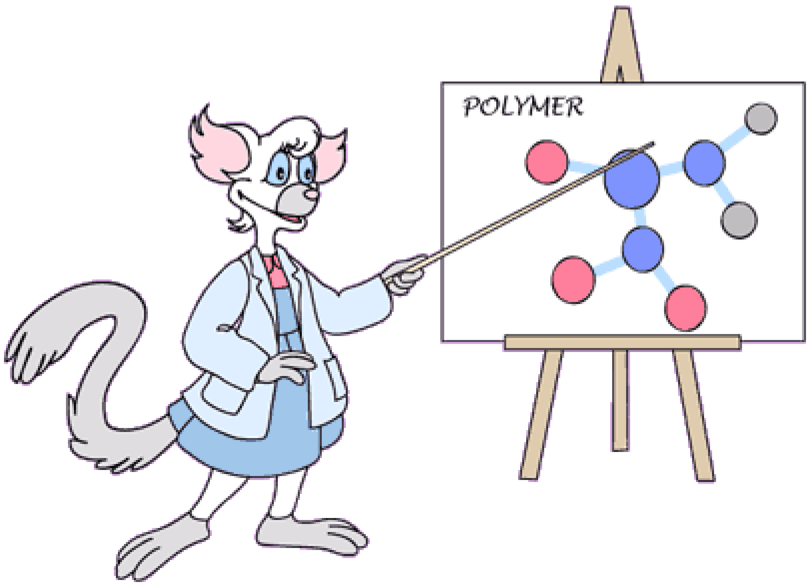
4.

Polimerlerin Mekanik Özellikleri

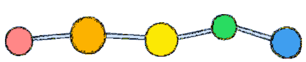
Polimerlerin Mekanik Özellikleri
Polimerlerin Molekül Ağırlıkları Karakterizasyonu
Polimerlerin Molekül Ağırlıkları Dağılımı





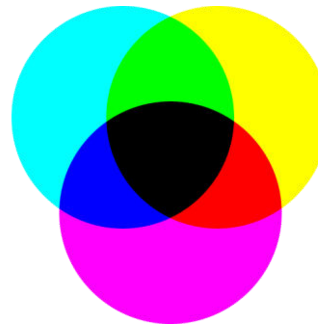
Scientists have come up with all kinds of ways to test polymers to answer questions like:

-How easy is it to scratch?
- How much weight can a thread (or fiber, or rope) hold?
- How long will it last if it's left out in the sun?
-How will it act if it gets hot? Will it melt if I leave it in the car in the middle of summer?
-How much heat does it take to make it all goopy?
-How fast will it dissolve in your tummy? (That one is important for pill coatings.)
-How well can I see through it?
-What happens if I hit it with a hammer? (This one might sound funny, but polymers that can take a hit with a hammer might just be good for something like a skateboarding helmet or hockey shin pads for goalies.)

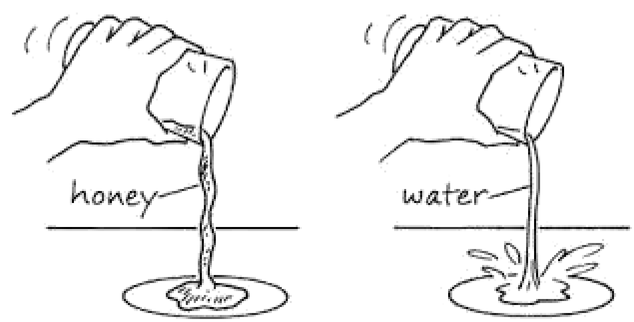


Some Polymer Properties

Broad Classes: Mechanical; Thermal

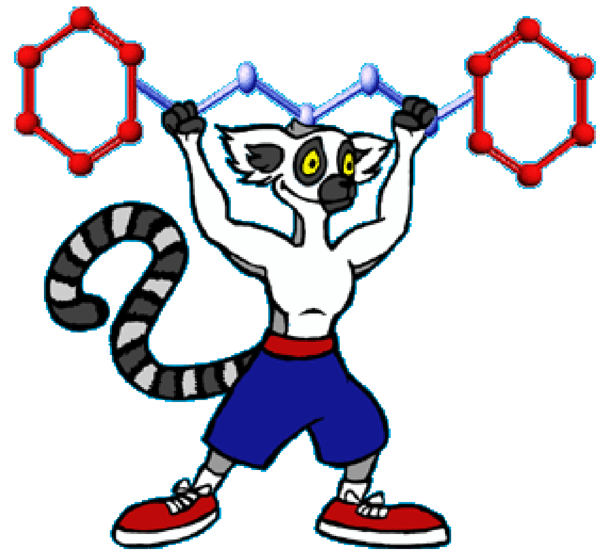


color
viscosity
how fast or slow it takes to flow; the more viscous, the slower it flows
tensile strength
how much it will stretch before it breaks
UV resistance
Will it fade or break down if it's out in the sun?
density
How heavy is a cube that measures 1 cm on each side?
scratch resistance
heat resistance
impact resistance
thermal conductivity
How well it conducts heat... Would this polymer be a good insulator against heat or cold?
electrical conductivity
How well it conducts electricity... Would this polymer be a good insulator for electrical wires?
transparency (transmittance)
drape
how well does a piece of fabric drape over your arm?
hand
how does fabric feel in your hand? (smooth or rough?)
compressive strength
how well does it stand up to being squished (or compressed)?
elongation at break
elasticity modulus in tension
creep modulus in tension
melting point
glass transition point
tensile impact strength
shear strength



