NON-AQUEOUS ELASTOMERIC IMPRESSION MATERIALS

Requirements of an Ideal Impression Material

- no dimensional change during polymerization
- no dimensional change during storage
- suitable working and setting times
- adequate detail reproduction
- good tear strength
- easy to mix
- compatible with die and model materials
- non-toxic and non-irritating
- acceptable odor and taste
- long shelf life
- requires minimal equipment for use

Classification of Impression Materials

Non-elastics
- Impression compound
- Impression plaster
- Waxes
- Zinc oxide-eugenol

Aqueous Elastomers
- Reversible hydrocolloids (agar)
- Irreversible hydrocolloids (alginate)

Nonaqueous elastomers
- *Polysulfides*
- *Condensation polymerizing silicones*
- *Addition polymerizing silicones [poly(vinyl siloxanes)]*
- *Polyethers*

The American Dental Association s three categories for the nonaqueous elastomeric impression materials are not based on chemistry, but on 24-hour dimensional change following setting and certain elastic properties (maximum permanent deformation and maximum flow in compression). For the most part, the elastomeric impression materials are viscoelastic since their physical properties vary with rate of loading. After setting, they should be removed from the mouth with a rapid motion. This increases their tear strength and decreases their permanent deformation.

Categories based on Viscosity
- Type 0: very high viscosity: (i.e., putty)
- Type 1: high viscosity: (i.e., heavy body)
- Type 2: medium viscosity: (i.e., medium body)
- Type 3: low viscosity: (i.e., light body)

Impression materials are also classified as hydrophilic if their contact angle is from 80 to 105 degrees or hydrophobic if their contact angle is from 40 to 70 degrees.[1]

Polysulfides (Rubber base, Thiokol Rubber, Mercaptan)

Polysulfides are supplied as two pastes, a base and a catalyst,

that are mixed in a 1:1 ratio.

Setting Reaction: a condensation (oxidation) reaction of pendant and terminal thiol (mercaptan, sulfhydral, SH) groups with lead dioxide and sulfur to produce disulfide linkages and water; this produces chain lengthening and crosslinking. Chain lengthening predominates at first and causes an increase in viscosity. Crosslinking secondarily occurs which leads to development of elastic properties.

Composition

Base:		
polysulfide prepolymer	80%	reactant
titanium dioxide or zinc oxide	5%	pigment and thickener
calcium sulfate	15%	thickener and reinforcer

Catalyst:		
lead dioxide	78%	reactant
sulfur	4%	reactant
dibutyl phthalate	17%	thinner;forms a paste with lead dioxide and sulfur

Classes

Type 1: heavy body for mandibular dentulous impressions and tissue displacive edentulous impressions
Type 2: medium (regular) body for routine dentulous impressions
Type 3: light body for dentulous impressions (syringe material) and for some mucostatic edentulous impressions

The viscosity of the three types is determined by the amount of filler (titanium dioxide or zinc oxide) in the base component.

Working and Setting Times: The syringe material (Type 3 or light body) has a longer setting time to allow the clinician adequate time to use it. Polysulfides should be mixing within one minute to allow ease of handling, although technically their working time ranges from 4 to 7 minutes. Setting time ranges from 9 to 14 minutes. Accelerators (water) and retarders (oleic acid) can be used to adjust the working and setting times, however the base-to-catalyst ratio should not be altered by more than 20% as a means of manipulating the working and setting times. If it is, dimensional accuracy and physical properties will be adversely affected. Water is not only a by-product of the reaction but also a catalyst, which explains why the polysulfides set faster under humid conditions. Warm ambient conditions will also shorten the setting and working times.

Advantages and Disadvantages:
Advantages: good tear strength and flexibility, low cost
Disadvantages: poor dimensional stability, offensive odor, stains clothing, long setting time

General Information: Polysulfides are dark in color because the lead dioxide in the catalyst is dark brown. Because of their less extensive crosslinking, the polysulfide materials exhibit more permanent deformation during removal from the mouth than any of the other non-aqueous elastomeric materials. Over a 24-hour period, polysulfides undergo polymerization shrinkage of approximately 0.3%. Dimensional change during storage occurs from three sources: thermal change when the impression is removed from the warm mouth and stored at room temperature; shrinkage from continued polymerization contraction; and evaporation of the water by-product formed during the polymerization reaction. Impressions made from polysulfide materials should be poured within 30 minutes following removal from the mouth, because in the first hour they undergo 50% of their 24-hour shrinkage.[2] Unmixed material can be stored in a refrigerator to prolong its shelf life, but should not be used immediately after being removed from the refrigerator because water that condenses on it will shorten its working and setting times. Normal shelf life is 5 years, but storage under warm conditions can shorten it. Use of a custom tray with the polysulfides results in a more accurate impression than does a stock tray. The custom tray should not be used the same day that it is made because it undergoes 90% of its polymerization shrinkage within the first 8 to 10 hours.[3]

Examples: Permlastic (SDS/Kerr), Coe-Flex, Omniflex (GC America)

Condensation Polymerizing Silicones

Setting Reaction: crosslinking of an hydroxy-terminated polydimethyl siloxane by an alkyl silicate catalyzed by tin or stannous octoate. Ethyl alcohol is a byproduct which volatilizes leading to dimensional change.

