

Impression materials

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Purpose

To prepare accurate and true **replicas** of oral structures (teeth, mucosa)

The **replica** is prepared in 2 steps:



Step 1. Making a negative (impression)

Step 2. Prepare a model or a cast - accurate positive

Requirements

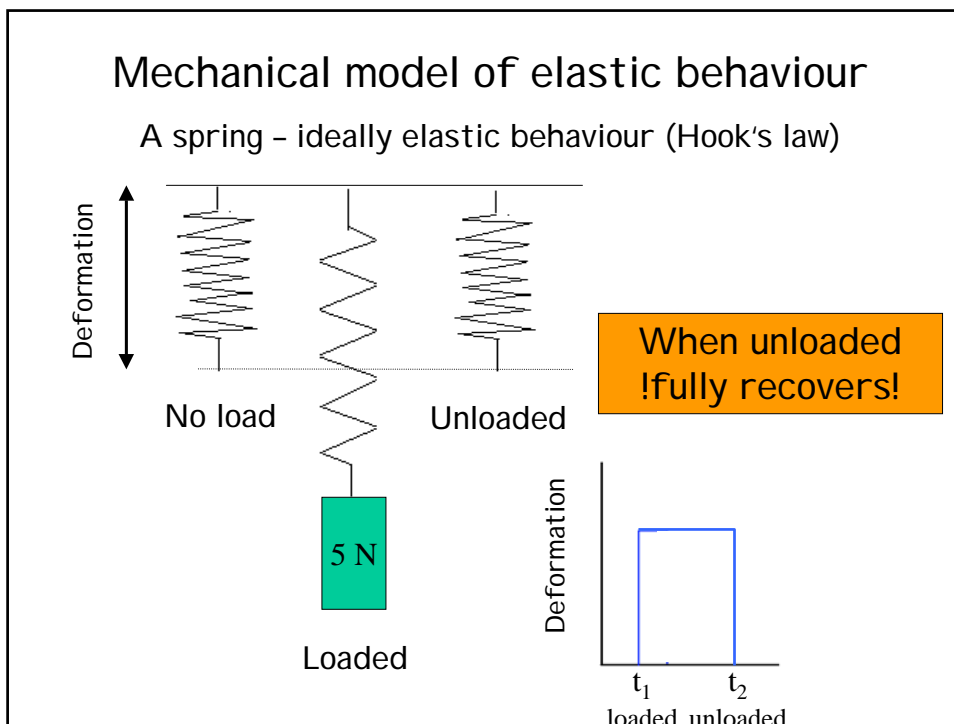
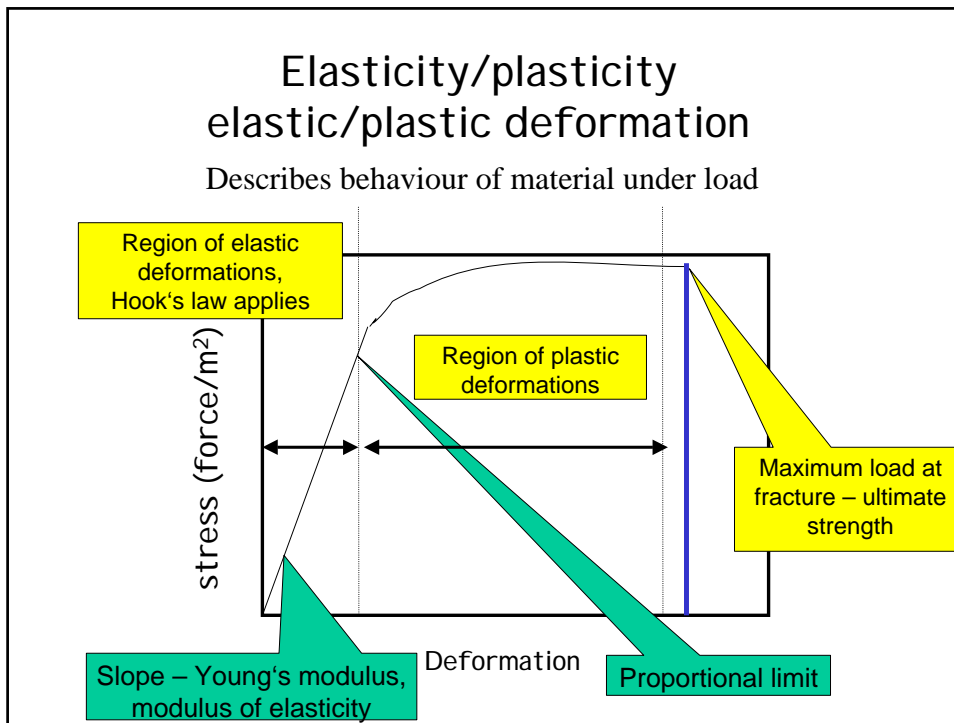
1. Capable of plastic to rigid body transformation
2. Acceptable for a patient
 - non-toxic, non-irritant, tasteless, reasonable setting time up to 5-7 min
3. Good handling properties – easy to prepare/mix plastic before set, but viscous enough not to flow out of a tray (thixotropic), adequate working and setting times

After being set:

4. Accuracy and detail reproduction (25-50 μ m),
5. Dimensionally stable
6. Resistant to mechanical stress - elastic and rigid
7. Compatible with model materials
8. Resistant to disinfectant solutions
9. Cost effective

Important terms

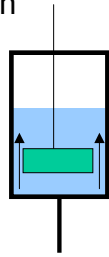
- Elastic/plastic deformations
- Strength
- Pseudoplastic/thixotropic
- Hydrophilic/hydrophobic
- Working time
- Setting time