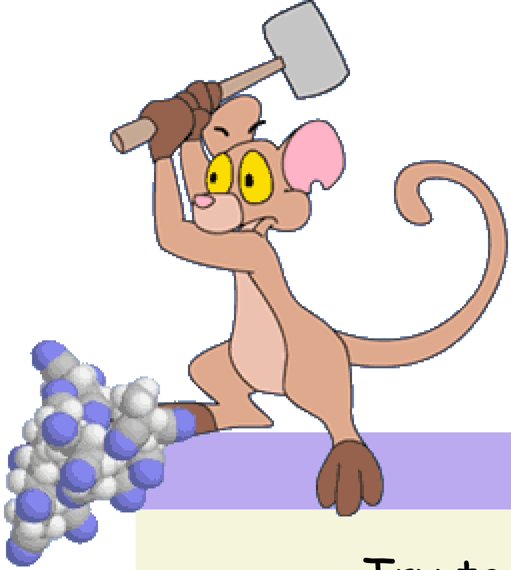
Polimerin Güçlü olması ne demektir?

Mukavemet in birden çok çeşidi vardır. Polimerin mukavemetinin hangisi olduğu polimer üzerinde ne şekilde çalışıldığına bağlıdır.



Örneğin; elinizin büyüklüğünde ve kalınlığında plastik alın iki ucundan alıp çekin eğer hiçbir şey olmuyorsa polimeriniz güçlü demektir.

Bu tür mukavemeti anlatmanın en iyi yolu (*tensile strength) gerilme / çekme mukavemetidir.* Gerilme mukavemeti mesela gerilme (tension) durumundaki malzemeler için önemlidir..



"**Mekanik davranış**" terimi , plastik malzemeye yük uygulandığında bünyede meydana gelen GERİLME ve ŞEKİL DEĞİŞTİRME" lerin incelenmesini ifade eder.

Try to pull it (çekmeye çalış) --	tensile strength (gerilme / çekme mukavemeti)
Try to compress it (sıkıştırmaya çalış) --	compressional strength (basınç mukavemeti)
Try to bend (or flex) it (bükmeye çalış)--	flexural strength (esneklik mukavemeti)
Try to twist it(burmaya çalış)--	torsional strength (burulma mukavemeti)
Try to hit it sharply and suddenly -- (as with a hammer)(aniden vurmaya çalış)	impact strength (darbe dayanımı)

