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Н. М. Полонейчик, К. И. Метелица

МОДЕЛИРОВОЧНЫЕ МАТЕРИАЛЫ, ПРИМЕНЯЕМЫЕ В СТОМАТОЛОГИИ

MODELLING MATERIALS USED IN DENTISTRY

Учебно-методическое пособие

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Р е ц е н з е н т ы: д-р мед. наук, проф., зав. каф. ортопедической стоматологии С. А. Наумович; д-р мед. наук, проф., зав. каф. ортодонтии И. В. Токаревич

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Содержит необходимые студенту сведения о моделировочных материалах, их классификации и свойствах, области применения. Рассматривается каждая группа моделировочных материалов, их состав и свойства, показания к применению.

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Полонейчик Николай Михайлович
Метелица Кристина Игоревна

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Ответственный за выпуск Н. М. Полонейчик
Переводчик К. И. Метелица
Компьютерная верстка С. Г. Михейчик

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INTRODUCTION

The main aim of this textbook is to present modelling materials.

Modelling materials are auxiliary dental materials used in prosthodontics in the dentist's everyday practice. We can distinguish waxes and ashless plastics.

Waxes are used in many aspects of dentistry in the clinic and the laboratory. Each has particular properties depending on what it is used for. Their basic constituents are essentially similar, their exact proportion is different.

Although not used in the final dental restoration, waxes are often important in the fabrication and success of the final metal or ceramic restoration. The use of wax in dentistry dates back 200 years to the taking of impressions of the teeth with beeswax.

Nowadays in many processes we can replace wax with ashless plastics.

This textbook includes information on classification, properties and composition of modelling materials, knowledge about it individualizes indications to their use and other decisions referred on quality of the prosthodontics treatment of dental diseases improvement.

MODELLING MATERIALS. WAXES AND THEIR GENERAL CHARACTERISTICS

Modelling materials — auxiliary materials applied at a stage of modelling and for some additional works (pasting, isolation, etc.). In dentistry the materials that are used for modeling are waxes and ashless resins.

WAXES

Waxes have several applications in dentistry. A variety of natural resins and waxes have been used in dentistry for specific and well-defined purposes. They are used as patterns for inlays, crowns, pontics, and partial and full dentures. Waxes are very useful for bite registration and can be used to obtain impressions of edentulous areas. In addition, they have many applications for processing in all areas of restorative dentistry. In some instances, the most favorable qualities can be obtained from a single wax such as bees wax, but more often a blend of several waxes is necessary to develop the most desirable qualities. Waxes were first used in dentistry for recording the impression of edentulous mouth.

COMPOSITION

Waxes are organic polymers consisting of hydrocarbons and their derivatives (e.g., esters and alcohols). These are thermoplastic materials, which are normally solid at room temperature but melt without decomposition to form mobile liquids. The average molecular weight of a wax blend is about 400 to 4 000, which is low in comparison with structural acrylic polymers. Dental waxes are blends of ingredients, including natural waxes, synthetic waxes, natural resins, oils, fats, gums, and coloring agents.

GENERAL PROPERTIES OF WAXES

Waxes have a number of important properties in relation to their dental use. Different uses require different properties. Waxes for patterns probably require most careful balance. Some of the important properties are:

1. melting range;
2. thermal expansion;
3. mechanical properties;
4. flow;
5. residual stresses;
6. ductility.

MELTING RANGE

Waxes have melting ranges rather than melting points. Mixing of waxes may change their melting range. Melting range varies depending on its use.

THERMAL EXPANSION

Waxes expand when subjected to a rise of temperature and contract when the temperature is decreased.

Coefficient of thermal expansion and its importance. Dental waxes and their components have the largest CTE among the materials used in restorative dentistry. Temperature changes in wax patterns after removal from the mouth, can produce *inaccuracies* in the finished restoration.

MECHANICAL PROPERTIES

The elastic modulus, proportional limit and compressive strength of waxes are low compared to other dental materials. These properties are strongly dependent on the temperature. When temperature decreases, the properties improve.