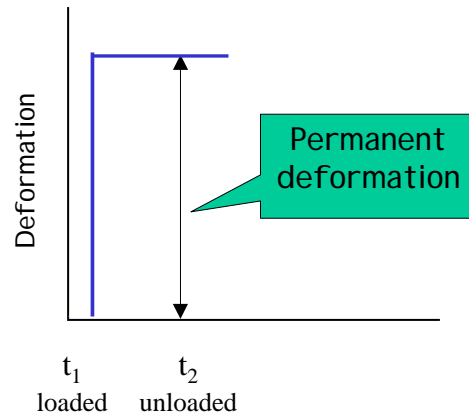
Mechanical model of plastic behaviour

A dashpot - ideally plastic behaviour

Plastic = permanent/irreversible deformation

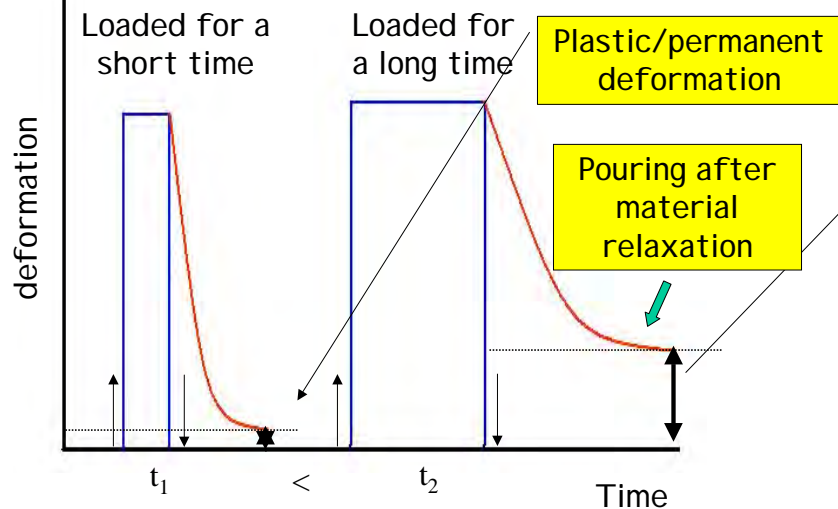


When unloaded
!No recovery!

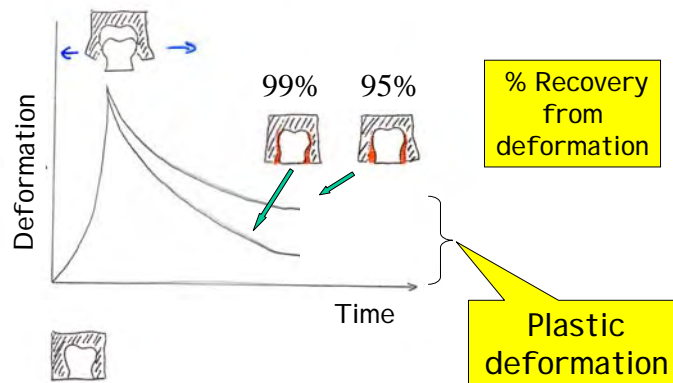


Recovery from deformation

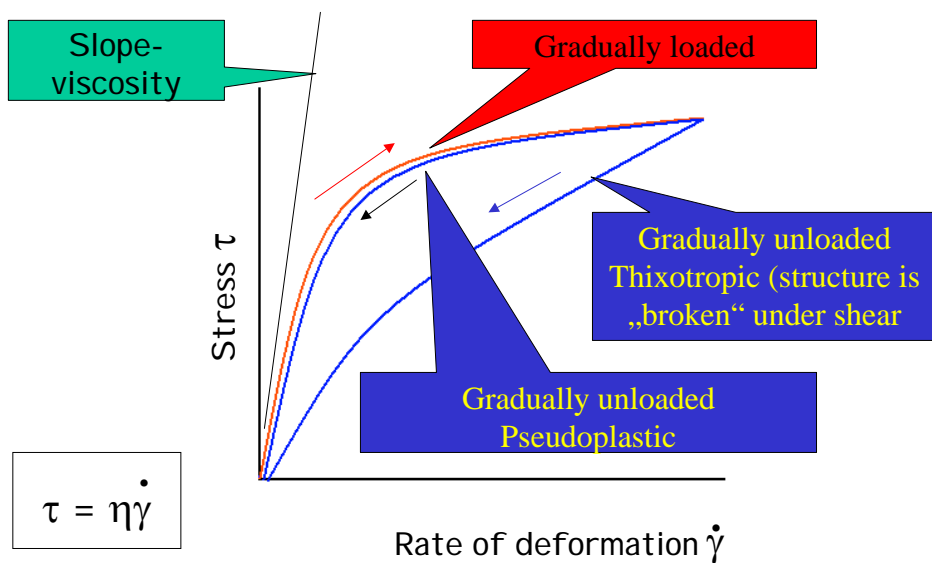
combination of a spring and a dashpot - a model of viscoelasticity