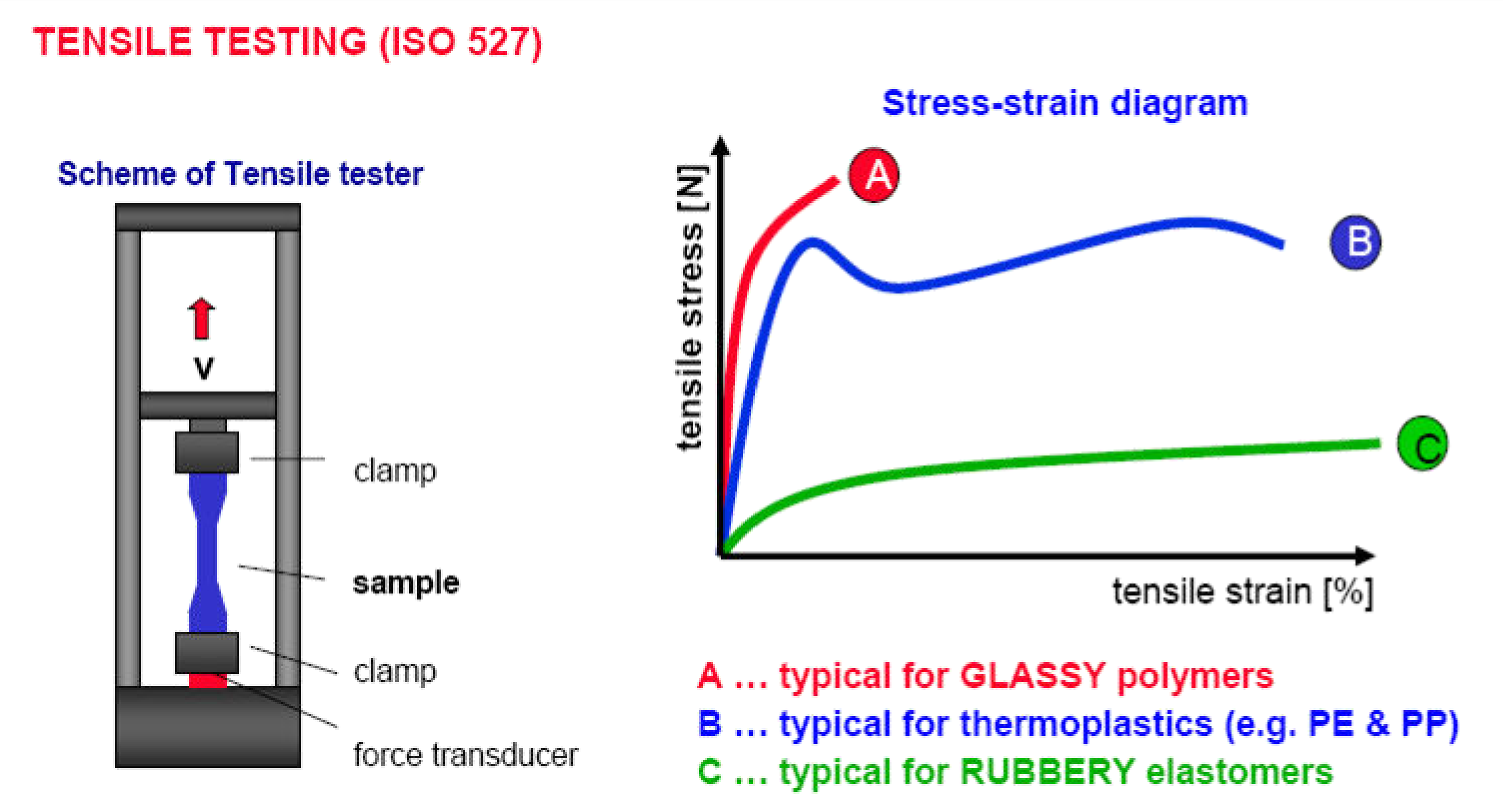
Dayanıklılık

How is toughness (uzayabilirlik) different from strength? From a physics point of view, the answer is that strength tells how much force is needed to break a sample, and toughness tells how much energy is needed to break a sample. But that doesn't really tell you what the practical differences are

What is important is knowing that just because a material is strong, it isn't necessarily going to be tough as well. A great example is something that's rigid (sert) and brittle (kırılgan): it's strong, but not tough, meaning that can't stretch very far before it breaks.

GERİLME - UZAMA

Amorf Polimer'lerin gerilme-uzama davranışları, metallerinkine benzerdir.Aşağıda üç farklı polimer'in davranışı görülmektedir.



A : Gevrek plastik
B : Normal plastik
C : Elastomer-lastik

Normal bir plastiğin GERİLME – UZAMA eğrisinde ;

" E " : **Elastisite modülü** - Tıpkı metallerdeki gibi hesaplanır. ($\sigma = E * \varepsilon$)

Süneklilik (% ε) = (ΔL / L0). 100 – Tıpkı metallerdeki gibidir

Akma mukavemeti $\sigma_{ak} = (F_{ak}/A_0)$ Metallerden farklıdır.Elastik bölgeden hemen sonraki max.nokta akma mukavemetini belirtir.

Çekme mukavemeti , $\sigma_{çek} = F_{kop}/ A_0$ Metallerden farklıdır.Etkiyen yük,akma yükünden düşükte olabilir,yüksekte olabilir.

MEKANİK DAVRANIŞLARIN KIYASI

POLYMER	METAL
E ≈ 10 MPa - 4GPa	E ≈ 50 - 400 GPa
$\sigma_{çek}$ = 10 - 100 MPa	σ çek = 100 MPa - 4 GPa
% ε = % 1000	% ε = % 100 < küçük
T_g ↓ ken Gevrek	
T_g ↑ ken Lastik gibi	
ε ↓ iken lastik gibi	

Elastisite modülü,
Malzemenin kuvvet altında elastik şekil değiştirmesinin ölçüsüdür. Tanımı gereği birim kesit alanına sahip bir malzemede (genellikle 1 mm^2) birim boyu bir kat arttırmak için (örneğin 1m lik teli 2m yapmak için) uygulanması gerekli kuvveti gösterir. Kimi kaynaklarda Young modülü olarak da geçer.

