



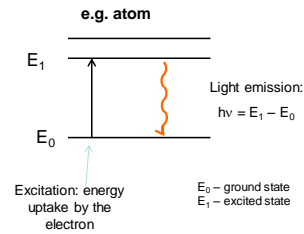
Physical basis of dental material science 11.

Optical and other properties. Summary

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Luminescence

Light emission over the thermal radiation.
Light emission after excitation.



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Application of luminescence

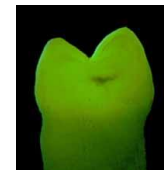
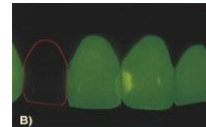
excitation	name: -luminescence	example
light	photo-	quinine-sulphate, phosphor, ...
X-ray	X-ray	Nal(Tl)
radioactive radiation	radio-	Nal(Tl)
electric field	electro-	mercury-lamps
mechanical effect	tribo-	sugarcube
chemical reaction	chemo- (bio-)	firebug
heat	thermo-	$\text{CaSO}_4(\text{Dy})$



+ materials analysis, structure of biological macromolecules, fluorescence microscopy, sensors, monitors, radiation detectors, ...

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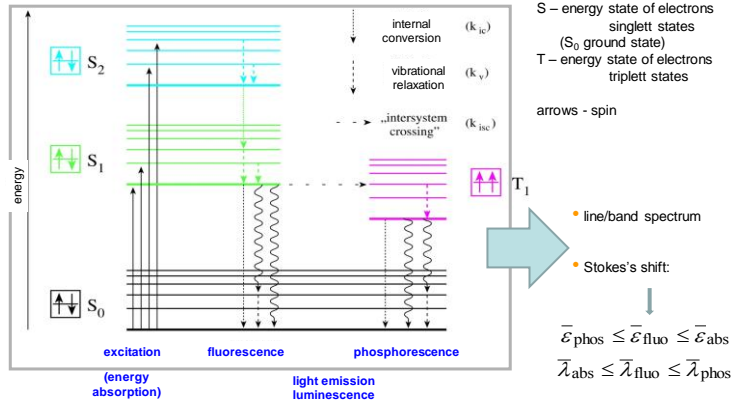
Dental application



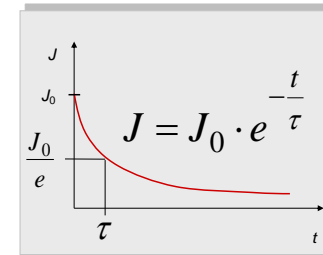
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Electronic states

Jablonski diagram:

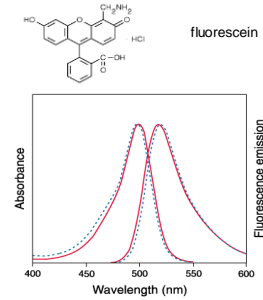


Life-time (τ): time while the intensity decreases by factor e.



$$\bar{\tau}_{flu} \ll \bar{\tau}_{phos}$$

emission spectrum: $J(\lambda)$
(Intensity of the emitted light versus wavelength)



Quantum efficiency (Q):

$$Q = \frac{\text{no. of emitted photons}}{\text{no. of absorbed photons}}$$

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Optical properties

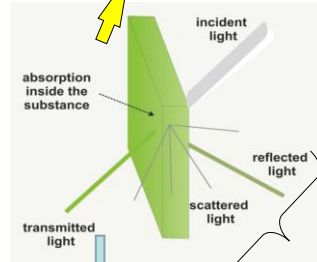
transparent - translucent - opaque

A high degree of regularity in the primary structure that is maintained in the long-range repeating structure because the particles in a solid are jumbled and disordered - they move about

translucent:
diffuse transparency

opaque:
not transparent,
diffuse reflection

fluorescence after absorption



color 2

color 3



Depends on the spectrum of the incident light!



