

Plastic material basics

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Teolliset valmistustekniikat ja materiaalit

Plastic material basics

- Chemistry
- Ways to classify
- What else than polymer in plastics

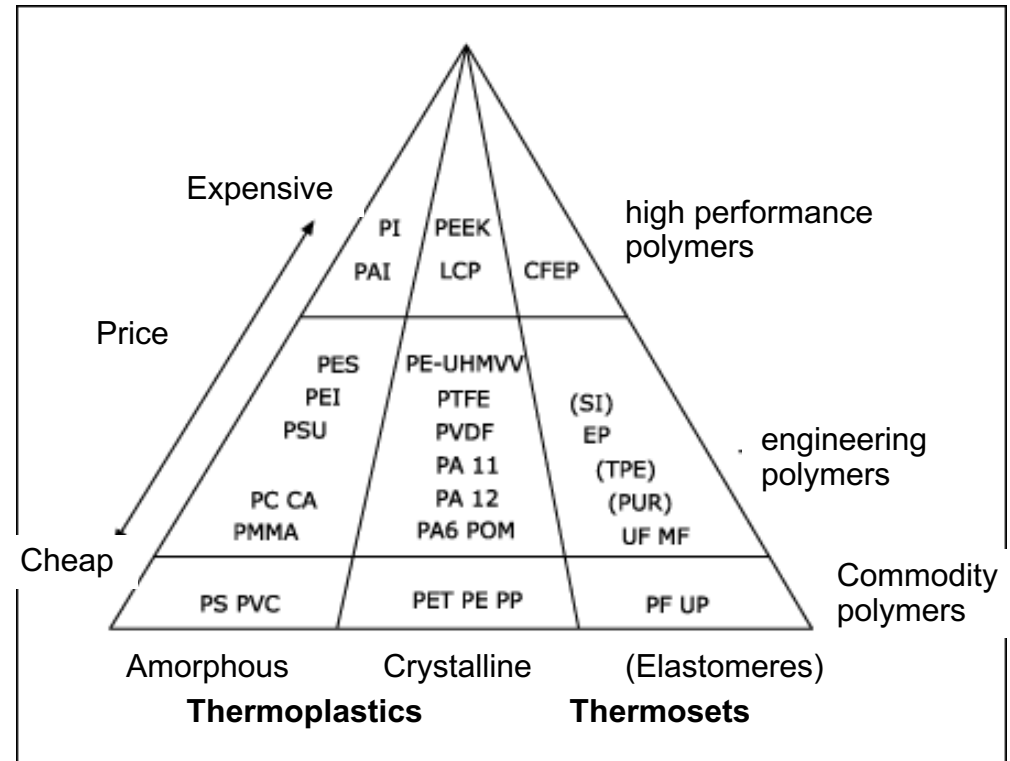
Are all plastics the same?

Features of plastics

- Light
- Flexible
- Impact resistance
- Good corrosion resistance
- Chemical resistance
- Easy to form
- Good insulator → bad conductor
- Does not stand high temperatures
- Creep
- Cracking by tension

Ways to classify plastics

- Thermosets / thermoplastics /elastomers
- Commodity polymers / engineering polymers / high performance polymers
- Synthetic plastics / natural plastics



Plastics

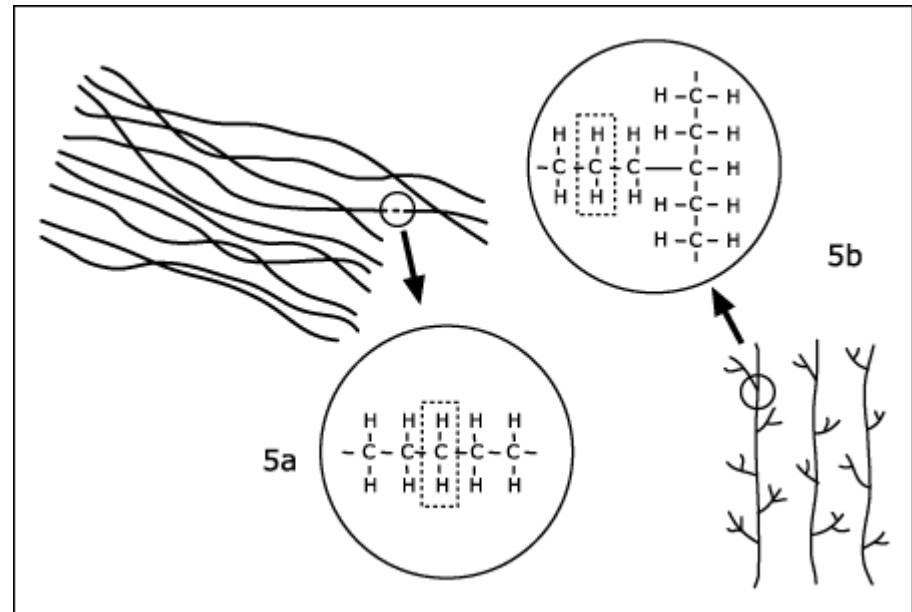
- **Polymer**
- Fillers
- Additives
- Reinforcements
- Pigments