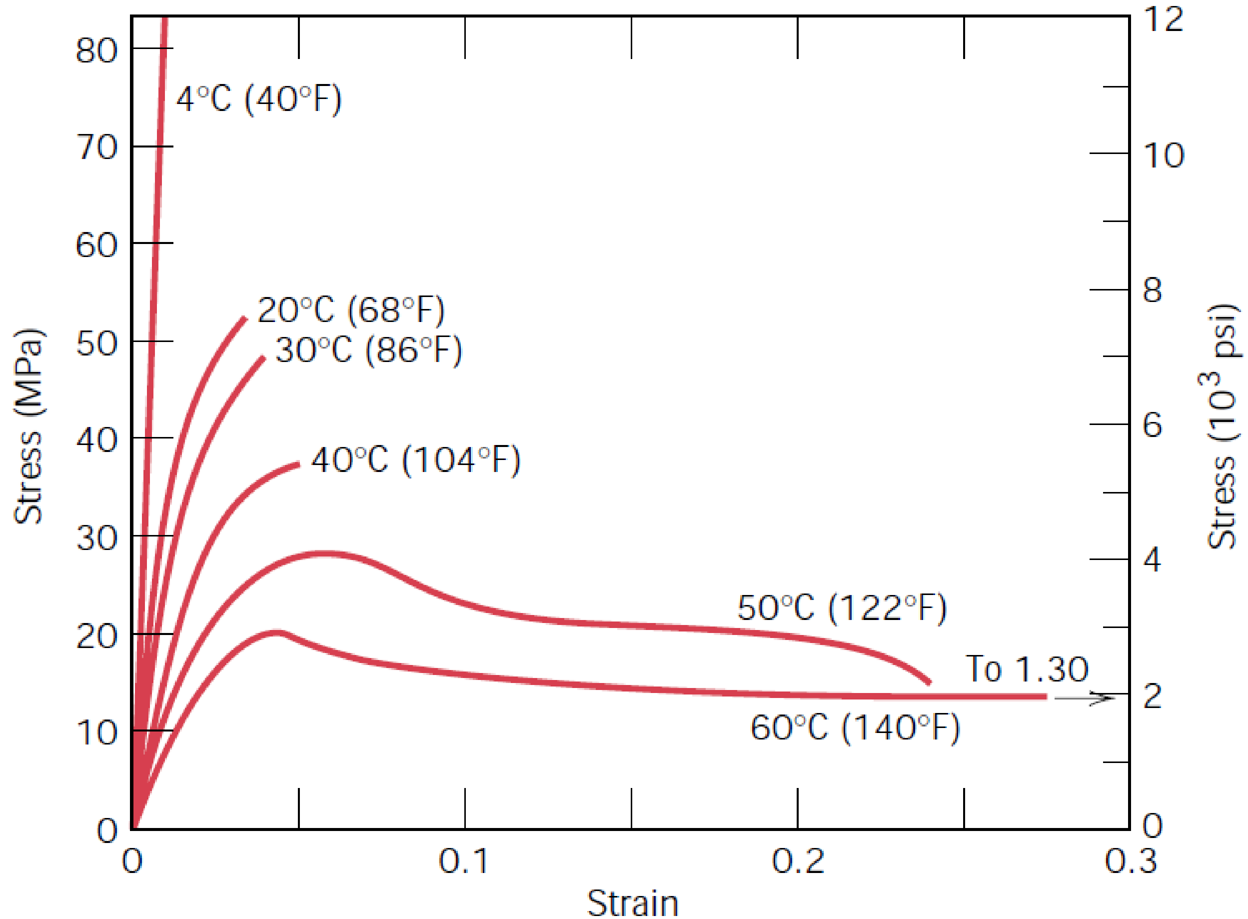
SICAKLIK ETKİSİ

SICAKLIK ARTARSA ;

1)- (E) azalır

2)- $\sigma_{Çek}$ azalır

3)- % ε artar

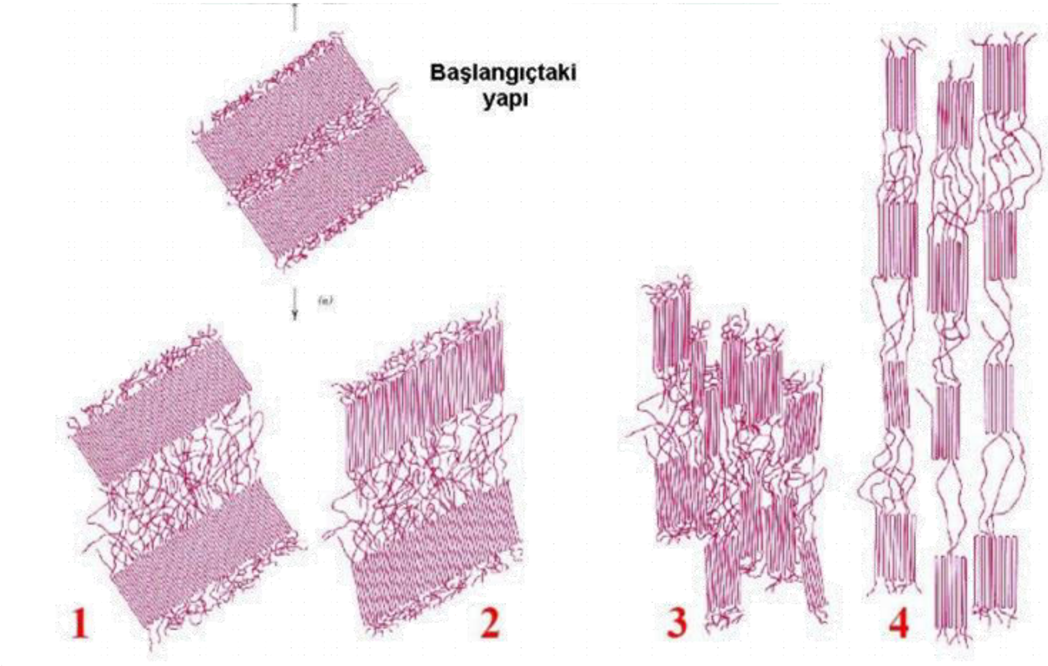


The influence of temperature on the stress–strain characteristics of polymethyl methacrylate