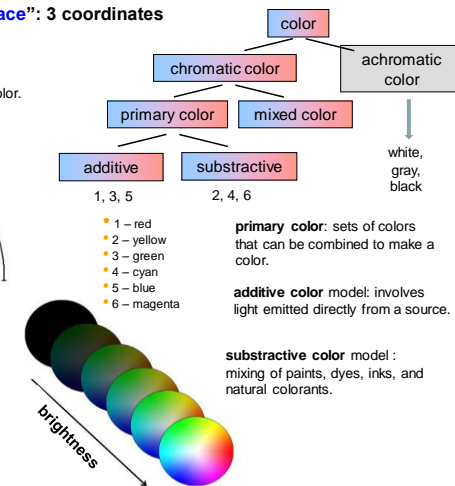
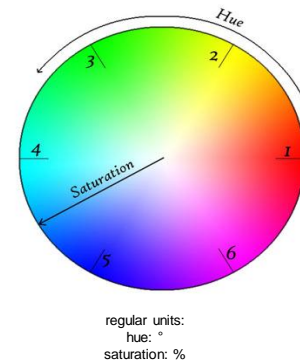
color 1

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Color

„color space”: 3 coordinates

Hue: refers to a pure color
Saturation: perceived intensity of a specific color.

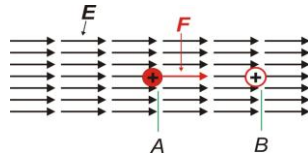


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Electric properties

Electric charges in materials: electrons, ions.

Q – charge, unit: C (coulomb)



Coulomb-force: attractive or repulsive
E: strength of the electric field = F/Q

$$\text{Work: } W_{AB} = \sum \vec{F} \cdot \Delta \vec{s} = Q \cdot \sum \vec{E} \cdot \Delta \vec{s}$$

Voltage (V):
unit: volt (V)

$$V_{AB} = \frac{W_{AB}}{Q}$$

current (I): flow of charges.
(due to the electric field)
unit: ampere (A)

$$I = \frac{\Delta Q}{\Delta t}$$

Ohm's law:

$$R = \frac{U}{I}$$

R: resistance, unit: ohm (Ω)

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Electric properties

Resistivity (ρ): -
(specific resistance)

$$\rho = \frac{R \cdot A}{l}$$

unit: Ωm

R: resistance
A: cross-section
l: length

Conductivity (σ):

$$\sigma = \frac{1}{\rho}$$

unit: $(\Omega m)^{-1} = S/m$

S: siemens, unit of conductance
conductance = 1/R

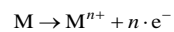
material	$\sigma (S/m)$	
silver	$6.8 \cdot 10^7$	conductors
gold	$4.3 \cdot 10^7$	
platinum	$0.94 \cdot 10^7$	
germanium	2.2	semi-conductors
silicon	$4 \cdot 10^{-4}$	
hyacinth	$\approx 10^{-10}$	insulators
porcelain	$\approx 10^{-11}$	
glass	$\approx 10^{-13}$	
PMMA	$\approx 10^{-12}$	
PE	$\approx 10^{-16}$	

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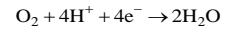
Chemical properties

Corrosion is the disintegration of a material into its constituent atoms due to chemical reactions.

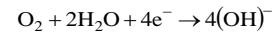
- Oxidation and corrosion of metals



in acidic medium

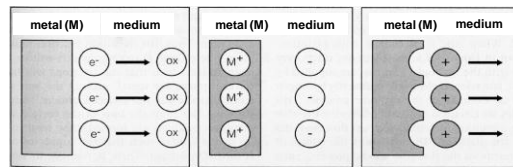


neutral or alkaline medium



galvanic series of
elements (in salt water)

Pt	inert
Au	
Ti	
Ag	
Cu	
Ni	
Sn	
Pb	
Al	
Zn	active



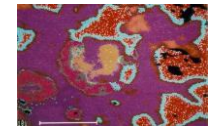
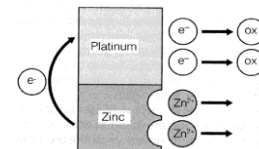
corrosion of the amalgam