FLOW

Flow is an important property, especially in inlay waxes. When melted the wax should flow readily into all the parts of the die. Flow depends on:

− Temperature of the wax.
− Force applied.
− The length of time when the force is applied.

Flow increases as the melting point of the wax is approached.

RESIDUAL STRESS

Regardless of the method used to make a wax pattern, residual stresses will exist in the completed pattern. The stress may be compressive or tensile in nature. *Example A* When a specimen is held under compression during cooling the atoms and molecules are forced closer together. After the specimen is cooled to room temperature and the load is removed, the motion of the molecules is restricted. This restriction results in residual stress (hidden stresses) in the specimen. When the specimen is heated, release of the residual stress is added to the normal thermal expansion, and the total expansion is greater than normal. *Example B* When a specimen is cooled while under tension, the release of the residual tensile stress results in a dimensional change that is opposite to thermal expansion, i.e., it can result in overall contraction of the specimen.

DUCTILITY

Like flow, the ductility increases as the temperature of the wax is increased. In general, waxes with low melting points have greater ductility than those with high melting points.

CLASSIFICATION OF WAXES

Dental waxes are classified according to their origin and use.

According to their origin waxes are classified as:

- natural waxes: mineral, plant, inset and animal (table 1);
- synthetic waxes;
- other additives. Obtained as both natural materials and synthetic products.

Table 1

Natural waxes

Type	Example	Source	Structure	Properties
Mineral waxes	Paraffin wax	Obtained during the distillation of crude petroleum.	Straight chained hydrocarbon.	– Brittle at ambient temperature. – Crystalline in the form of plates or needles. – Softening temperature: 37–55 °C. – Melting range: 40–71 °C.
	Microcrystalline wax	Obtained from petroleum.	Branched chain hydrocarbon.	– Less brittle than paraffin wax due to their oil content. – Melting range: 60–80 °C. – Added to modify the softening and melting ranges of wax blends. – Less volumetric change during solidification.
	Ozokerite		Contains both straight chain and branched chain hydrocarbons.	– It is earth wax. – Melting temperature: 65 °C. – It is similar to microcrystalline wax.

Type	Example	Source	Structure	Properties
	Ceresin	From natural and mineral petroleum.		– Added to increase the melting range of paraffin wax.
	Montan wax	Obtained by extracting lignites.	Mixtures of long chain esters.	– Melting temperature: 72–92 °C.
Plant waxes	Carnauba wax		Composed of straight chain esters, alcohols, acids and hydrocarbons. Consists of 40–60 % paraffin hydrocarbons.	– Melting temperature: 84–91 °C. – Added to increase the melting range and hardness of paraffin wax.
	Candelilla wax			– Melting temperature: 68–75 °C. – Added to harden paraffin waxes.
	Japan wax			– Tough malleable and sticky material. – Melts at 51 °C. – Added to improve tackiness and emulsifying ability of paraffin wax.
	Cocoa butter			– Brittle substance at room temperature. – Used as a protector against dehydration of soft tissues.
Insect waxes	Bees wax			– Primary insect wax. – Less brittle. – Melting temperature: 63–70 °C.
Animal waxes	Spermaceti wax	Obtained from the sperm of whale.		– Used as a coating in the manufacture of dental floss.

Synthetic waxes have specific melting points and are blended with natural waxes. These are carefully prepared under controlled conditions to give standardized reliable results. Low-molecular-weight polyethylene is an example of a synthetic wax. Natural waxes vary more depending on their sources and need to be monitored more for properties than synthetic waxes, which are more uniform in composition.

Wax additives:

− *Montan.* It is hard, brittle and lustrous. It can be substituted for plant waxes.

− *Gums.* They are viscous, amorphous exudates from plants that harden when exposed to air. They are complex substances mainly made of carbohydrates. They either dissolve in water or form sticky, viscous liquids, e.g., gum Arabic and tragacanth.

− *Fats.* They are tasteless, odorless and colorless substances. They are similar to wax but have lower melting temperatures and are softer. Chemically they are composed of glycerides, e.g., beef tallow and butter. They can be used to increase melting range and hardness of waxes.