Plastics

- Thermoplastics
 - Crystal
 - Amorphous
- Thermosets
- Elastomer
 - Thermoplastic elastomers
 - Rubbers

Thermoplastics

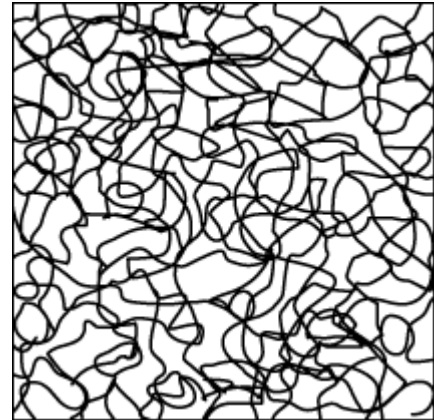
- Straight chains
- From chain to an other weak force
- Melts
- Reformable



Amorphous plastics

- Can be transparent
- Small shrinkage
- Poor chemical strength

- PS, PVC, PC, PMMA



Amorphous plastics

- Polystyrene PS
- Hi-impact polystyrene HIPS
- ABS (Acrylnitrilebutadienestyrene)
- Polyvinylchloride PVC (nylon)

Polystyrene PS

High impact polystyrene HIPS

- Amorphous commodity plastic
- Softens at 70-78 C
- Density 1kg/l
- PS
 - Transparent like glass
- HIPS
 - Impact resistant polystyrene not transparent
- PS-E
 - Shell polystyrene

PS usage

- Injection molding PS
 - Transparent boxes, CD-package
- Injection moulding HIPS
 - tv-chasing, video cassettes, toys, household items, pens, magazine holders
- Thermoformig PS-sheet
 - Transparent throw away glasses
- Thermoforming HIPS- sheet
 - Jogurth packaging, refrigerator inside
- PS-E insulation



PMMA polymethyl metacrylate

(acrylic)

- Amorphous, more transparent than glass
- Hard surface, cratch resistant
- Stiff
- Good UV resistance
- Poor impact resistance
- Tension cracking
- 2/3 made to sheets
 - Cast, stronger
 - Extruded, even thickness, better for thermo forming
 - Impact strenghtened version
 - Acrylic shell board

PMMA use

- PMMA- sheet
 - Advertisement boxes, thermo formed products, lamps
 - Stands
 - Roof windows
- Acrylic shell sheet
 - Green houses
- Profile extrusion bathroom lamps
- Injection molding: rear lamps, reflectors

ABS acrylonitrile butadiene styrene

- Copolymer of HIPS and acrylonitrile
- Like HIPS but
 - Stronger, better surface quality
- Softens at 90 C
- Density 1kg/l

ABS use

- Injection molding, telephones wacuum cleaners, chrome tap handles,
- ABS-sheet: thermoformet parts for vehicles, boats

Polyvinyl chloride PVC

- Amorphous commodity plastic
- Easy to adjust features with additives
- Density 1,4 kg/l
- PVC-U hard
- PVC-P softened
- Chlorine relieves when heated
- Softens at 70 C

PVC usage

- PVC-U tubes, sheets and profiles
- PVC-P coatings, tapes, hoses films and cable cover
- Injection moulding: pipe joints
- PVC-U sheet plastic cards, binder sheets. kansion välilehdet, die cutting base
- PVC-P sheet: raincoats dirve thorough doors seals

