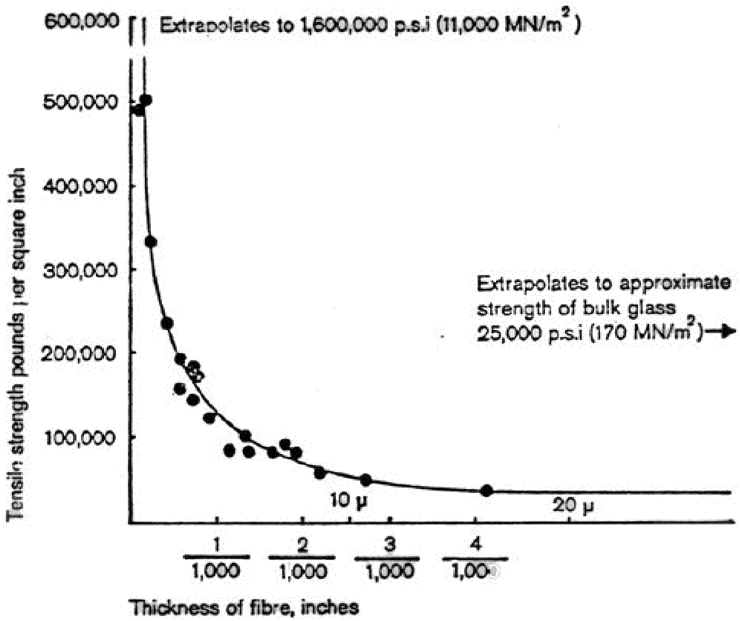
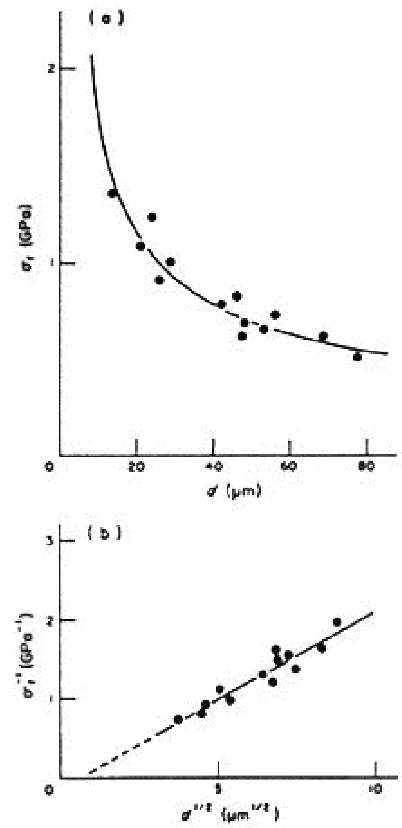
WHY ARE THEY WEAK? - BRITTLE SOLIDS

GLASS FIBERS



SURFACE CRACKS

POLYDIACETYLENE SINGLE CRYSTALS



CRYSTAL DEFECTS SUCH AS SURFACE STEPS

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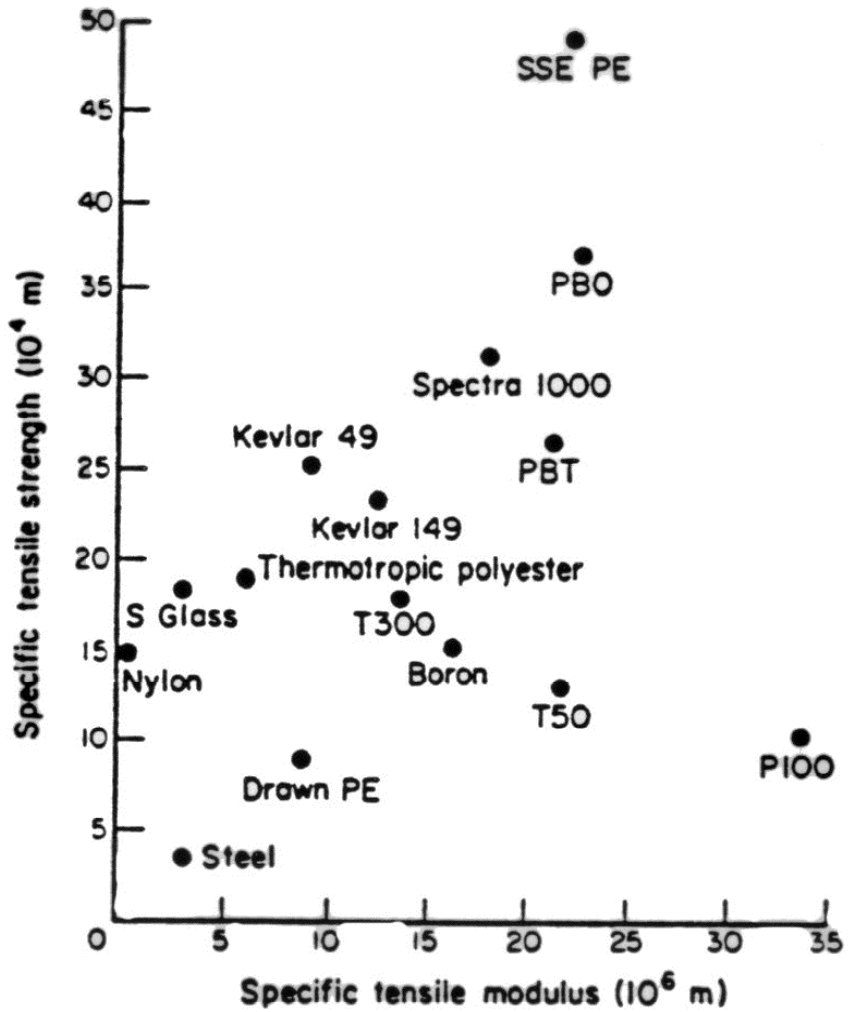
The New Science of Strong Materials, Second Edition*,*
Penguin Books (1976).