KISMİ KRİSTALİN YAPIDAKİ PLASTİKLERİN MEKANİK DAVRANIŞLARI

Böyle kısmi kristalli bir yapı zorlanırsa ;

1. ci şekilde görüldüğü gibi amorf bağ zincirleri uzar
2. ci şekilde görüldüğü gibi çekme eksenine doğru, yani “lamelli kristalin”lerine doğru bir yöneliş olur.
3. cü şekilde görüldüğü gibi kristalin blok segmentleri ayrılır.
4. cü şekilde görüldüğü gibi çekme ekseni boyunca hem kristalin ve hem de amorf bölgeleri zorlanır.

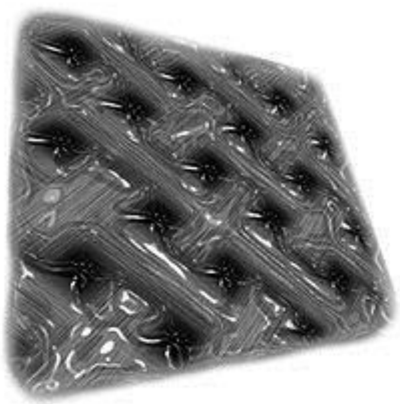


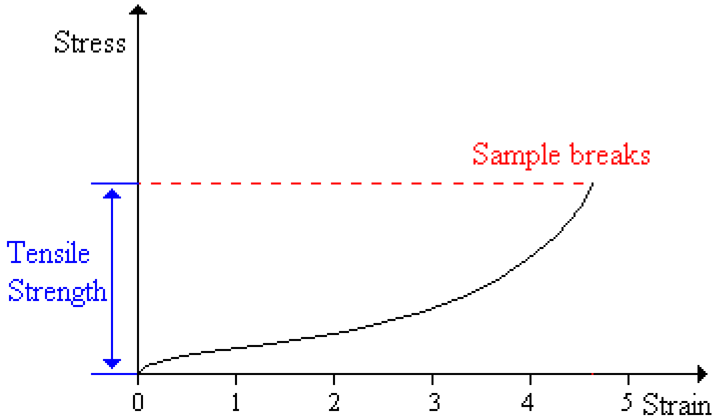
Geirlme Mukavemeti

- Gerilme mukavemeti bir malzemeyi kırmak için gerekli olana gerilmedir. Birimi Pascal dır veya psi (pounds per square inch)

1 MPa = 145 psi

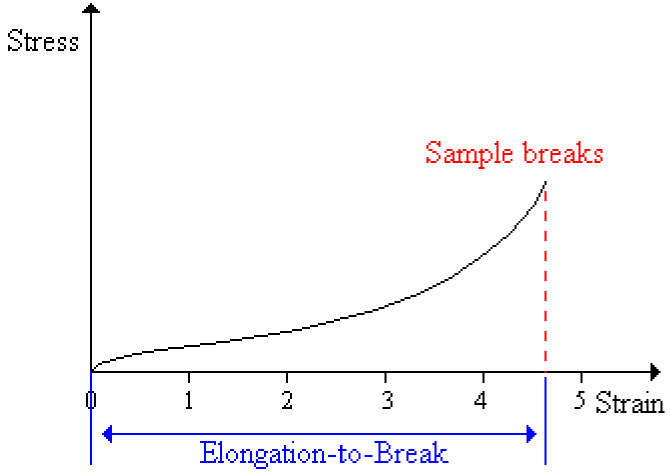
- Gerilme mukavemeti uzatılabilen polimerler için çok önemli bir özelliktir. Fiberlerin çok iyi gerilme mukavemetine sahip olmaları gerekir.





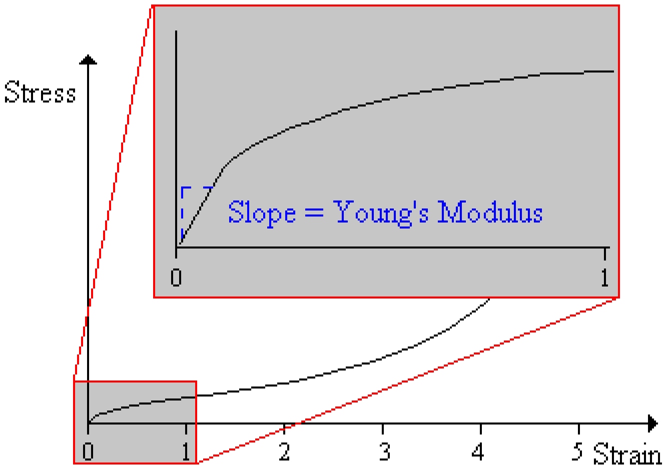
% (Süneklilik)Elongation to (kopma)Break

- The elongation-to-break is the **strain on a sample when it breaks**. This usually is expressed as a percent.
- The elongation-to-break sometimes is called the ultimate elongation.
- Fibers have a low elongation-to-break and elastomers have a high elongation-to-break



Young's Modulus (Elastisite Modülü)

- Young's modulus is the ratio of stress to strain. It also is called the modulus of elasticity or the tensile modulus.
- **Young's modulus is the slope of a stress-strain curve.** Stress-strain curves often are not straight-line plots, indicating that the modulus is changing with the amount of strain. In this case the initial slope usually is used as the modulus, as is illustrated in the diagram at the right.
- Rigid materials, such as metals, have a high Young's modulus. In general, fibers have high Young's modulus values, elastomers have low values, and plastics lie somewhere in between.