− *Oils.* They lower the melting point of paraffin. Hydrocarbon oils soften waxes. Silicone oils improve ease of polishing of waxes.

− *Resins* are exudates of certain trees and plants (except shellac which is from insects). They are complex, amorphous mixtures of organic substances. They are insoluble in water. They improve toughness. They are also used to make varnishes (by dissolving in an organic solvent).

− *Synthetic resins* are also used.

According to their use waxes are classified as:

− pattern (inlay, casting, resin, base plate);
− processing (boxing, sticky, carding, blockout, white, utility;
− impression (corrective, bite registration).

PATTERN WAXES

Pattern waxes include inlay, resin, casting, and base plate waxes.

INLAY WAXES

Inlay waxes (Kerr) are used to make inlay, crown, and pontic replicas for the lost wax pattern technique. In the lost wax pattern technique, a pattern of the desired dental restoration is first made or constructed by wax that duplicates the shape and contour of the desired restoration. The carved wax pattern is then embedded in a mix of investment material to form a mold with a special channel for the entry of the molten metal into the mold.

According to ADA specification number 4, there are two types of inlay waxes:

− Type I inlay waxes are hard and used for the direct inlay technique.

− Type II inlay waxes are soft and used for preparing replicas on dies and models.

In addition, inlay waxes are sometimes used for the attachment of miscellaneous parts.

Dispension. Inlay waxes are manufactured in different color, size and shapes, e.g. deep blue, green or purple, etc. in sticks 3 inches long and $^{1}/_{4}$ inch in diameter and also dispensed in the form of small pellets or cones (fig. 1).

Fig. 1. Inlay waxes

Composition. Inlay waxes contain both natural and synthetic waxes. The detailed composition of inlay waxes is given in table 2. In some instances, Candelilla wax is also added either partially or wholly to replace the carnauba wax. It provides the same qualities as that of the carnauba wax but its melting point is lower and it is less hard than carnauba wax.

Table 2

Composition of inlay waxes

Igredient	Wt%	Functions
Paraffin wax	60 %	– Main ingredient. – Used to establish melting point. – It is likely to flake while trimming. – It does not give a glossy surface and hence modifiers are added.
Carnauba wax	25 %	– Added to increase the melting range, decrease the flow at mouth temperature. – Contribute to the glossiness of the wax surface.
Ceresin	5 %	– Modifies the toughness and the general working and carving characteristics of wax.
Gum dammar resin	3 %	– Added to enhance smoothness of the surface. – Gives more resistance to flakiness or chipping. – Improves toughness of the wax.
Bees wax	5 %	– Added to reduce the flow at mouth temperature. – Makes the wax less brittle at mouth temperature.
Synthetic resins	2 %	– Helps in stable flow properties.
Coloring agents	Trace	– To impart the desired color.

Manipulation of inlay waxes. In the process of manipulating inlay wax, dry heat is generally preferred to the use of water bath. The use of water bath can result in:

– inclusion of droplets of water that could splatter on flaming;
– distort the pattern during thermal changes;
– leaching out of volatile, low melting point components into the surrounding medium.

Each of the types of inlay wax has different manipulating procedures that have to be undertaken carefully.

Direct Technique:

− In the direct pattern forming procedure, the stick of inlay wax (type-I hard) is held well above the Bunsen flame and softened by heating and quickly rotated till the wax becomes soft and plastic.

− The wax should not be allowed to melt and must be softened to a uniform degree.

− Then the wax is kneaded thoroughly and inserted in the tooth cavity and held under pressure till it hardens.

− In order for the wax to be condensed easily and register accurate cavity details, the temperature of the insertion should be more than 45 °C to ensure adequate flow and the wax held under pressure as it hardens.

− Pressure may be applied either with finger or by the patient biting the wax. It is not necessary to chill the pattern with cold water.

− Then it should be carefully withdrawn along the long axis of the preparation.