Reproduced with permission from C. Galiotis and
R. J. Young, Polymer*,* ***24****, 1023 (1983).*

STRENGTH AND MODULUS OF VARIOUS MATERIALS



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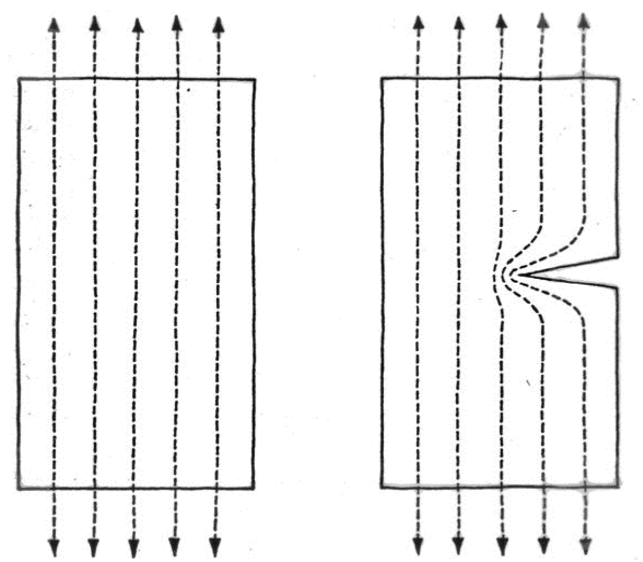
TOUGHNESS - OR HOW TO STOP CRACKS

PLINY - TO DETERMINE IF A DIAMOND IS GENUINE, IT SHOULD BE PUT ON AN ANVIL AND HIT VERY HARD WITH A HAMMER
- NOT A RELIABLE TEST !!!

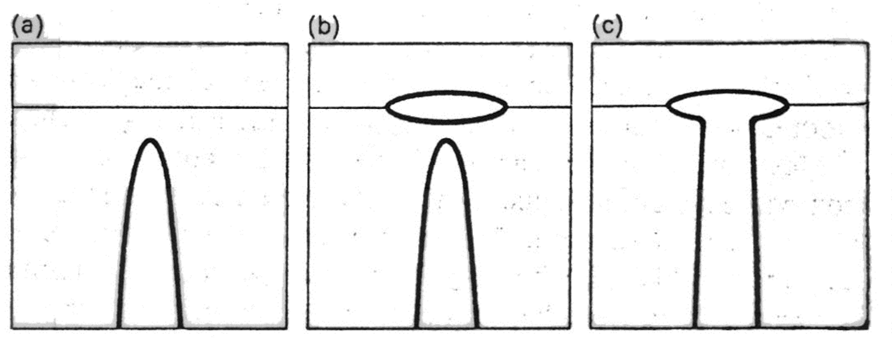
CONFUSES BRITTLENESS AND HARDNESS

BRITTLENESS - LACK OF RESISTANCE TO THE PROPOGATION OF CRACKS



TOUGHNESS - OR HOW TO STOP CRACKS

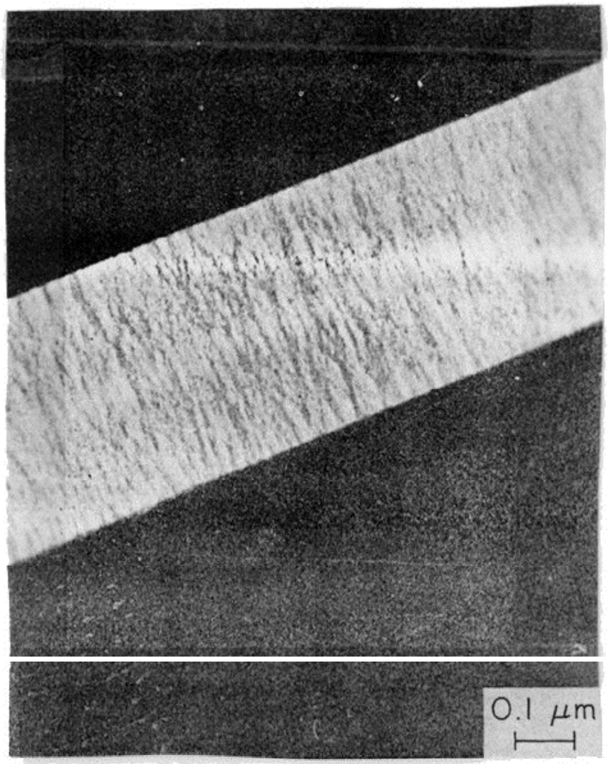
NOW CONSIDER TWO BRITTLE MATERIALS; WINDOW GLASS (IN THE FORM OF FIBERS) AND A THERMOSETTING POLYESTER RESIN (HIGH Tg). DISPERSE ONE IN THE OTHER,BUT KEEP THE INTERFACE WEAK