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Type of corrosion

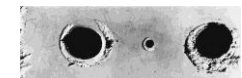
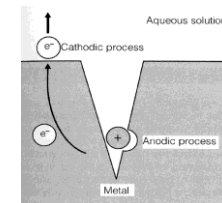
Galvanic corrosion:

one metal corrodes to another when both metals are in electrical contact and immersed in an electrolyte.



crevice corrosion:

is a corrosion occurring in spaces to which the access of the working fluid from the environment is limited.



p. 643 corrosion of the amalgam

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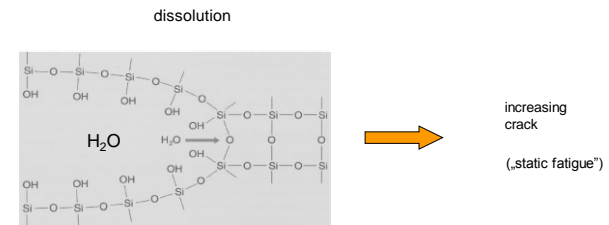
Typical amalgam

typical constitution	
metal	weight%
Ag	67-74
Sn	25-28
Cu	0-6
Zn	0-2
Hg	0-3

+ Hg

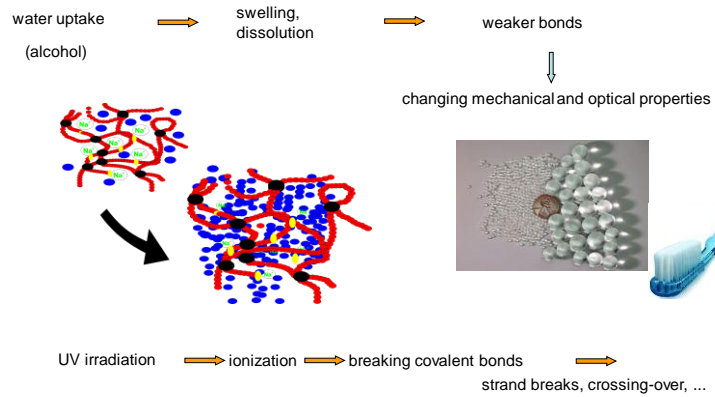
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Corrosion of ceramics



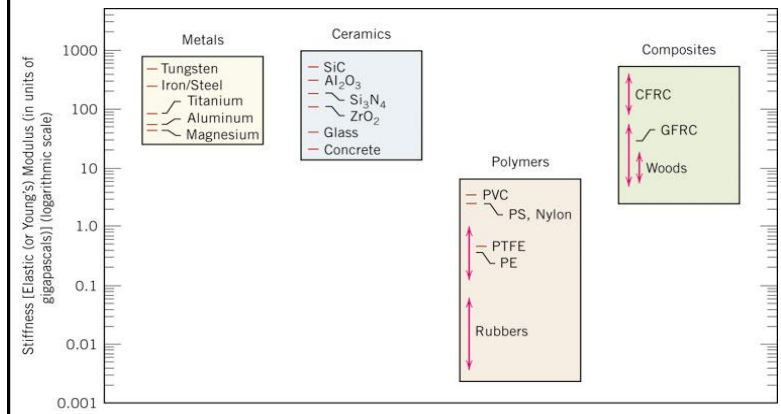
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Degradation of the polymers