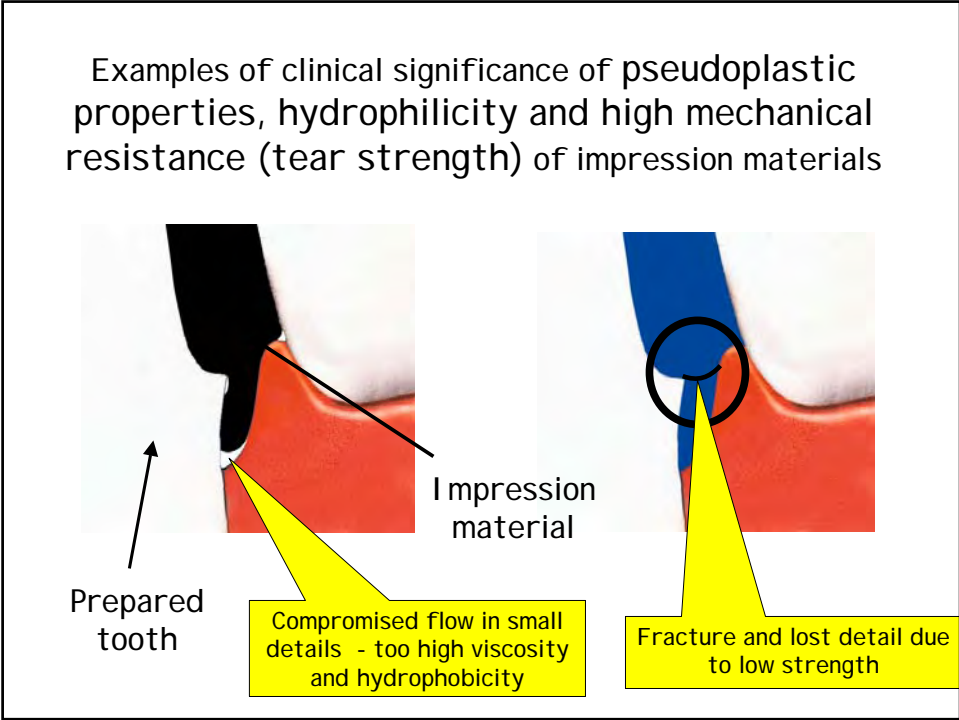
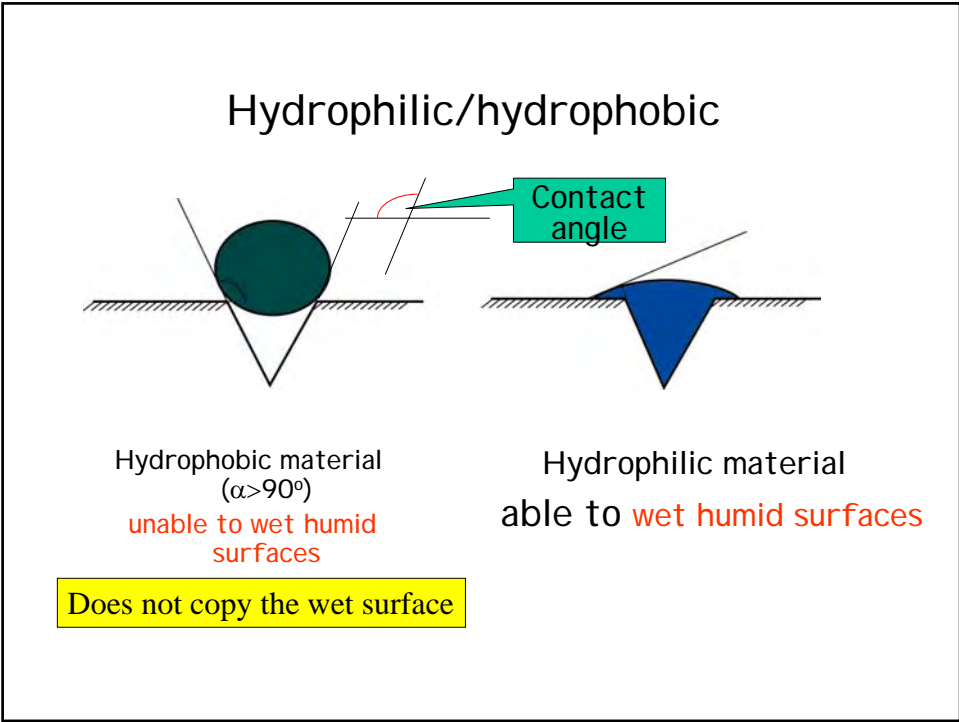


The effect of recovery from deformation on the accuracy of a model



Pseudoplasticity/thixotropy of fluids





Working time – a period from the start of mixing to the final time at which the impression can be seated in the mouth without its distortion

Setting time – a period from the start of mixing till the impression becomes elastic enough to resist deformation during its withdrawal from the mouth

Classification of impression materials

	Irreversible	Reversible
Inelastic/rigid	ZnO-eugenol (ZOE) Impression plaster	Impression compounds
Elastic	Alginate Elastomeric: Polysulfide Polyether Silicone	Agar hydrocolloid

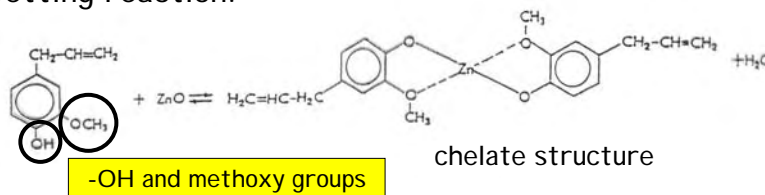
Inelastic/rigid impression materials

A. Irreversible

1. Zinc-oxide eugenol impression pastes (ZOE)

Main indications: impression of edentulous ridges, surgical dressing

Setting reaction:



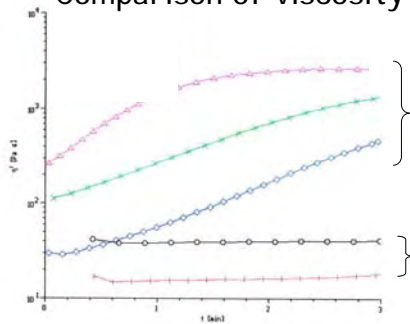
A two-paste system composed of:

Paste A - ZnO/mineral or vegetable oil as a plasticizer

Paste B - oil of cloves with app. 85 % of eugenol or pure eugenol, resins and fillers, accelerators

H₂O, acetic acid, Zn acetate

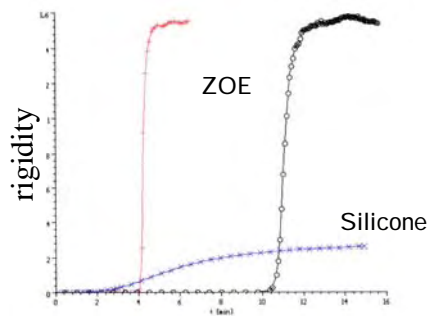
Comparison of viscosity changes during ZOE setting



Silicone impression materials

Low viscosity of ZOE impression pastes - enables mucostatic impressions

Edentulous ridges - low viscosity is favourable to avoid displacement of tissues



Advantages:

1. Low viscosity - no compression of soft tissues
2. Dimensional stability (shrinkage less than 0.1 %)
3. Good surface detail reproduction
4. Low price

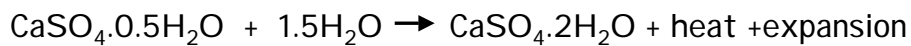
Disadvantages:

1. Cannot be used in deep undercuts
2. Eugenol allergy in some patients (o-ethoxy benzoic acid [EBA] to replace eugenol)

2. Impression plaster

Main indication: impression of edentulous ridges

Setting reaction:



Composition:

app. 0.1 lin %

$\text{CaSO}_4 \cdot 0.5\text{H}_2\text{O}$ β -hemihydrate

Potassium sulfate - to reduce expansion but accelerates setting

Borax - a retarder to prolonge setting time

Diatomaceous earth, quartz, lime - to make the plaster more brittle

Advantages:

1. Cheap and long shelf life, easy to prepare
2. Very good surface detail reproduction
3. Excellent dimensional stability

Disadvantages:

1. Very rigid - often need to be fractured when removed from the mouth
2. Fractures if undercuts are present
3. Non-toxic but may dry soft tissues - unpleasant to patients

Old fashioned - not frequently used

B. Reversible

3. Impression compounds

(Kerr's, Stent's impression compounds)

Thermoplastic material (softens when heated to 50°C and hardens on cooling) for making impressions of edentulous ridge, tooth impressions in a copper band

Composition:

1. Resins (wax, shellac, guttapercha)
2. Filler (talc)
3. Lubricants (stearic acid, stearin)

Advantages:

1. Can be reused, easy to use
2. Non-irritant and non-toxic

Disadvantages

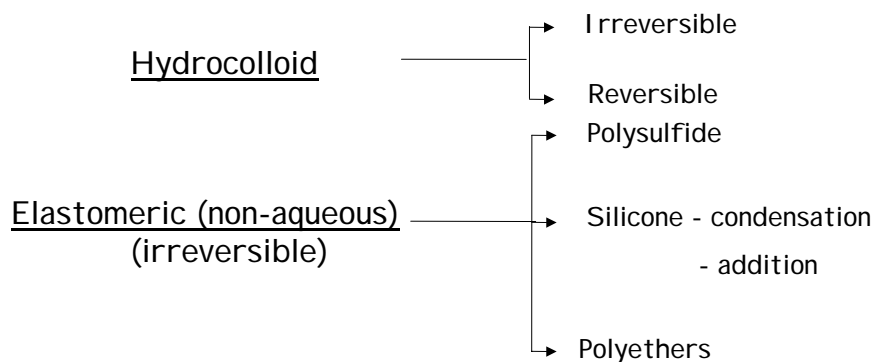
1. Poor dimensional stability
2. Easy to distort when withdrawn from the mouth

Old fashioned - not frequently used

Elastic impression materials

A. Hydrocolloid impression materials

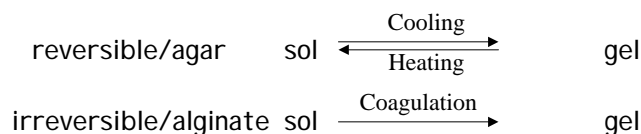
B. Elastomeric impression materials



A. Hydrocolloid impression materials

Hydrocolloid - a colloidal system (particle size up to app. 0.5 μm) with water as a dispersion medium so called **HYDROCOLLOID SOL** that can be transformed to a **semisolid GEL**

Setting reaction

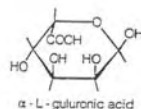
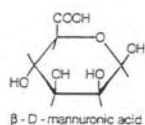


B. Irreversible hydrocolloid

Alginate impression materials

(Irreversible hydrocolloid impression material, preliminary, orthodontic impressions etc.)