Stone filled acrylics

- Corian

PC polycarbonate

- Amorphous
- Glass clear
- Heat resistant 130 C
- Hot water destroys
- Poor chemical resistance
- Soft surface
- Creep resistant

PC use

- Injection molding
 - CDs, car headlight, lamps
- Sheet
 - Safety shields, snowmobile glasses
- Hard surface PC
 - windows, burglar and bullet proof
- Shell sheet
 - greenhouse

ABS+PC

- Byblend means mixture of ready made polymerers
- ABS+PC acrylonitrile butadiene and polycarbonate
- Impact and heat resistant
- Easier to mould and cheaper than PC
- Use
 - Injection molding cellphone covers laptops

Cellulosic (CA, CAB, CP)

- Chemical modification
 - acetic acid => cellulose acetate, CA
 - Sellophane film
 - Rayon fibre
 - Cellulose propionate, CP
 - Cellulose -asetatebutyrate, CAB
- Resilient, good surface .
- Limited chemical resistance
- Gets fragile in cold

Use

- Glasses frames
- Lamps
- Packaging
- Brush handles, bottoms
- Near human body



Polyethylene PE

- Crystalline
- Most used
- Density below 1kg/1litre = floats
- Good chemical resistance
- Cheap
- Softens att 40 C
- Doesnt tolerate UV-radiation

Crystalline polymer

- Wear resistant
- Big shrinkage
- Good chemical strength

- PE, PP, PET



PE usage

- PE-LD films, coating cardboard
- PE-LD copolymers: packing films
- PE-HD
 - Main usage: tubes, pipes blow moulding
 - Injection molding: toys beverage boxes packaging boxes, household dishes
 - Sheet: hockey rink sides
- PE-(U)HMW
 - Cutting: cutting board cogwheel
 - Compression moulding: steering ski of snowmobile



Polypropylene PP

- A lot like PE, slightly better
- Fragile in cold
- Crystalline
- Density below 1kg/1litre = floats
- Good chemical resistance
- Softens in 55 - 68 C
- Integral hinge

PP usage

- Main usage:
 - Films and fibres
- monofilament
 - Ropes
- Injection molding
 - Bottle tops, freeze caskets, bumpers
 - PP+ talc, garden chairs, electric boxes
- Thermo forming
 - Packaging and
- Cutting
 - Technical parts



PA polyamids

- Crystalline engineering plastics
- PA 6, PA66, PA12, PA11, copolymeres
- Wery impact resistant
- Good chemical resistance
- Absorbs water impact resistance increases, expands

PA use

- Extrusion PA 6: sausage skin
- Injection molding PA 6: tools casings in car motor wheels
- Injection molding PA 66: car inlet manifold, electric chasaings, switchers



POM acetal polyoksymethene

- Crystalline engineering plastics
- Springs
- Strong, rigid, wear resistant
- Good moisture, heat and solvent resistance
- Needs UV stabilizer out doors

POM use

- Injection molding
 - Car door handles, waterpans tap inner parts
 - Snap buckles
- Cutting
 - Gears strings

PC polycarbonate

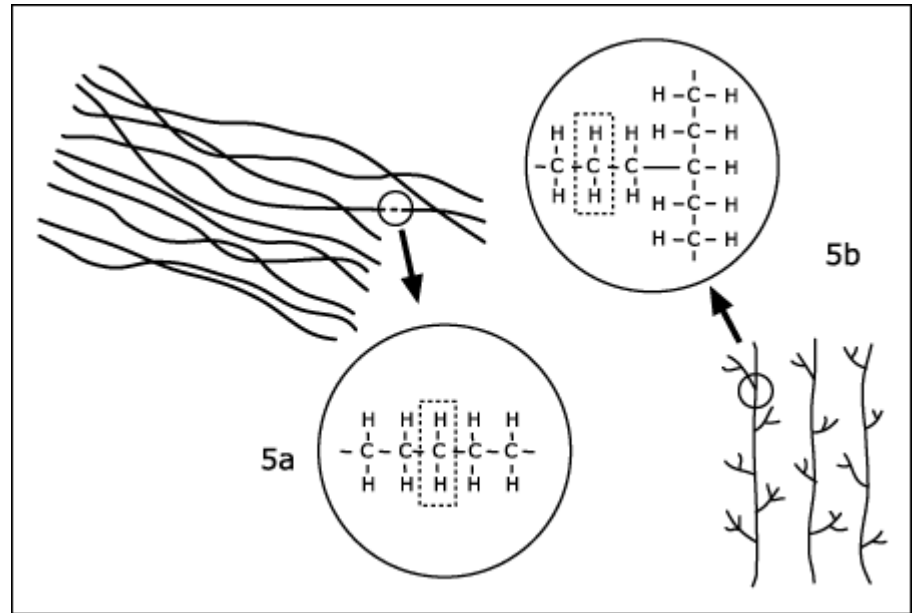
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Polytetrafluoroethylene (PTFE)