NOTE: CRACK STOPPING IS NOT THE ONLY "TOUGHENING" OR ENERGY ABSORPTION MECHANISM.YOU SHOULD KNOW WHAT CRAZING AND YIELDING ARE

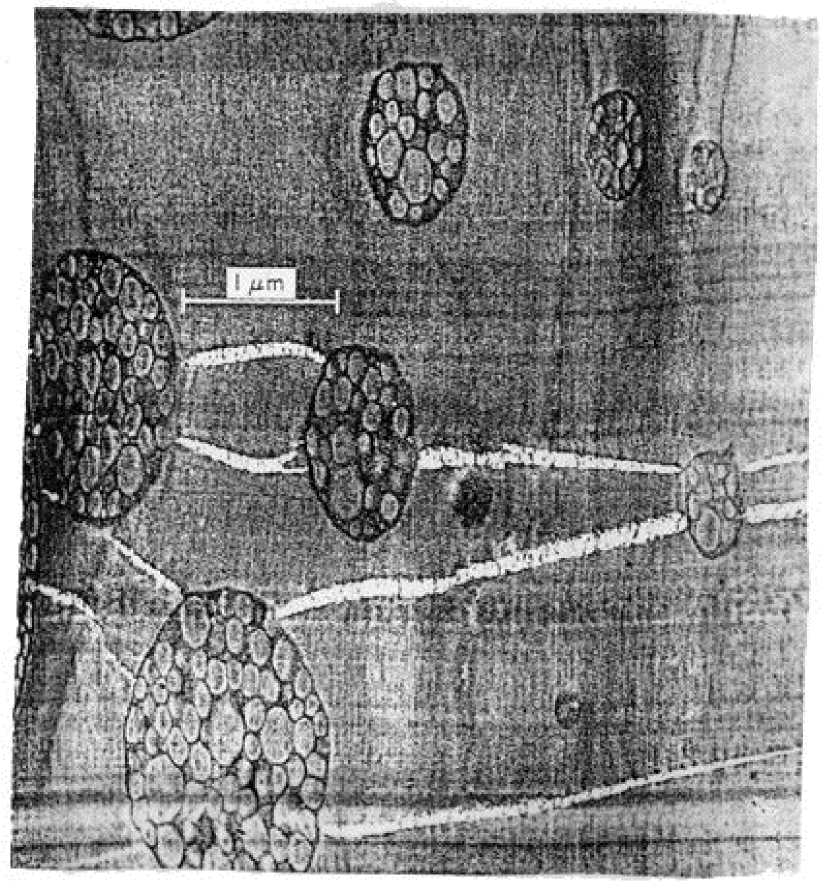
CRAZING

CRAZE - CRACK BRIDGED BY SMALL FIBERS



Reproduced with permission from P. Beahan et al., Proc. Roy. Soc. London, ***A343****, 525 (1975).*