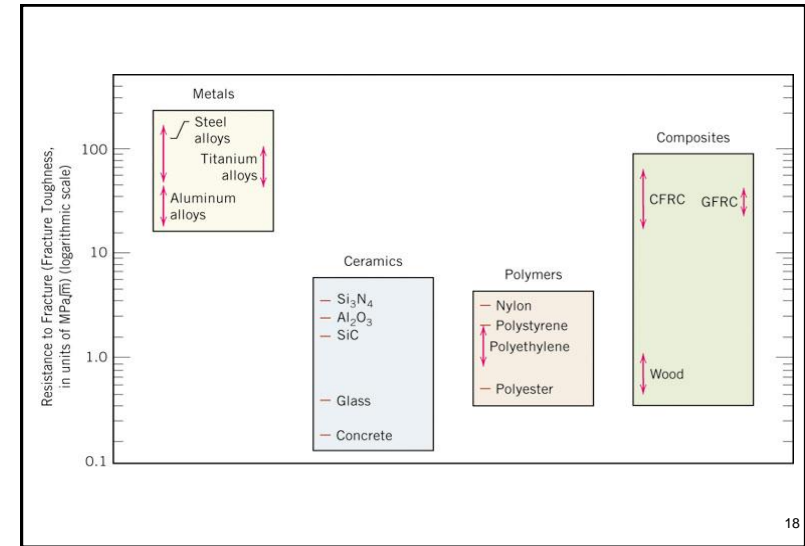
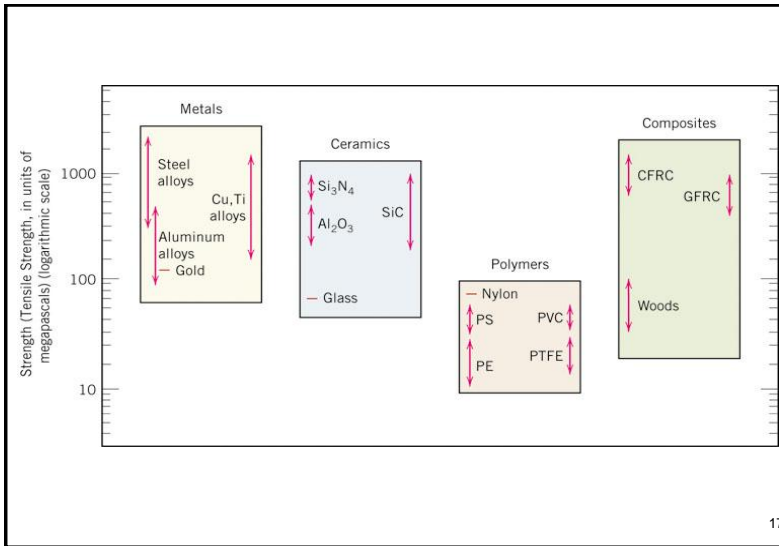


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Comparison of the properties of the materials



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Metals

properties in general:

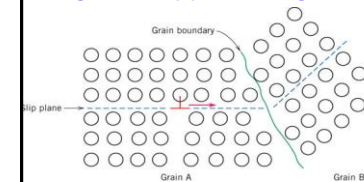
- high density
- stiff
- strong
- ductile (plastic)
- tough (tough fracture)
- hard
- thermal conductor
- electric conductor
- opaque, metal color
- corrosive



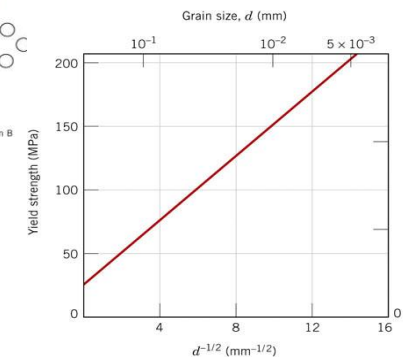
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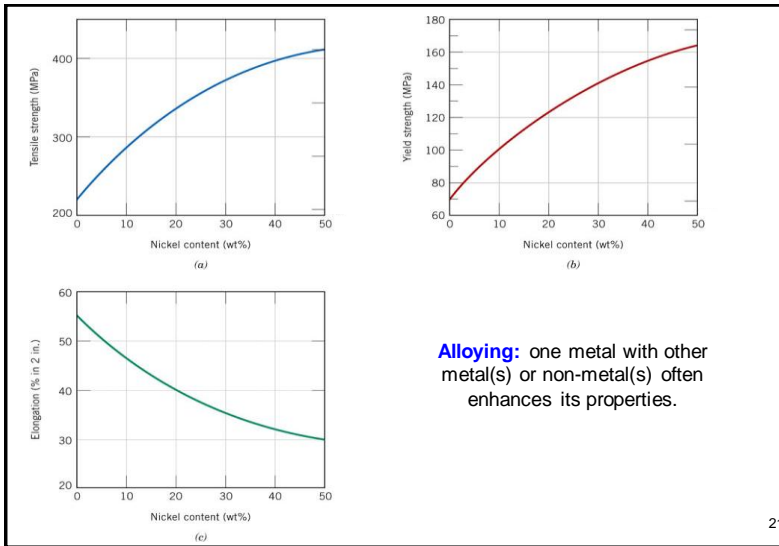
Increasing the strength of the metals