− A cold carving instrument must be generally used for direct patterns.

Indirect Technique:

− Impression of the prepared cavity is taken with a suitable impression material, usually a rubber-based impression material.

− A die is prepared from that impression.

− The die is then coated with a lubricant in order to minimize or prevent the wax from sticking to the die. The lubricant should be applied to the pattern in a film of minimal thickness. Any excess may prevent intimate adaptation of the wax to the die.

− The melted wax may be then added in layers with a wax spatula or an enamel hair brush onto the die, as shown in fig. 2.

− In the case of full cast or crown, the die may be dipped repeatedly into the liquid wax.

− The prepared cavity is over filled, and the wax is then carved to the proper contour. When the margins are being carved, extreme care should be taken to avoid abrading of the die.

− A silk cloth may be used for final polishing of the pattern.

Precautions:

− The pattern should be touched as little as possible with the hands as it introduces thermal changes and leads to distortion or warpage.

− Wax pattern after removal should be checked for any cracks, or lack of marginal continuity and then washed and cleaned for any separating medium or saliva of the patient present.

− Overbuilding and underbuilding of wax must be avoided.

− For the best results, the pattern must be invested as soon as possible after it has been removed from the mouth or the die.

Fig. 2. Preparation of wax pattern by indirect technique

PATTERN RESINS

Pattern resins are characterized by higher strength and resistance to flow than waxes, good dimensional stability, and burnout without residue. Full-crown patterns fabricated from pattern resins and inlay waxes have similar marginal discrepancies. A pattern is fabricated by applying the resin in 3- to 5-mm layers and curing in a light chamber or with a handheld light-curing unit. Resin is completely eliminated from the mold before casting by heating at 690 °C for 45 minutes.

CASTING WAXES

Casting waxes are used for thin sections of certain removable and fixed partial denture patterns. They are particularly convenient in the preparation of copings or clasps requiring uniformly thin regions.

Dispension:

− Casting waxes are available in the form of sheets, usually of 28 and 30 gage (04 and 0.32 mm) thickness.

− Readymade shapes and in bulk.

− Readymade shapes are supplied as round, half round and half pear-shaped rods and wires of various gages of approximately 10 cm in length. Different types of casting waxes are shown in the fig. 3.

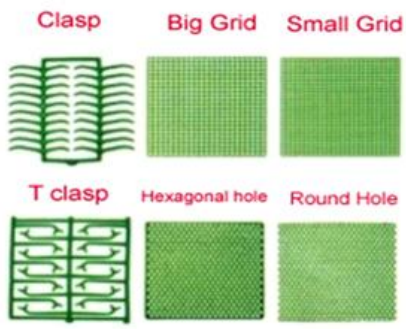


Fig. 3. Examples of casting waxes

Although casting waxes serve the same basic purpose as inlay waxes in the formation of patterns for metallic castings their physical properties differ slightly.

Composition:

- Paraffin wax — 60 %.
- Carnauba wax — 25 %.
- Ceresin — 10 %.
- Bees wax — 5 %.

Uses:

− To establish minimum thickness in certain areas of the partial denture framework, such as the palatal and lingual bar.

− To produce the desired contour of the lingual bar.

− For postdamming of complete maxillary denture impressions.

− Used for checking high points of articulation.

− For producing over bites of cusp tips for the articulation of the stone cast, etc.

Properties. These waxes are *tacky* and highly *ductile* as they must adapt easily and stick onto the refractory cast. They should copy accurately the surface against which they are pressed. The pattern for the RPD frame is made on a special cast known as the *refractory cast* (fig. 4). Since the wax comes in ready-made shapes, it is quite easy to assemble. The wax forms are sticky and pliable and can be adapted easily on to the cast. After the pattern is completed it is invested and ignited. Like inlay wax they too must vaporize with *little residue* during burnout.

Fig. 4. RPD pattern formed from preformed waxes used in the construction of removable partial dentures

BASEPLATE WAX

Baseplate wax is used in the construction of full denture patterns and for occlusal rims, although an occlusal rim wax is also available. Setup wax may be used instead of baseplate wax to set denture teeth.