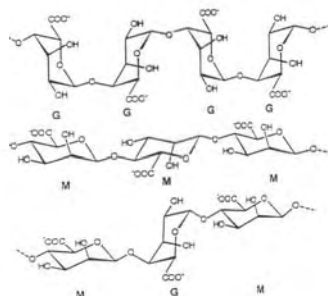
Based on natural polysaccharide - Na⁺, K⁺, triethanol amine alginate salts (isolated from brown seaweeds)



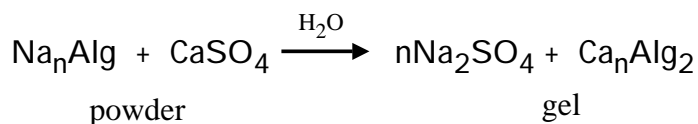
Constituent units

Alginate chains M = 30 - 150 000

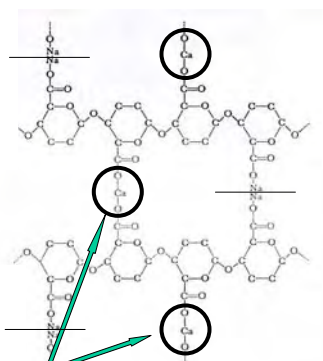
Form viscous sols and gels after addition of Ca²⁺ ions



Setting/gelation reaction:



Egg-box structure



Cross-linked structure of alginate gels

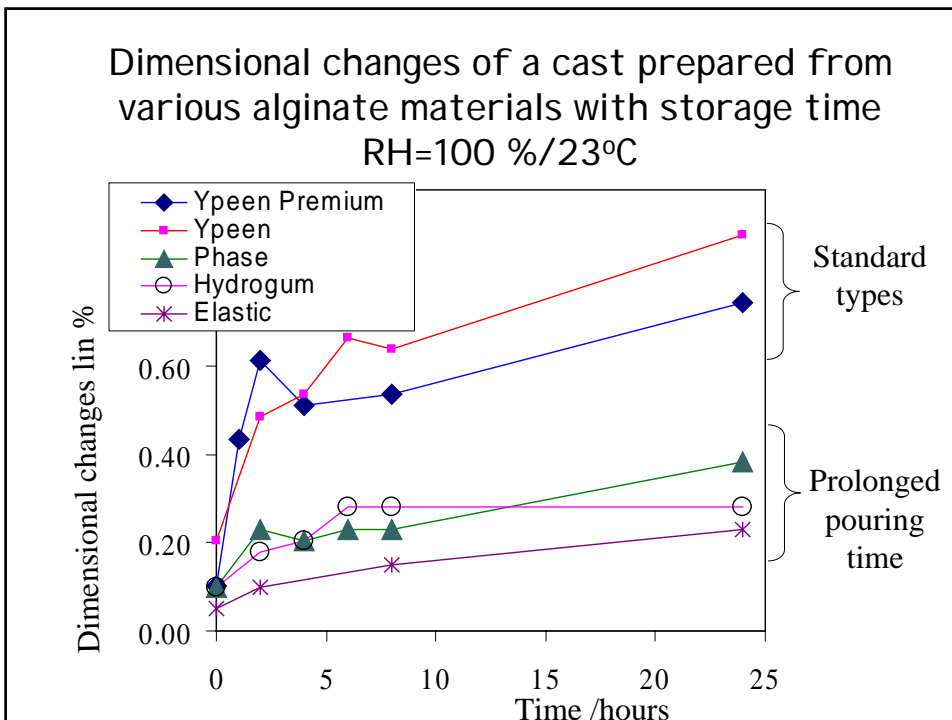
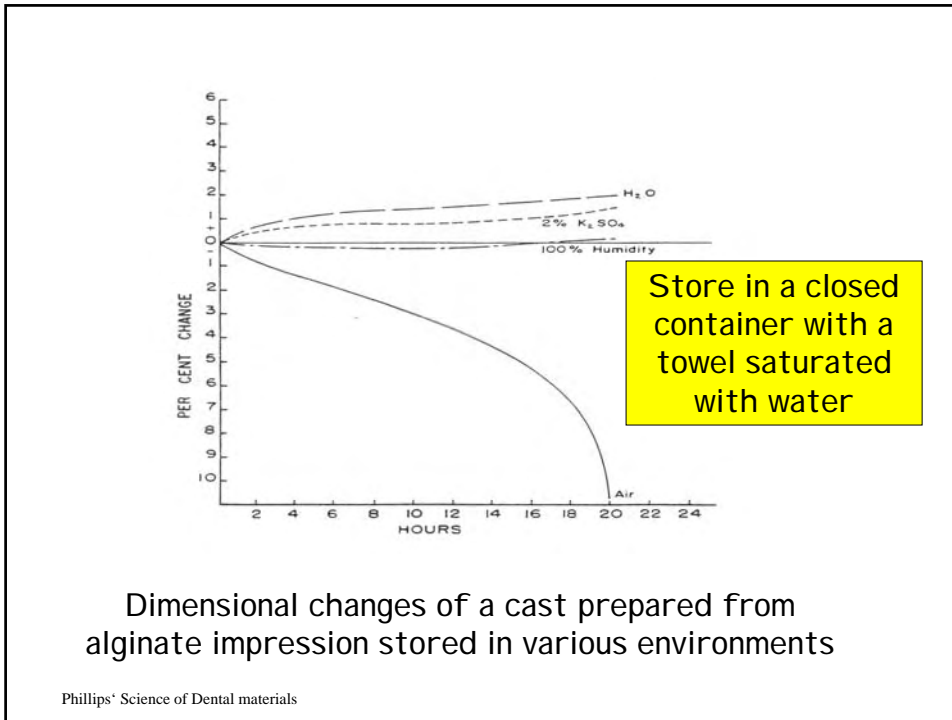
Composition:

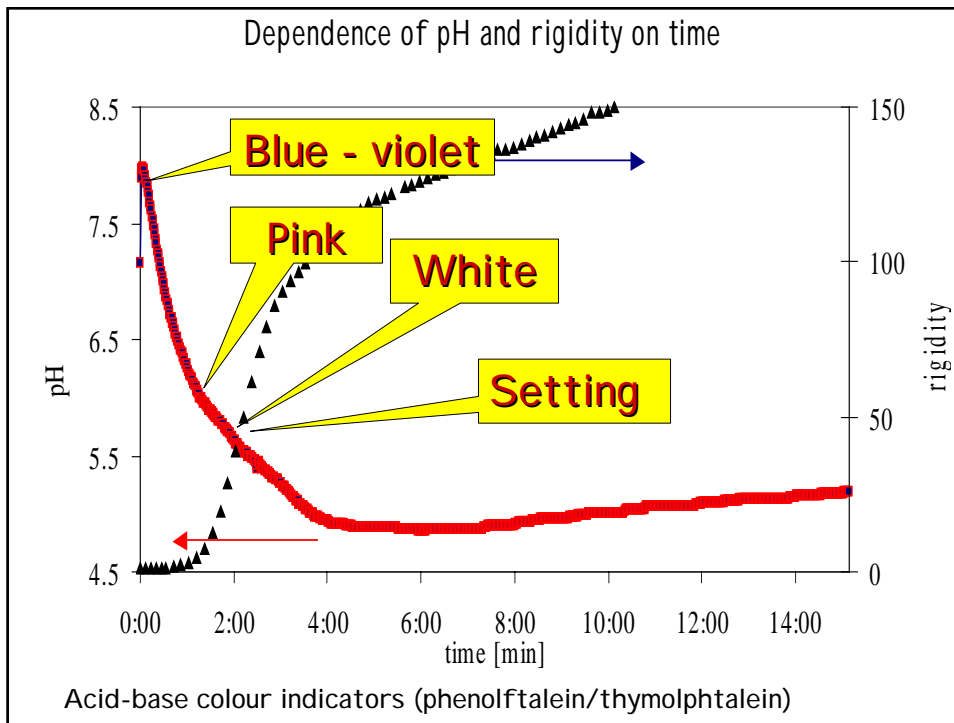
1. Na/K alginate
2. Calcium sulfate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$, $\text{CaSO}_4 \cdot 1/2 \text{H}_2\text{O}$)
3. Diatomaceous earth (amorphous SiO_2)
4. Retarder - phosphates prolonge working time
$$2\text{Na}_3\text{PO}_4 + 3\text{CaSO}_4 \longrightarrow 3\text{Na}_2\text{SO}_4 + \text{Ca}_3(\text{PO}_4)_2$$
5. Setting accelerator - K_2TiF_6 (makes also stone surface hard)
6. Additives - glycol, paraffin oils - to agglomerate particles and make material „dustless“

Mixing ratio powder/water app. 10 g/20 mL

Properties:

1. Set after mixing with water
2. Shrink due to loss of water by **Syneresis** - expression of water from the surface of impression (if contains Na_2SO_4 - decreased quality of stone surface); by **Evaporation** of water from the surface
3. **Imbibition** - sorption of water causing a dimensional change
4. Chromatic phase indicator may be incorporated to signal the impression setting





Most frequently used impression material

Advantages:

1. Very good biological tolerance
2. Easy to use and mix
3. Fast setting
4. Low price

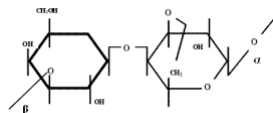
Disadvantages:

1. Poor dimensional stability
2. Setting dependent on water temperature and water hardness
3. Although 100 h pouring time is also recommended they should be poured as soon as possible
4. Sometimes problems with a model stone compatibility

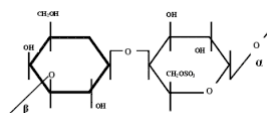
B. Reversible hydrocolloid

Agar impression materials (Reversible hydrocolloid impression material)

Based on thermoreversible gelation of natural polysaccharide
- agar (isolated from red algae/seaweeds)



Agarose, is a strongly gelling, non-ionic polysaccharide



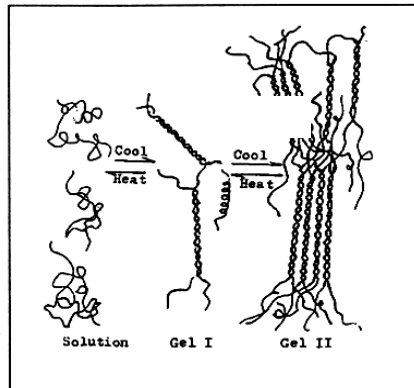
Agaropectin, is more complex polysaccharide having sulfate groups

1,3- linked β-D-galactopyranose and
1,4-linked 3,6-anhydro-α-L-galactopyranose units

Gelation:

Agar sols form gels upon cooling of a hot solution to (30 – 40)°C

Agar gels melt to sols upon heating to (90 – 95)°C



Sol
random coils

Gelation I
Double helices

Gelation II
aggregation of
helices

Composition:

1. Agar
2. Borax to increase the gel strength
3. Potassium sulfate as a gypsum hardener
4. Water - dispersion medium

Supplied in two forms - in tubes and cartridges



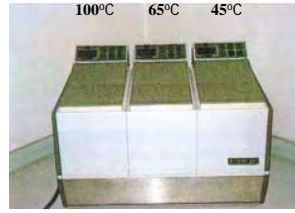
Tray material



Filled tray



Material in syringes applied to teeth



Compartments for liquefying 100°C, storage 65°C and tempering the material in a tray at 45°C