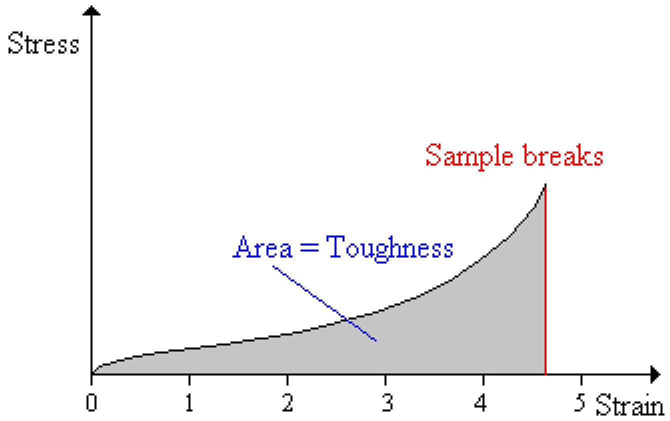


Toughness(uzayabilme gücü)

- The toughness of a material is the **area under a stress-strain curve**. The stress is proportional to the tensile force on the material and the strain is proportional to its length. The area under the curve then is proportional to the integral of the force over the distance the polymer stretches before breaking.

$$\text{Area} \propto \int F(L)\,dL$$

This integral is the work (energy) required to break the sample. **The toughness is a measure of the energy a sample can absorb before it breaks**.

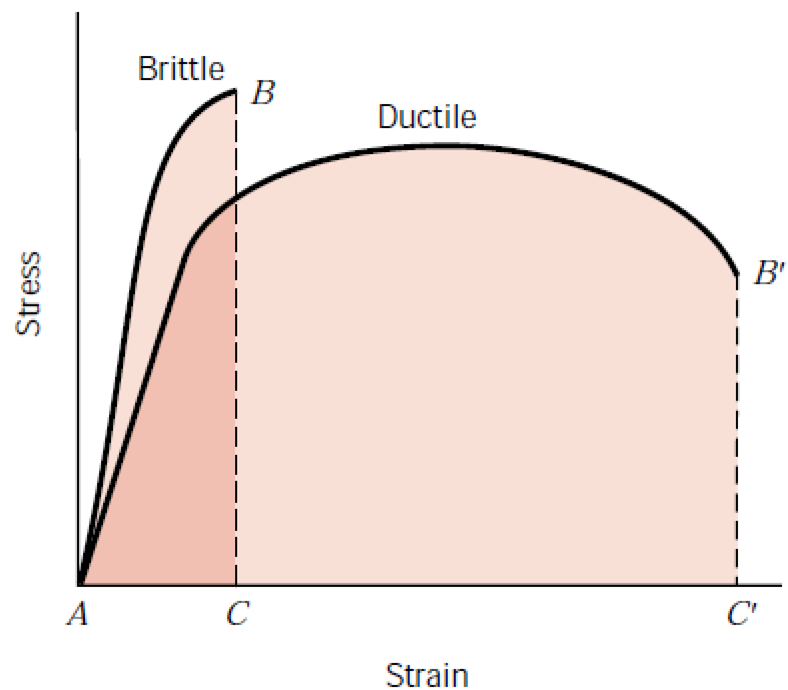


Typical Materials - Mechanical Properties

Material	Tensile Strength (MPa)	% Elongation-to-Break	Young's Modulus (GPa)
Stainless Steel Balls	2,000	Very small	200
Cellophane Film	50 - 120	10 - 50	3
Nitrile Rubber Sheet	20 - 30	250 - 500	Very low
Fiberglass Yarn	1400 - 2000	3 - 4	72
Nylon	50	150	2

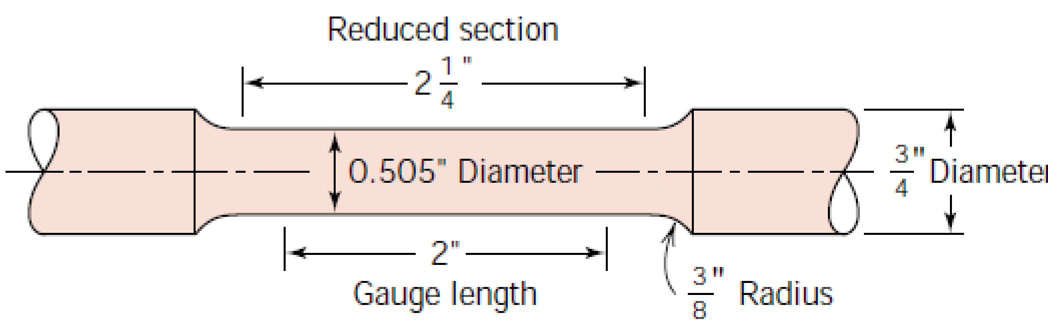
DUCTILITY

- **Ductility** is another important mechanical property. It is a measure of the degree of plastic deformation that has been sustained at fracture. A material that experiences very little or no plastic deformation upon fracture is termed brittle.