The American National Standards Institute/American Dental Association has established a specification that includes three types of baseplate wax: Type I is a soft base plate wax for veneers and contours. Type II is a medium-hardness base plate wax designed for temperate climates for patterns to be tried in the mouth. Type III is the hardest base plate wax and is for patterns to be tried in the mouth in tropical climates. The hardness is based on the amount of flow the wax shows at 45 °C. Base plate wax is also used as a mold for the construction of provisional fixed partial dentures and as a bite registration wax. It has some applications in orthodontics.

Dispension. The baseplate waxes are normally supplied in sheets of dimension 7.6 × 15 × 0.13 cm in pink or red color (fig. 5).

Fig. 5. Baseplate wax

Composition. Baseplate waxes may contain 70–80 % paraffin base waxes or commercial ceresin, with small quantities of other waxes, resins and additives to develop the specific qualities desired in wax.

Typically the composition as follows:

- Ceresin — 80 %.
- Bees wax — 12 %.
- Carnauba — 2.5 %.
- Natural and synthetic resin — 3.0 %.
- Microcrystalline or synthetic waxes — 2.5 %.

PROCESSING WAXES

Processing waxes include boxing, beading, sticky, carding, blockout, white, and utility waxes.

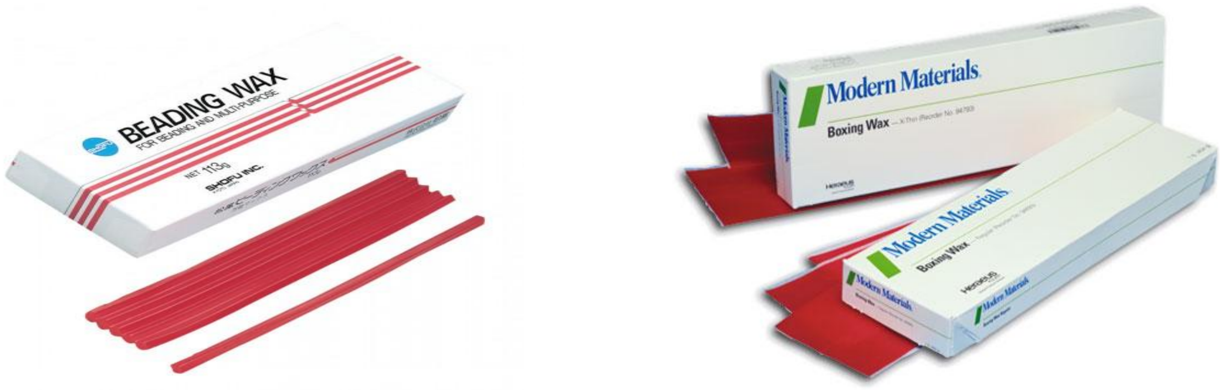
BEADING AND BOXING WAX

Boxing wax is used to build up vertical walls around the impression of an edentulous arch in order to pour the stone and make a cast. The procedure is known as *boxing*. It is also used to fabricate replacement pontics for provisional fixed partial dentures. The terms carding wax and boxing wax appear to be interchangeably, although boxing wax is more correct according to usage.

Dispension. Boxing wax is produced in sheets, beading wax in strips (fig. 6).

Properties. They are pliable and can be adapted easily. A slight tackiness allows it to stick to the impression.

Note. The terms carding wax and boxing wax have been used interchangeably. Carding wax was the original material on which porcelain teeth were fixed when received from the manufacturer. Boxing wax is a more acceptable term.



a ***b***

Fig. 6. Beading wax (a) and boxing wax (b)

Advantages of beading and boxing:

1. Preserves the extensions and landmarks.
2. Controls the thickness of the borders.
3. Controls the form and thickness of the base of the cast.
4. Conserves the artificial stone.

Technique. Beading wax is adapted around the periphery. This wax should be approximately 4 mm wide and 3–4 mm below the borders of the impression. The height is adjusted until a boxing wax strip extends approximately 13 mm above the highest point on the impression. Stone is vibrated into the boxed impression. The boxed impression is shown in the fig. 7.