RUBBER TOUGHENED POLYMERS



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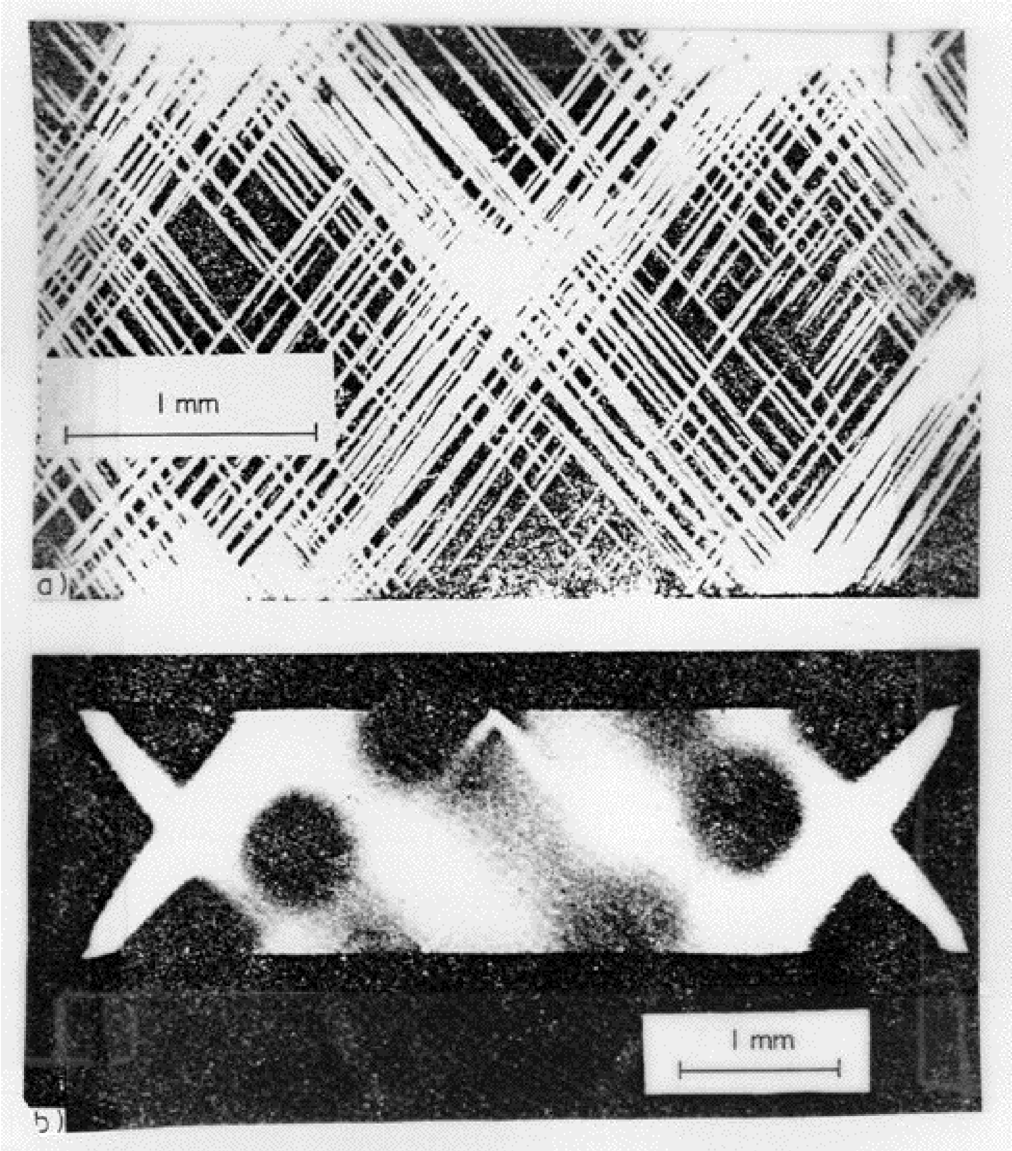
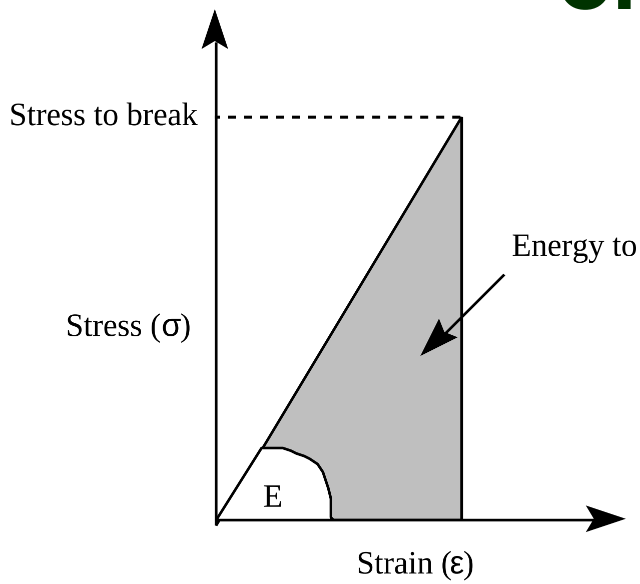
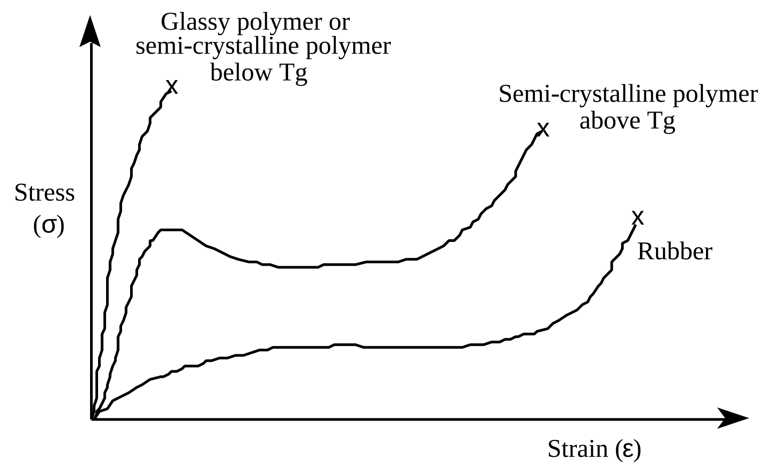
YIELDING



Reproduced with permission from P. B. Bowdon, *Philos. Mag.*, ***22***, 455 (1970).