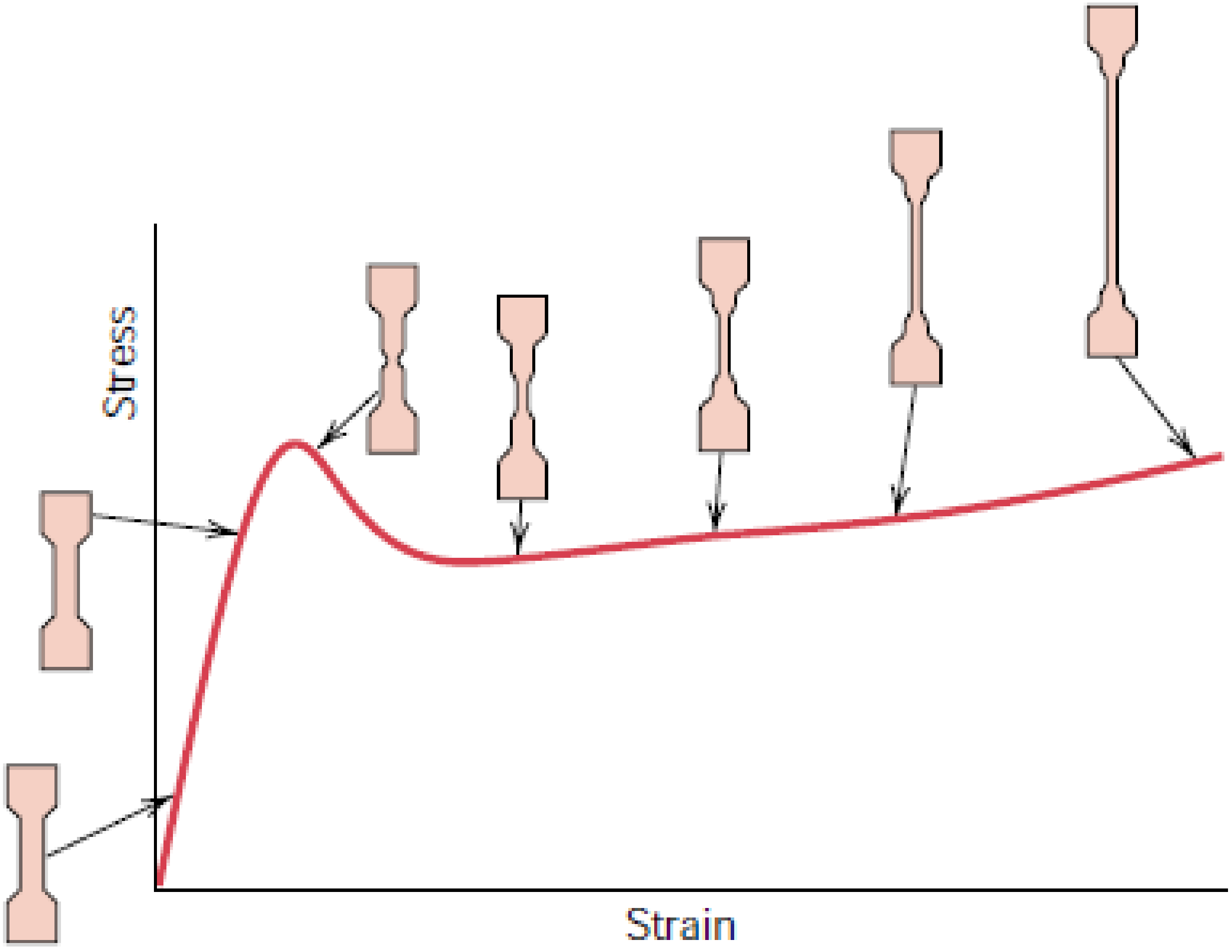
DUCTILITY

- **Ductility** may be expressed quantitatively as either percent elongation or percent reduction in area. The percent elongation %EL is the percentage of plastic strain at fracture,



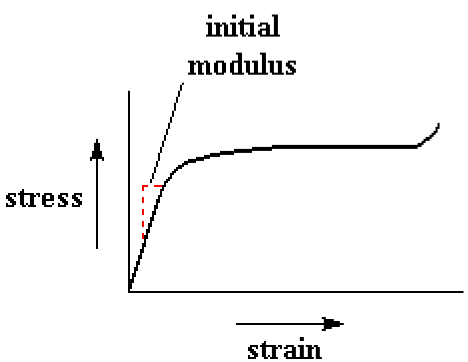
$$\%\text{EL} = \left(\frac{l_f - l_0}{l_0}\right) \times 100$$