Fig. 7. Boxed impression ready for pouring stone

STICKY WAX

Sticky wax (Kerr) is used to join materials temporarily. Sticky wax is also called as Model cement. A suitable sticky wax for prosthetic dentistry is formulated from a mixture of waxes and resins or other additive ingredient such a material is sticky when melted and will adhere closely to the surfaces upon which it is applied. At room temperature however the wax is firm and free from tackiness and is brittle.

Dispension. It is usually dispensed in the form of sticks (fig. 8).

Fig. 8. Sticky wax

Composition. It is mainly made of bee's wax, which gives the sticky property to the wax and some naturally occurring resins. There are a number of formulas representing both high and low resin content. In addition to the rosin and yellow bees wax, which is major constituent, coloring agents and other natural resins such as gum damar may be present.

Uses:

– To seal a plaster split to a stone model in the process of forming porcelain facings.

– Used to seal broken denture fragments prior to denture repair.

Used to join metal fragments prior to soldering.

UTILITY WAX

There are numerous instances in which an easily workable, adhesive wax is desired. A standard perforated tray for use with hydrocolloid for example, may easily be brought to a more desirable contour by such a wax. This is done to prevent a sag and distortion of impression material. A soft pliable adhesive wax may be used on the lingual portion of a bridge pontic to stabilize it while a labial plaster splint is poured.

Dispension. It is supplied in strip, stick and sheet form in a dark red or orange color (fig. 9).

Fig. 9. Utility wax

Composition. It consists largely of bee's wax, petrolatum of other soft waxes in varying properties, exact composition is not known.

Uses:

− Used with standard perforated tray for use with hydrocolloid.

− A soft, pliable, adhesive wax may be used on the lingual portion of a bridge ponti to stabilize it while a labial plaster splint is poured.

Carding wax is used for attaching parts and in some soldering techniques.

Blockout wax is used to fill voids and undercuts for removable partial denture fabrication.

White wax is used for making patterns to simulate a veneer facing.

IMPRESSION WAXES

Impression waxes (Bite Wax, Mizzy) exhibit high flow and distort on withdrawal from undercuts. Waxes used for denture impressions are limited to use in edentulous regions of the mouth. Corrective waxes are used as wax washes to record detail and displace selected regions of soft tissue in edentulous impressions. Bite waxes are used in certain prosthetic techniques; a typical use would be bite registration.

CORRECTIVE IMPRESSION WAX

It is claimed that this type of impression material records the mucous membrane and underlying tissues in a functional state in which movable tissues are displaced to such a degree that functional contact with the base of the denture is obtained.

Composition. They are formulated from hydrocarbon waxes such as paraffin and ceresin and may contain metal particles.

Uses. Used as a wax veneer over an original impression to contact and register detail of the soft mucosa.

BITE REGISTRATION WAX

They are the type of waxes, which distort if they are withdrawn from undercut areas and therefore limited use (fig. 10).

Fig. 10. Bite registration wax

Composition: They are frequently made from 28 gage casting wax sheets or from hard base plate wax. But waxes identified as bite waxes appear to be formulated from bees wax or hydrocarbon waxes such as paraffin or ceresin. Certain bite registration waxes contain aluminum or copper particles.

Uses:

− They are used in edentulous portion of mouth.

− Used to articulate accurately certain models of opposing quadrants.

ASHLESS PLASTICS

Ashless plastics — auxiliary modelling materials without wax in their composition. These materials are called modelling (ashless) plastics.

For dentistry ashless plastics are produced in the form of standard preparations: pins (fig. 11a), patrix of attachmens (fig. 11b), sprues fig. 11 c), etc., polyvinylchloride disks for deep extension of caps (Adapta system) (fig. 11d) and polymeric compositions of chemical (Pattern resin LS, DuraLay, Temp Red, etc.) or light (Triad VLC, Palavit GLC, LC Block-Out Resin, etc.) curing.

a *b* *c* *d*

Fig. 11. Ashless plastic:
a — standard ashless pins; *b* — patrix for attachmens; *c* — sprue formers; *d* — polyvinylchloride disks for deep extension

TEST-CONTOL QUESTIONS

In the following multiple-choice questions, one or more responses may be correct.