STRESS / STRAIN CHARACTERISTICS OF POLYMERS



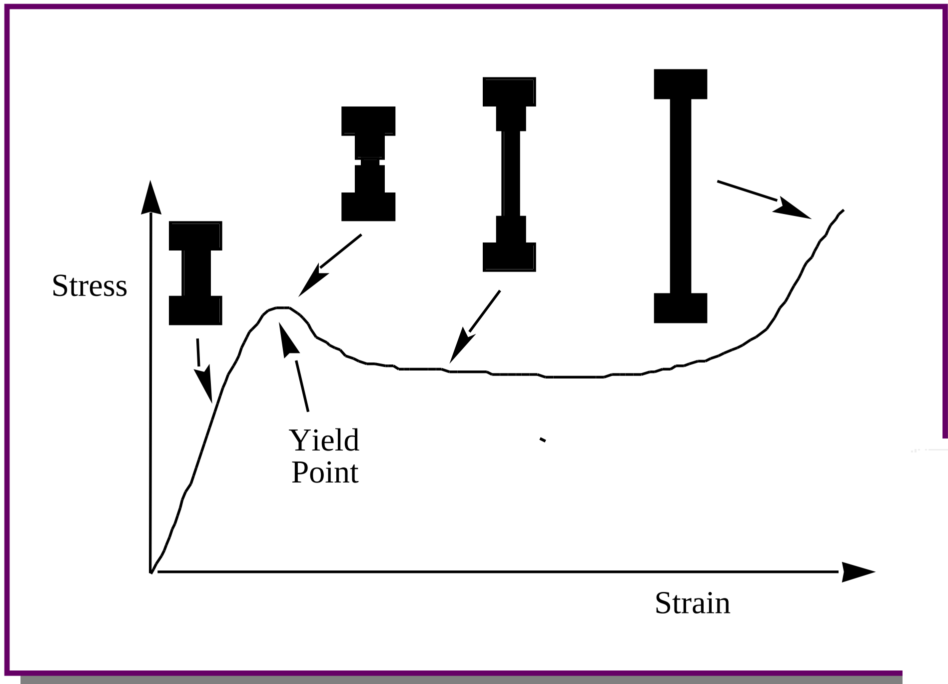


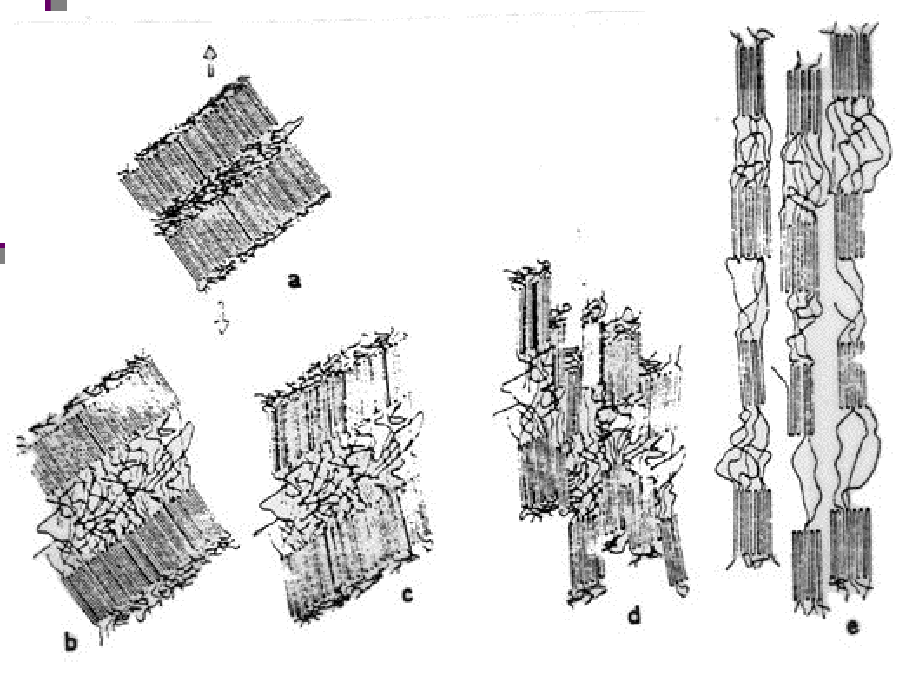
Many of the mechanical characteristics of polymers that we have just discussed (Eg strength,stiffness, toughness,yield behaviour) can be determined from Stress/strain measurements.

On the left is shown a stress/strain diagram for a hypothetical material that obeys Hooke's law all the way to failure

Real stress/strain diagrams are much more complicated

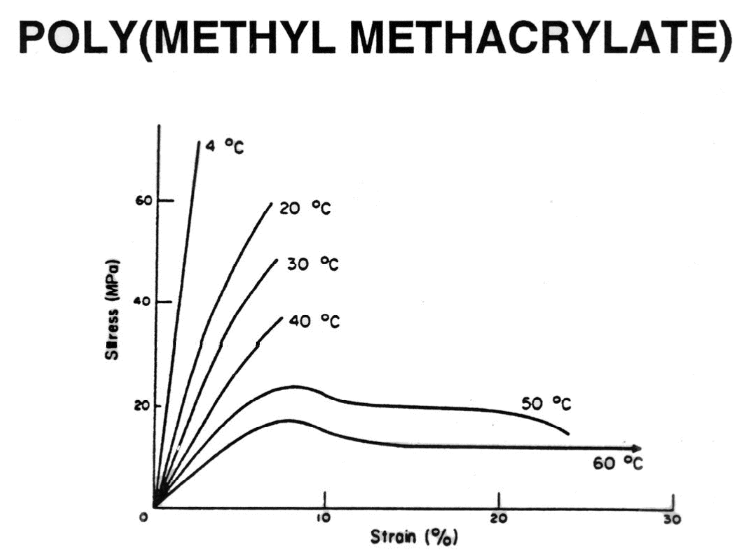
YIELDING IN SEMI-CRYSTALLINE POLYMERS





Reproduced with permiss-ion from J. Schultz, *Polymer Material Science*, Prentice-Hall, New Jersey, 1974.