Composition: Compositions are proprietary, however these materials are usually supplied in a tube and a smaller tube or dropper bottle. The tube contains the silicone reactants and filler while the dropper bottle contains the catalyst, crosslinking agent (organohydrogen siloxane) along with a thinner, dye, and/or pigment.

Classes: In addition to the heavy-, medium-, and light-body materials, a very heavy-body (i.e., putty) is supplied which is usually used to convert a stock tray into a custom tray for use in the wash technique.

Working and Setting Times: Times are controlled by alterations in the base-to-catalyst ratio. Alteration of the setting and working times outside of a prescribed range, however, is not recommended. The usual setting time is about 7 minutes.

Advantages and Disadvantages:
Advantages: moderate tear strength, good working and setting times

Disadvantages: poor dimensional stability, poor wettability

General Information: A putty-wash impression technique is commonly recommended with these materials to reduce the effects of polymerization shrinkage. This technique has been shown to produce the most accurate impression with the condensation polymerizing silicones. These materials undergo shrinkage over 24 hours of about 0.6%. Shelf life is usually approximately 2 years but is reduced by warm conditions.

Examples: Speedex (Coltene/Whaledent), Accoe (GC America)

Addition Polymerizing Silicones [Poly(Vinyl Siloxanes)]
Setting Reaction: crosslinking of a vinyl terminated polydimethyl siloxane catalyzed by a platinum salt (chloroplatinic acid). Hydrogen gas is a byproduct of the polymerization reaction. Dimensional change during the reaction is essentially zero.

Composition: Compositions are proprietary however they are usually supplied in two equal-size tubes, often in cartridges for use in an automix dispenser gun. The base-to-catalyst ratio is 1:1.

Classes: In addition to the heavy-, medium-, and light-body materials, a very heavy-body (i.e., putty) is supplied which is usually used to convert a stock tray into a custom tray for use in the wash technique.

Working and Setting Times: Although times vary with brands, the addition silicones generally have a working time of from 2 to 4 minutes and a setting time of from 5 to 8 minutes. Changes in base-to-catalyst ratio can produce inconsistent changes in working and setting times and may increase hydrogen gas production.

Advantages and Disadvantages:
Advantages: excellent dimensional stability, good tear strength, good working and setting times, excellent wettability, automixed system
Disadvantages: hydrogen gas release, inhibition of setting by sulfur-containing materials, expensive, stiff

General Information: Three impression making techniques can be employed with the addition silicones: the single mix, the double mix, and the putty wash. No significant difference in accuracy between the three techniques has been found.[4] The single-mix technique is one in which a medium-body material is used in both the syringe and in the custom tray. A double-mix technique employs a light-body material in the syringe and a medium- or heavy-body material in the custom tray. This is the technique suggested by some authors as being the best technique to use with addition silicones.[5] The third way, The putty-wash method, is

not necessary to compensate for polymerization shrinkage with addition silicones. However, it is often used for convenience because clinicians want to avoid having to make an acrylic custom tray. In the putty-wash technique, the putty is used to convert a stock metal tray into a custom tray (i.e., take a stock tray, paint it with adhesive, and make a putty impression of a spaced diagnostic model). This tray is then used clinically to make the final impression by using a light-body addition silicone in the syringe and a medium- or heavy-body addition silicone in the tray.[4] Making an impression with a putty consistency material in a stock tray and a light-body syringe material using a one-step or simultaneous technique is contraindicated because the putty invariably duplicates parts of the prepared teeth. Putties are not capable of recording fine enough detail for this purpose. Other shortcomings of using a one-step putty technique also exist.[4]

There are no reports of patient sensitivity to the addition silicones. Hydrogen gas liberation during polymerization can lead to a pitted cast or die. The hydrogen gas is formed because of terminal hydrogen impurities on the poly(vinyl siloxane) chains. Palladium powder has been added to the impression material to absorb the gas and this has essentially eliminated the problem. However, to ensure that no pitting occurs, it is recommended that pour-up be delayed for an hour. A way to see if gas is being liberated from the impression is to place it under water and examine its surface for the presence of air bubbles.

Retardation of the setting reaction of addition silicones can occur if they come into contact with latex gloves or other rubber products. This was first encountered when putty consistency addition silicones were mixed with gloved hands. Slowing of the setting time may even result from contact of the impression material with the patient's teeth after the operator has touched the teeth with his gloves. It is theorized that residual sulfur in the gloves (which serves as an accelerator and/or surfactant in the manufacture of rubber latex) inhibits the action of the platinum salt catalyst.[6] Some researchers believe that it is the powder on gloves that is the source of the problem, but others question this.[7] In addition, sulfur-containing retraction cord additives such as ferric sulfate (found in Astringedent) and aluminum sulfate may also produce this effect.