grain size (d) decreasing

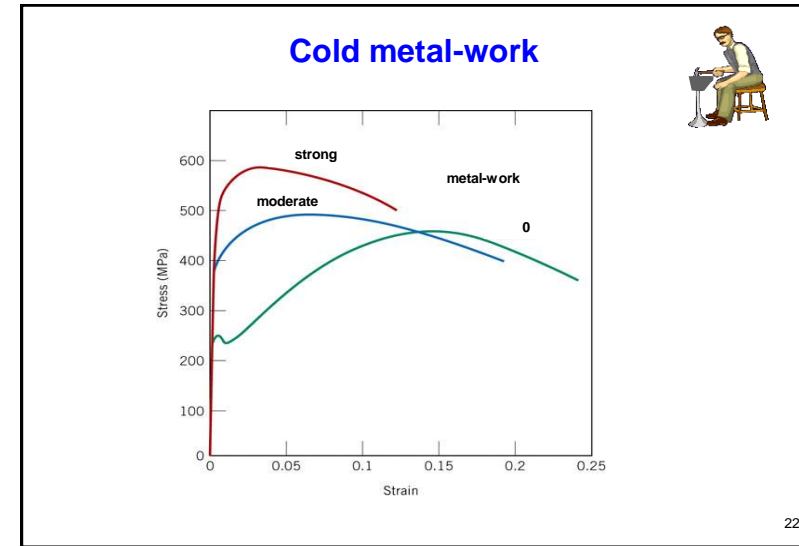


Motion of dislocations!





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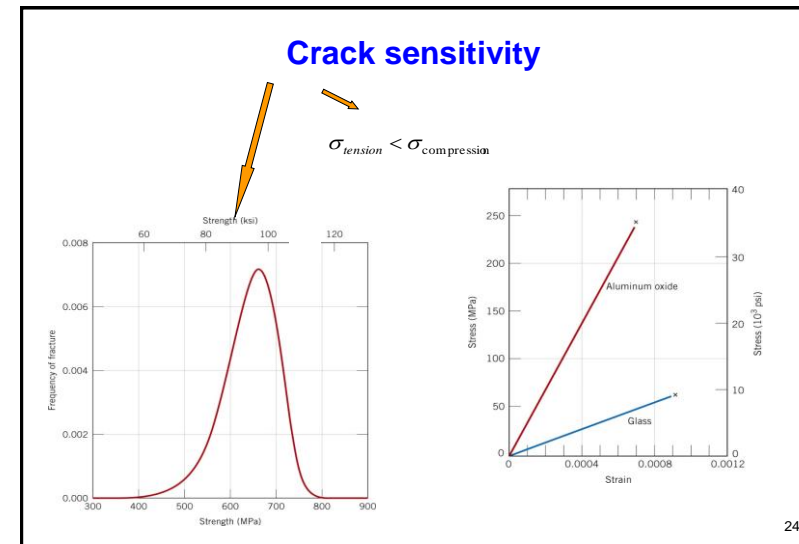
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Ceramics

properties in general:

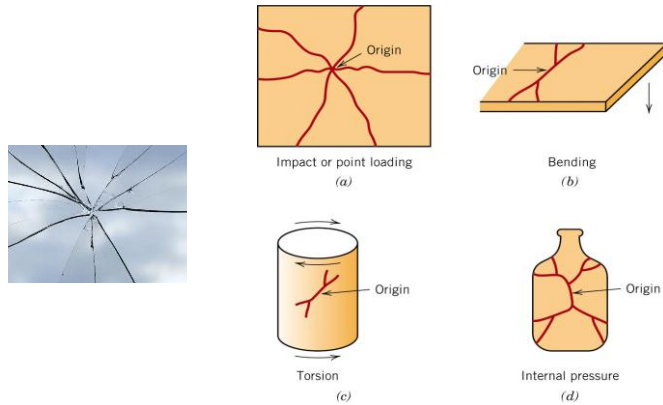
- medium density
- rigid
- strong (in rupture medium)
- not plastic
- brittle (brittle fracture)
- hard
- thermal insulator
- weak thermal shock tolerance
- electric insulator
- different optical properties
- low chemical corrosion