THE EFFECT OF HEAT AND PLASTICIZERS ON THE MECHANICAL PROPERTIES OF GLASSY POLYMERS



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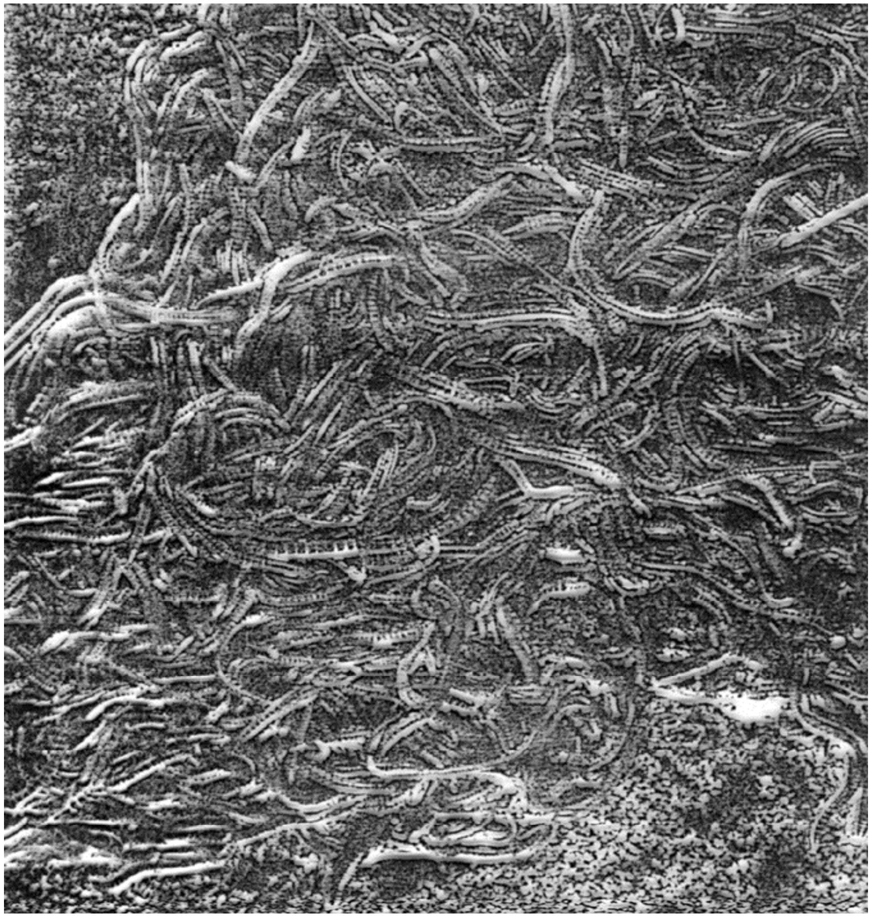
QUESTIONS ;

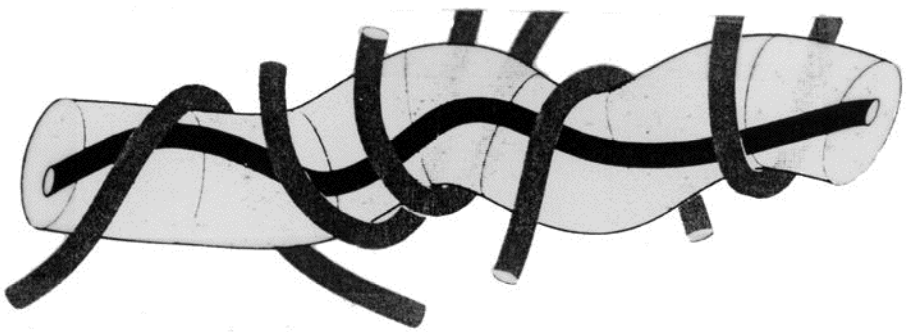
WHICH CURVE WOULD BEST REPRESENT THE BEHAVIOUR OF PURE PVC AT ROOM TEMPERATURE?

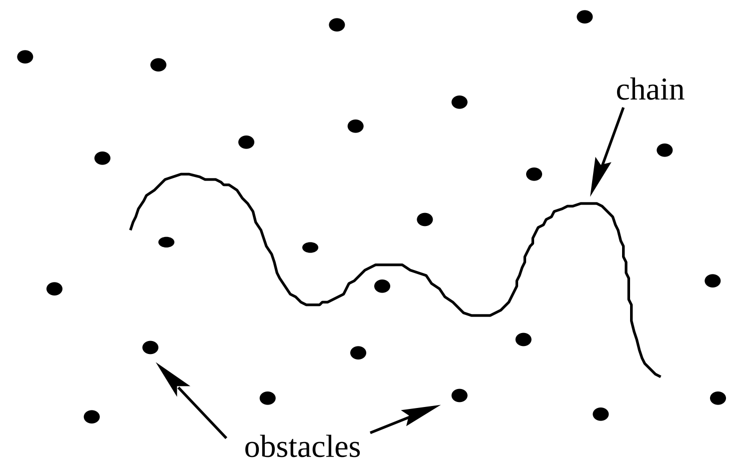
WHAT WOULD HAPPEN IF THE PVC WAS NOW MIXED WITH A PLASTICIZER?