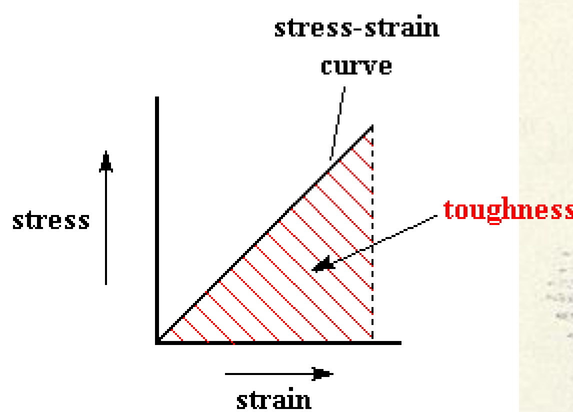
where lf is the fracture length and lo is the original gauge length


Stress
Strain

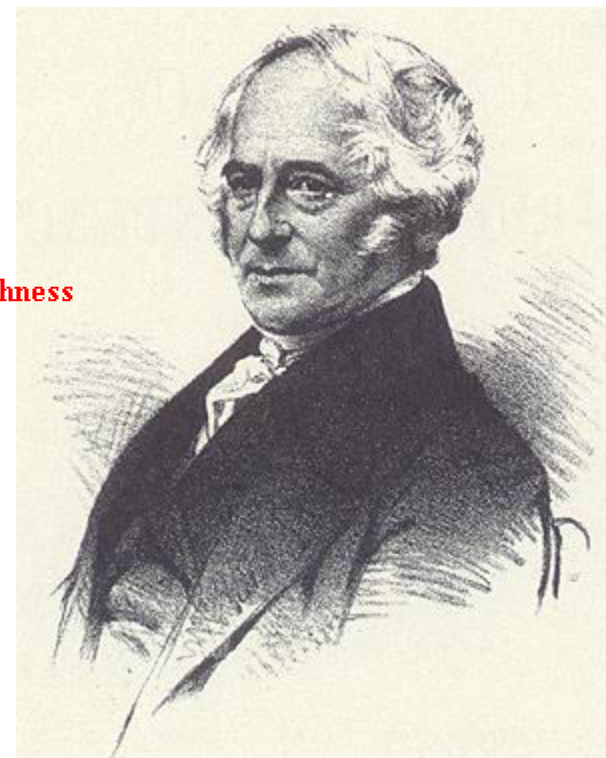
Mechanical Properties of Polymers

If you've been reading much of *The Macrogalleria* you'll notice that we talk a lot about polymers as being "strong" and "tough" or maybe even "ductile". Strength, toughness, and ductility are all mechanical properties. But what do these words really mean? How do we measure how "strong" a polymer is? What is the difference between a "strong" polymer and a "tough" polymer? This page is dedicated to sorting out all these matters.

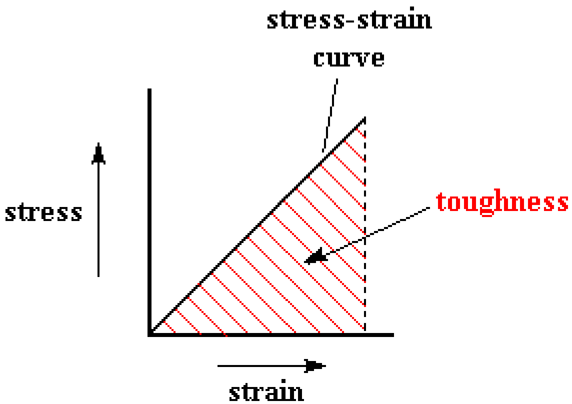


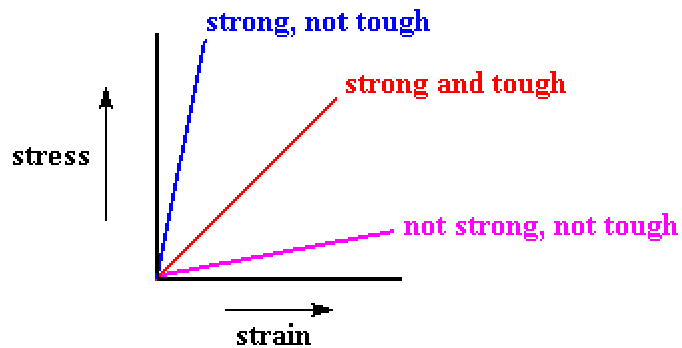


After Odian, George; *Principles of Polymerization, 3rd ed.*, J. Wiley, New York, 1991, p.34.



Mechanical Properties of Polymers





In real life, we usually want materials to be tough and strong. Ideally, it would be nice to have a material that wouldn't bend or break, but this is the real world. You have to make trade-offs. Take a look at the plots again. The blue sample has a much higher modulus than the red sample. While it's good for materials in a lot of applications to have high moduli and resist deformation, in the real world it's a lot better for a material to bend than to break, and if bending, stretching or deforming in some other way prevents the material from breaking, all the better. So when we design new polymers, or new composites, we often sacrifice a little bit of strength in order to make the material tougher.