1. Which of the following is approximately the coefficient of thermal expansion of a dental inlay wax?

a) $-50 * 10^{-6}$/°C;

b) $20 * 10^{-6}$/°C;

c) $80 * 10^{-6}$/°C;

d) $200 * 10^{-6}$/°C.

2. Which of the following is/are true of residual stress?

a) is developed in wax when it is cooled under stress;

b) results in a uniform dimensional change that can be compensated for in the casting process;

c) can be minimized by the manipulation of wax at a temperature as high as is practical;

d) can cause warpage that increases at higher storage temperature and during longer storage times.

3. A pattern wax might be used to do which of the following?

a) make a corrective impression;

b) form a mold around an impression;

c) form the general size and contour of a restoration.

4. Casting waxes possess useful properties, such as?

a) tackiness;

b) no residue other than carbon;

c) minimum values of flow at mouth temperature;

d) specified values of coefficient of thermal expansion;

5. Which of the following statements is/are true?

a) boxing wax is used for forming a mold around an impression before a gypsum cast is poured;

b) utility wax must stick to itself;

c) sticky wax must have less than 0.2 % residue on burnout;

d) utility wax is used to prevent sag and distortion of an alginate impression in a tray;

e) sticky wax is used to assemble metallic or resin pieces in a fixed temporary position and is brittle at room temperature.

6. Which of the following statements is applied to bite-registration waxes?

a) they are used to articulate models of opposing quadrants accurately;

b) formulations are made from carnauba wax;

c) the flow of these waxes is from 5 % to 80 % at 37 °C;

d) these waxes may distort when removed from the mouth.

Use short statements to answer the questions.

7. You are treating a patient on a hot day, and the office temperature is significantly higher than normal. You notice that when you use a wax bite record to mount casts on your articulator, the occlusal relationship is not correct. Which properties of wax were most likely responsible for this problem? What precautions could you take to prevent this problem?

8. A pattern wax is used to make a pattern for a crown on tooth number 30. The technician makes the pattern at the end of the day and plans to invest it for casting the next morning. Unknown to the technician, the heat fails in the laboratory overnight but returns to its original temperature by morning. Ultimately, the casting made from this wax pattern does not fit the die. Why did this problem occur? What properties of the wax used for the wax pattern are responsible? How can the technician decrease the chances of this problem occurring?

9. By mistake, a denture is made with Type I baseplate wax rather than Type II. What can be a result? If Type II wax was used, what would have happened?

10. You secure two gypsum casts together with sticky wax. On setting the casts on the counter just before mounting them on an articulator, a coworker bumps the casts, and the sticky wax fractures. Why should you be glad that you have used sticky wax?

11. Describe the techniques that can be used to limit the problem of residual-stress incorporation in wax.

Use short answers to fill in the following blanks.

12. Sticky wax is _______________ at room temperature.

13. Bite-registration waxes have been replaced clinically by________ bite-registration materials.

For the following statements, select true or false.

14. The flow of a dental wax increases as the temperature increases.

a) True;

b) False.

15. As wax is heated, a significant expansion occurs, but on cooling, contraction occurs reversibly.

a) True;

b) False.

16. Warm temperatures and long storage times increase the possibility of release of residual stress in wax patterns.

a) True;

b) False.

17. The release of residual stresses in a wax pattern will result in distortion of the wax pattern.

a) True;

b) False.

18. During burnout of a wax pattern, it is essential that the wax decompose and leave no residue.

a) True;

b) False.

19. If a wax pattern cannot be invested promptly, readapt the margins before investing the pattern.

a) True;

b) False.

20. Residual stresses in a wax pattern can be minimized by manipulating the wax at temperatures below room temperature.

a) True;

b) False.

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