POLYMER MELT RHEOLOGY



HOW DO CHAINS MOVE - REPTATION





THEORY PREDICTS

$$D \quad \frac{1}{M^2}$$

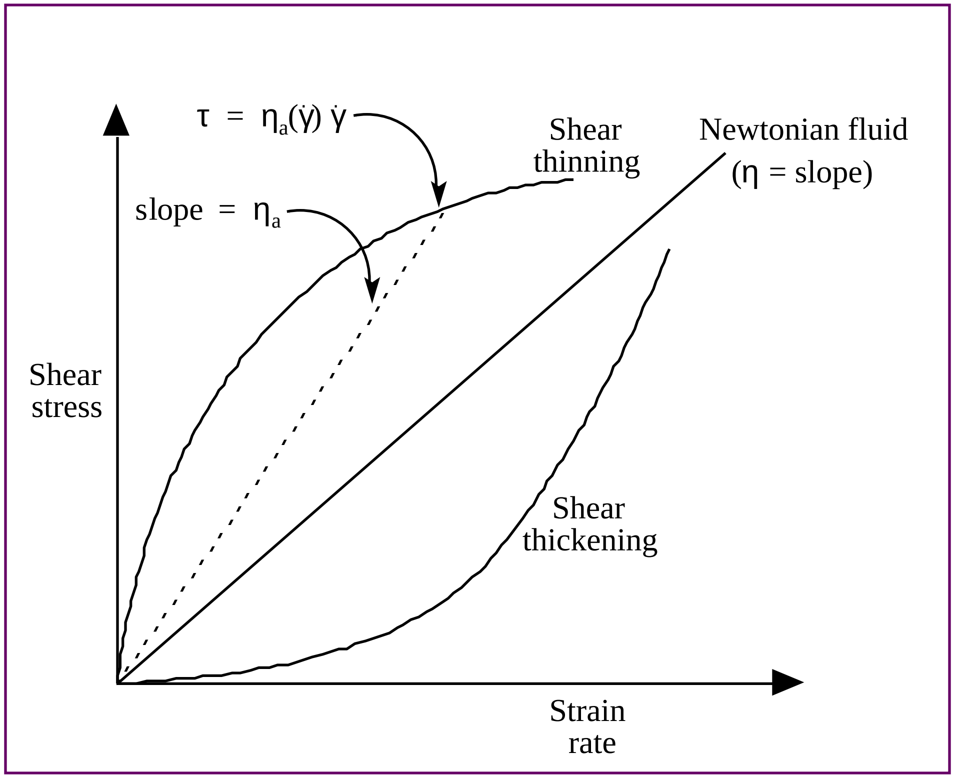
$$\eta_0 \quad M^3$$

NEWTONIAN AND NON - NEWTONIAN FLUIDS

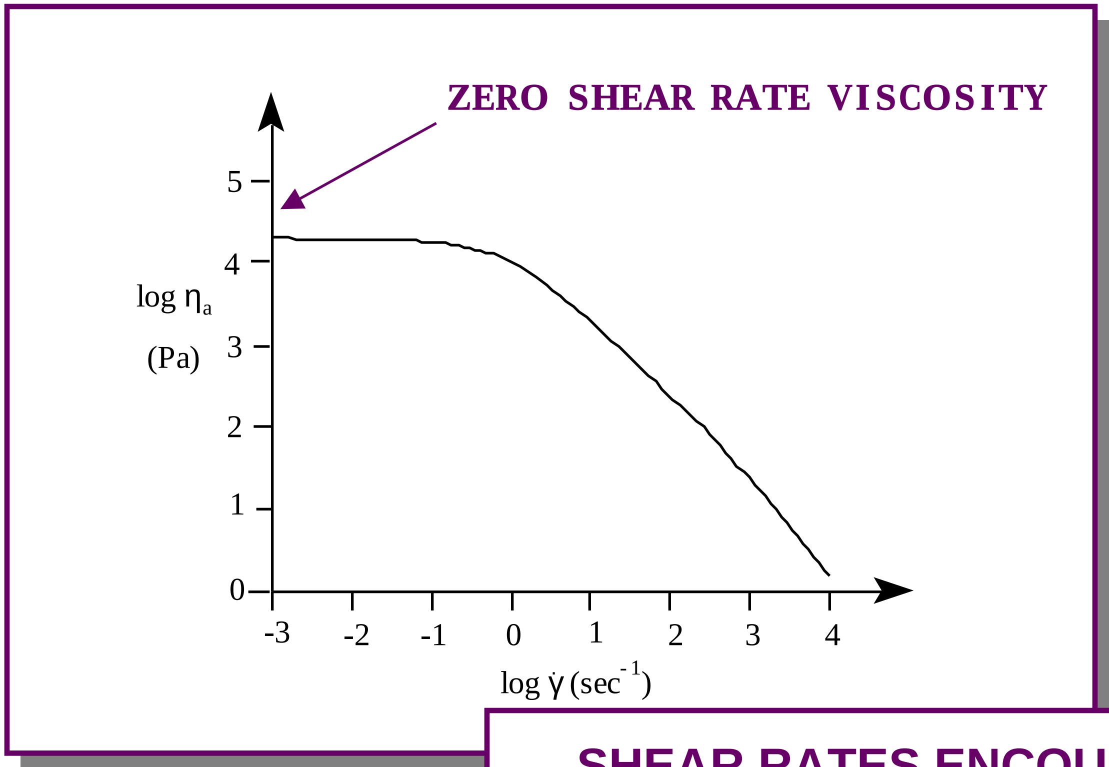
NEWTONIAN BEHAVIOUR:

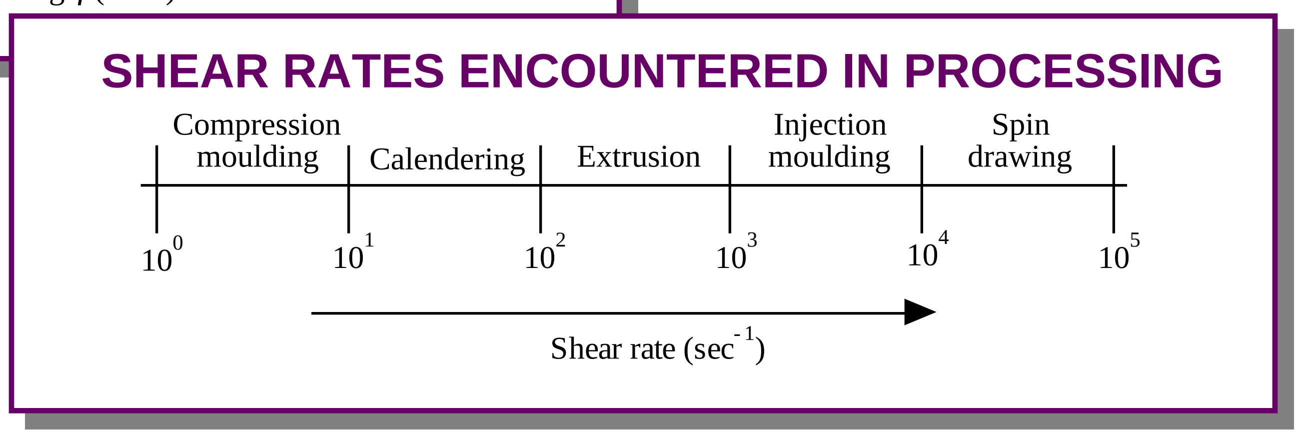
$$\tau_{xy} = \eta\dot{\gamma}$$

MOST POLMER MELTS ARE *SHEAR THINNING*

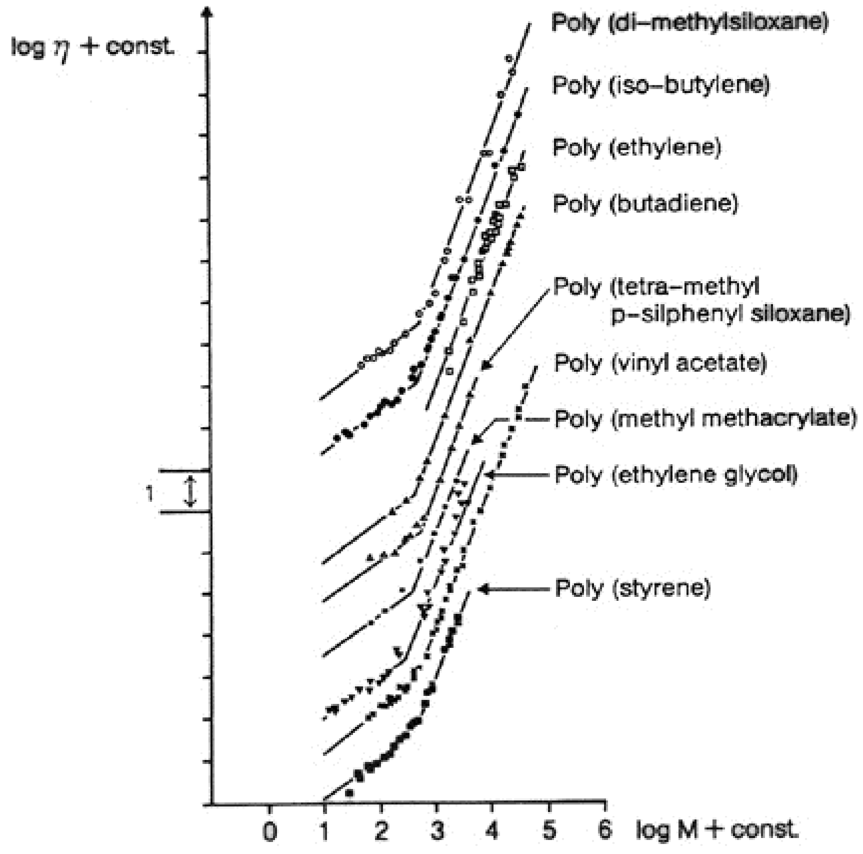


VARIATION OF MELT VISCOSITY WITH STRAIN RATE





VARIATION OF MELT VISCOSITY WITH MOLECULAR WEIGHT



$$\eta_m = K_L (DP)_w^{1.0}$$
$$\eta_m = K_H (DP)_w^{3.4}$$

Reproduced with permission from G. C. Berry and T. G. Fox, *Adv. Polym. Sci.*, **5**, 261 (1968)

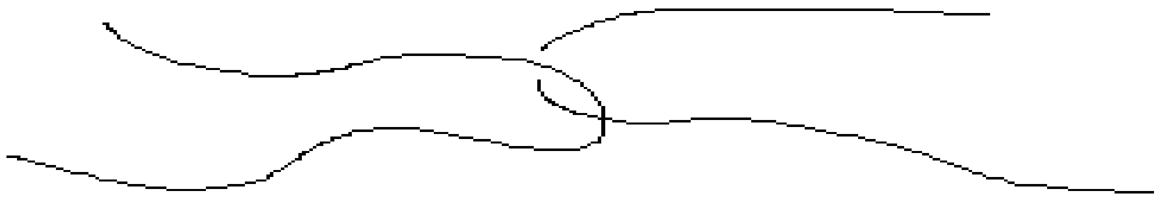
ENTANGLEMENTS

VISCOSITY - A MEASURE OF THE FRICTIONAL FORCES ACTING ON A MOLECULE

$$\eta_m = K_L (DP)_w^{1.0}$$

SMALL MOLECULES - THE VISCOSITY VARIES DIRECTLY WITH SIZE

AT A CRITICAL CHAIN LENGTH CHAINS START TO BECOME TANGLED UP WITH ONE ANOTHER,HOWEVER



THEN $$\eta_m = K_H (DP)_w^{3.4}$$