Advantages:

1. Very good biological properties
2. Excellent surface detail reproduction

Disadvantages:

1. Need special equipment (water bath) and special technique
2. Dimensionally instable - evaporation or imbibition
3. Low strength and poor tear resistance
4. Slow setting time

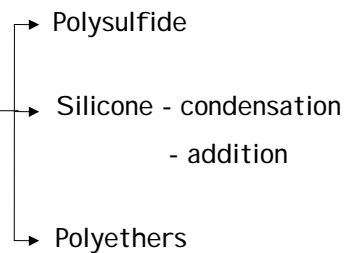
Other applications of hydrocolloid materials

Reversible hydrocolloid impression materials are used as duplicating materials to prepare dental cast models (gypsum or from investment materials)

C. Elastomeric (non-aqueous) impression materials

Synthetic polymers with rubber properties after setting

Elastomeric (non-aqueous)
(irreversible)



Main indications

- impressions for partial prostheses (removable)
- impressions for crowns and bridges (fixed)
- impressions for implantology

Polymerization shrinkage of elastomers is usually compensated for using a combination of:

1. Highly filled-viscous material „Putty“ for preliminary impression (low polymer content - of low shrinkage)
2. Low filled-low viscosity „wash“ or „light“ impression material (high polymer content - higher elasticity but higher shrinkage)

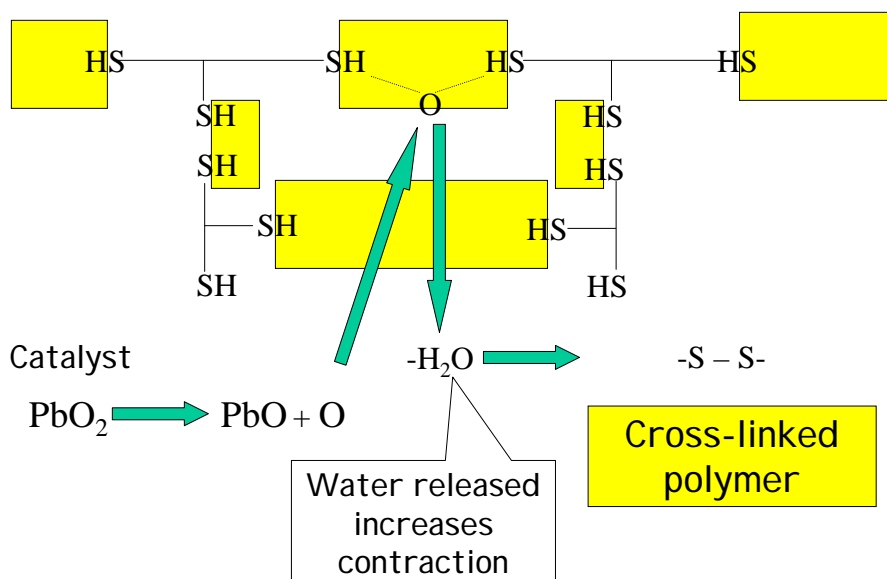
Polysulfide impression materials

(Thiokol rubbers, mercaptan rubbers)
The very first elastomeric impression material

Based on reaction between polymer with free mercaptan (-SH) groups and oxidizing agent PbO_2 which lengthens and cross-links chains via reaction of terminal and pendant -SH groups)

Setting reaction:

Linear polysulfide polymer



Composition:

Supplied in a two-paste system

Base paste:

polysulfide polymer, filler, plasticizer

Catalyst paste:

lead dioxide, sulfur, inert oil

Volume mixing ratio 1:1

Advantages:

1. Low price
2. Long working time

Disadvantages:

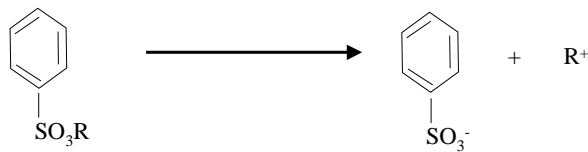
1. Should be poured within 0.5 - 1 hour
2. Lead oxide may cause toxic effects
3. Unpleasant mercaptane smell
4. Long setting time app. to 10 min
5. Poor elastic recovery - prone to plastic deformation

Old fashioned - not frequently used

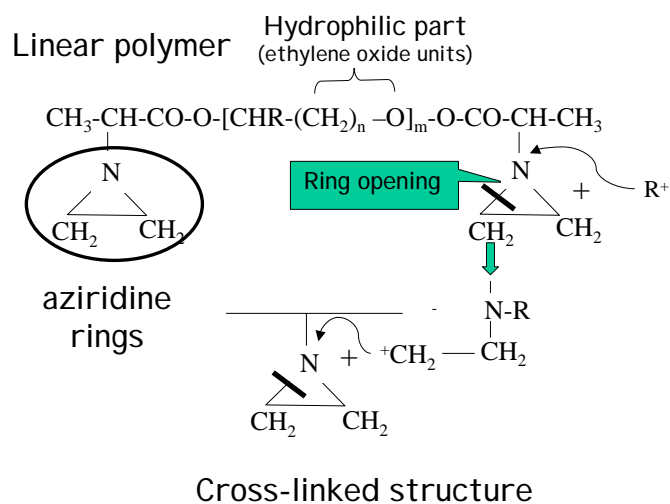
Polyether impression materials

Based on cross-linking of polyether chains via cationic polymerization of aziridine rings using an aromatic sulfonate ester as an initiator

Initiation:



Propagation:



Composition:

Supplied in a two-paste system

Base paste:

- Polyether
- Filler, plasticizer

Catalyst paste:

- Sulphonic acid ester
- Inert oil
- Filler

Advantages:

1. Naturally hydrophilic
2. Accurate and high dimensional stability
3. Good elastic recovery
4. Low setting contraction
5. Excellent surface detail reproduction

Disadvantages:

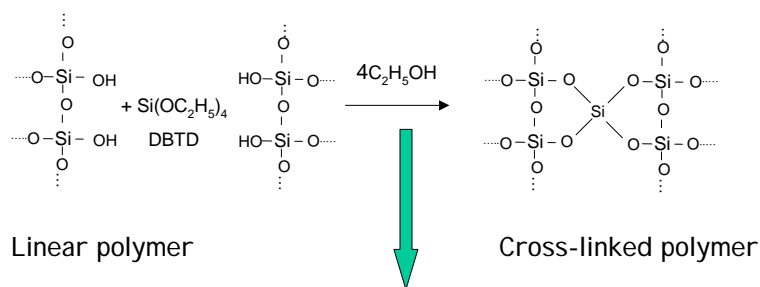
1. Rather stiff when set material (difficult to remove from mouth)
2. Very expensive
3. May cause allergic reaction due to the sulphonic acid ester

Silicone impression materials

C-silicone impression materials (condensation silicones)

Based on cross-linking polycondensation reaction of hydroxy terminated polysiloxane prepolymer with tetra alkoxy silanes catalyzed by dibutyl-tin dilaurate (DBTD)

Setting reaction - polycondensation



Alcohol releases from the reaction mixture and contributes to contraction/shrinkage of the impression

Composition:

Supplied as a two-component system

Base paste:

- Hydroxyterminated polysiloxane polymer
- Filler (cristobalite, talc, starch)

Catalyst:

Liquid catalyst:

- Cross-linking agent (e.g tetraethoxy silane) + activator (dibutyl-tin dilaurate)

Paste catalyst:

- Cross-linking agent, activator, inert oil
- Filler

Advantages:

1. Accurate impressions when poured soon
2. Good elastic recovery
3. Lower price

Disadvantages:

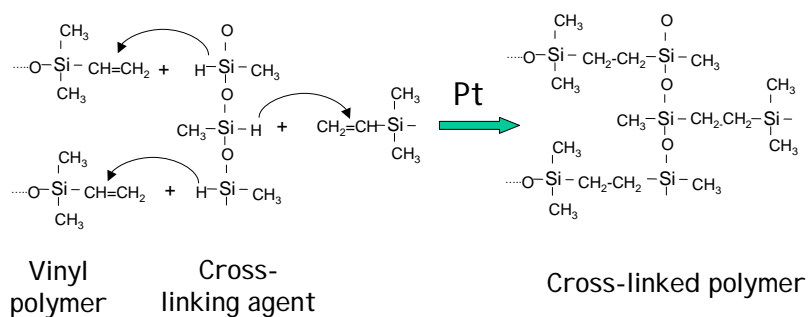
1. Hydrophobic
2. Shrinking of impression over time, pouring time till 4 h
3. Catalyst may cause allergic reaction
4. Difficult to dispense proper volumes of both components
5. Usually hand-mix version only

A-silicone impression materials (addition silicones, vinyl siloxane, poly(vinyl siloxane))

Impression material, duplicating material,
relining material, bite registration material,
root canal sealer

Based on cross-linking polyaddition reaction of vinyl terminated polysiloxane polymer with methylhydrogen silicone cross-linking agent in the presence of platinum catalyst

Setting reaction - polyaddition



Pt may release H_2 from water or -OH groups from the reaction mixture causing bubbles on a gypsum model

Composition:

Supplied as a two-component 1:1 system

Base paste:

1. Vinyl terminated polysiloxane polymer
2. Pt catalyst
3. Filler (cristobalite, talc)
4. Surfactant (hydrophilic agent)

Catalyst:

1. Vinyl terminated polysiloxane polymer
2. Cross-linking agent
3. Filler, silicone oil (adjust viscosity of duplicating materials)

Advantages:

1. Accurate impressions, very low shrinkage
2. Very good surface detail
3. Highly elastic
4. Perfect elastic recovery
5. Dimensionally stable
6. Non-toxic and non-irritant

Disadvantages:

1. Hydrophobic - necessary to add a surfactant
2. **Setting inhibited by latex gloves or some adstringents (sulfur, heavy metals)**
3. Hydrogen release - surface bubbles - pouring time 1 h after removal from the mouth
4. High price

Typical properties of elastic impression materials

Property	Algi-nate	Agar	Polysulfide	Polyether	C-silicone	A-silicone
No of components	1 powder	1	2 pastes	2 pastes	2 pastes	2 pastes
Working time [min]	1.5	-	4-7	2-3	2-4	2-4
Setting time [min]	3-4	3-5	7-10	5-6	5-8	4-7
Contraction [lin %] after 24 h	0.5	0.01	0.4-0.5	0.2-0.3	0.2-1.0	0.01-0.2
Recovery from deformation [%]	96	98.8	94.5-96.9	98.3-99.0	97.2-99.6	99.0-99.9
Detail reproduction [μm]	50	25	25	25	25	25
Hydrogen release	N	N	N	N	N	Y
Contact angle [°]	Very low	Very low	82	50-60	98	70*-80
Relative cost	Very low	high	low	Very high	lower	high

*Hydrophilic types

Partly from Phillips' Science of dental materials

Examples of typical packages of impression materials



Putty



Light



Light