It is a good idea to store the addition silicones in a refrigerator and use them immediately after removal because the cool storage conditions act to lengthen the working time by about 1.5 minutes without adversely affecting the material's accuracy. Addition silicones are second only to the polysulfides in tear strength but are second only to the polyethers in stiffness. The automix system available for the addition silicones has many advantages: it reduces the number of bubbles in the mixed material; is faster and more convenient; and reduces waste [hand mixing wastes 4 times the amount of impression material (4 mL) that the automixed systems waste (1 to 1.5 mL)]. Shelf life is

usually about 2 years but is reduced by warm conditions. Early forms of the addition silicones were hydrophobic, however most now available are hydrophilic because of inclusion of surfactants which reduce their contact angles with gypsum from approximately 90 to 50 degrees. This makes their contact angles with gypsum similar to those of the hydrophilic polyethers.[8] Just because the addition silicones are hydrophilic, however, does not mean that they can be used to make impressions of wet preparations. The field must be free of moisture for an accurate impression to be made with them. Warm room temperatures will accelerate the setting reaction. The addition silicones have excellent dimensional stability with shrinkage over 24 hours of only 0.05%. Dies produced at 7 days are, for all practical purposes, as accurate as those produced at 10 minutes.[9] Be aware, however, that the degree of dimensional stability varies by brand.

Examples: Extrude, Take 1 (SDS/Kerr), President (Coltene/Whaledent), Express, Imprint II (3M ESPE), Examix, Exaflex (GC America), Reprosil, Aquasil, Hydrosil (Dentsply/Caulk)

Polyether

Setting Reaction: Reaction between a difunctional epimine-terminated prepolymer and an alkyl benzene sulfonate ester.

Composition: Compositions are proprietary but the material is usually supplied in two collapsible tubes. One contains the prepolymer with additives while the other contains the sulfonate catalyst. A third tube is usually supplied that contains a thinner used to reduce the viscosity of the mixed material.

Classes: Since the material is usually supplied in two tubes, different classes are not normally described, however the unthinned material corresponds in consistency to a heavy-body polysulfide and the thinned mix compares to a medium-body (i.e., regular-body) polysulfide.

Working and Setting Times: Setting and working times are in the lower range of clinical acceptability. Alterations in the base-to-catalyst ratio should not be used to change the working and setting times because the physical properties can be adversely affected.

Advantages and Disadvantages:
Advantages: excellent wettability, good dimensional stability
Disadvantages: poor tear strength, short working and setting times, stiff, difficult to disinfect, expensive, patient sensitivity

General Information: Since these materials are hydrophilic, they should not be stored in a refrigerator because moisture condensing on them can lead to changes in dimensional stability. One also should avoid exposing polyether impressions to water

because they will readily absorb the water which changes dimensional stability. Shelf life is usually about 5 years but can be reduced by warm conditions. Some patients have been found to be sensitive to these materials (specifically to the alkyl benzene sulfonate ester found in some formulations). The polyethers exhibit a 24-hour shrinkage of about 0.1%.

Examples: Impregum F, Permadyne (3M ESPE), Polyjel (Dentsply/Caulk)

Disinfection of Non-Aqueous Elastomeric Impression Materials: Revised ADA guidelines[10] recommend disinfecting these materials by a spray or immersion technique using a recommended disinfectant for the suggested period of time. Although previous recommendations[11] limited disinfection of the polyethers to spray techniques, the new guidelines have been expanded to include immersion.

Genesis (Dentsply/Caulk)
For historical purposes, it is interesting to note that a light-activated final impression material was marketed years ago. The product, Genesis, was a visible-light-activated polyether urethane dimethacrylate impression material which contained a diketone photoactivator and an amine accelerator. From 40% to 60% silica was added to enhance light transmission. It was supplied in heavy- and light-body consistencies. Variations in consistency were produced by altering filler concentration. The heavy-body material comes in a 41-mL tube while the light-body was supplied in a 3.5-mL disposable syringe. Transparent acrylic trays and an adhesive were also supplied. Genesis was said to be capable of being polymerized to a depth of 16 mm in 20 seconds. Recommended curing times were 1.5 minutes for a quadrant tray and 2.5 minutes for a full arch tray. After polymerization, the surface of the material was tacky because of air inhibition. Margins in the impressions were difficult to read with direct light, however transillumination made evaluation easier. Advantages included a long working time, low flow, high tear strength, and low dimensional change. Disadvantages were difficulty in curing a full arch tray and post-polymerization tackiness.

Comparison of Physical Properties of the Non-Aqueous Elastomerics
Dimensional stability (from best to worst)
additional silicones>polyethers>polysulfides>condensation silicones>hydrocolloids

Setting Time (from longest to shortest)
polysulfides>silicones>polyethers

Tear Strength (from greatest to least)
polysulfides>addition silicones>condensation silicones>polyethers

Stiffness (from most to least)
polyethers>addition silicones>polysulfides>condensation silicones

Wettability (from best to worst)
polyethers>addition silicones>polysulfides>condensation silicones

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