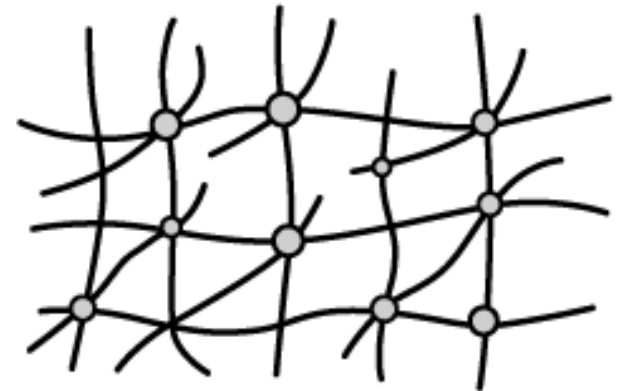
Teflon

- Doesn't react to anything
- Melting point 327 °C.
- Low friction
- Does not stick on anything
 - Compression molding



Thermosets

- Cross links
- Does not melt by adding heat
- Good heat resistance
- Good mechanical strength



Thermosets

- Polymerization by chemical reaction => hardening / cross linking
- Pre-polymer
- Hardening catalyst
- Non-reversible reaction
- 5% of all plastics

Thermosets

- Polyurethanes PUR
- Polyester UP
- Epoxy EP
- Vinyl ester VE
- Phenolic PF
- Melamine MF
- Urea UF

Polyurethanes PUR

- Wide variety forms and properties
- Good abrasion resistance
- Most commonly from isocyanate and polyol

Unsaturated polyester UP

- Mixture of polyester and monomer styrene
- Hardener / catalyst and accelerator
- exothermic reaction
- Some styrene evaporates
- Usage
 - Mostly reinforced, boats etc.



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Epoxy EP

- Epoxy resin and hardener
 - Small shrinkage
 - strong
 - Better thermal durability
 - No evaporating gas
-
- usage: sport equipment, tubes car parts, aerospace



Other thermosets

- Vinyl ester VE
 - Good chemical resistance
 - Tubes, tanks, chimneys
- Phenol formaldehyde PF Bakelite
 - One of the oldest plastics
 - Good thermal resistance
 - Usage: car and aerospace caskets
- Amino plastics
 - Melamine formaldehyde MF: table top laminate and kitchen utilities
 - Urea formaldehyde: electric parts

Elastomers

- Thermoplastic elastomers
- Rubbers

Thermoplastic elastomers, TPE

- Rubber like thermoplastics
- Mixtures of rubber and plastic

TPE types

- Copolymer
 - Polyurethane elastomer TPU
 - Styren block copolymer TPE-S
 - Copolyester elastomer TPE-E
 - Polyamid elastomer TPE-A
- Mixtures of plastics and rubber seokset
 - Polyolefin elastomers TPO
 - termoplastiic vulcanisates O-TPV

Thermoplastic Polyurethane elastomer TPU

- Harder and stiffer than other TPE:s
- Very good abrasion resistance
- Need stabilizer in outdoor use

- Use
 - Injection molding: mobile phone holders Boxit, slalom boots, shoe soles, roller skate wheels
 - extrusion: cable surface



Rubbers

- Stretches 2x original length and returns (quickly)
- vulcanisation

Classifying rubbers

- (natural rubber / synthetic rubber)
- General rubbers
 - Natural rubber like elasticity
- Special rubbers
 - Special features like oil, petrol, wheater, ozon or heat resistance
 - expensive
 - Difficult to mould