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Crack types



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Polimers

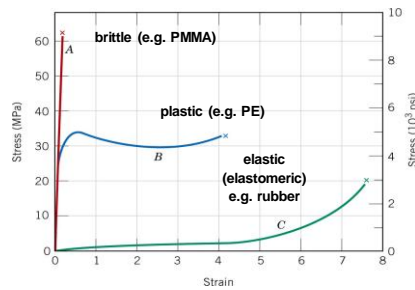
properties in general:

- low density
- elastic
- weak
- ductile
- medium tough - brittle
- soft
- viscoelastic
- thermal insulator
- electric insulator
- different optical properties
- degradation



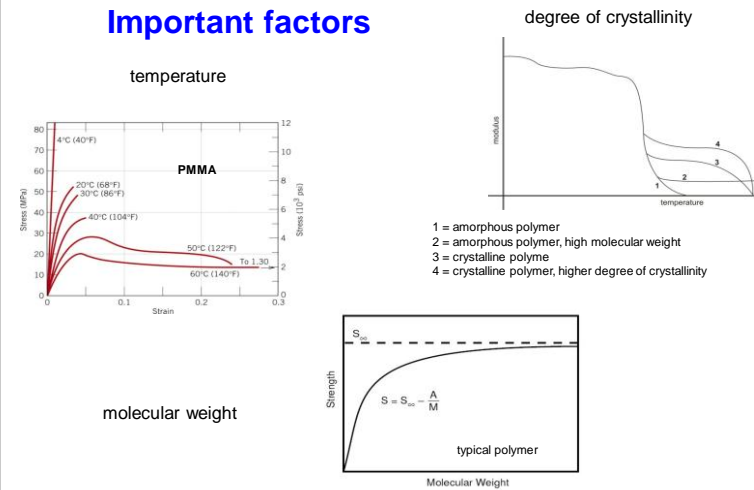
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High variety of properties



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Important factors



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Composites in dentistry

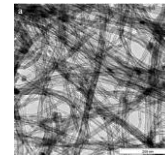
properties in general:

- low and medium density
- medium stiff - elastic
- strong
- ductile
- tough
- hard – medium hard
- thermal insulator
- electric insulator
- different optical properties
- small degradation



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Combination of advantageous properties

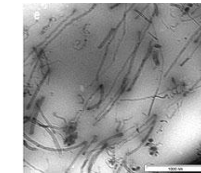
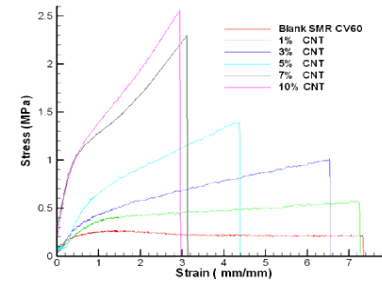


carbon nanotubes (CNT)

Composite:
rubber (SMR)
+
carbon nanotubes (CNT)

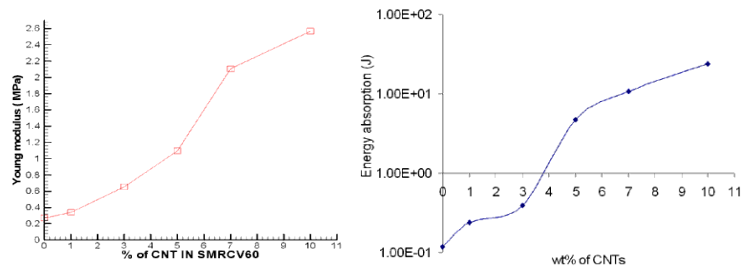


rubber (SMR CV60)



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Effect on properties



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