CORRELATION BETWEEN CALCIUM BENTONITE CONCENTRATION AND PARAFFIN WAX TO THE HARDNESS OF CARVING WAX

(HUBUNGAN ANTARA KONSENTRASI KALSIUM BENTONIT DENGAN PARAFIN MALAM TERHADAP KEKERASAN MODEL MALAM)

Widjijono

Biomaterials Department
Faculty of Dentistry, Gadjah Mada University
Jl. Denta, Sekip Utara, Yogyakarta

Abstract

The carving wax composes many natural or synthetic waxes and sometimes filler is added physical and mechanical properties. The aim of this study was to determine the correlation of concentration Ca-bentonite carving wax composition and the hardness. The paraffin, carnauba wax, bees wax, Ca-bentonite, and inlay wax were used in this research. The carving wax compositions were made of paraffin, Ca-bentonite, carnauba wax, and bees wax ratio (% weight): 50:20:25:5 (KI), 55:15:25:5 (KII), 60:10:25:5 (KIII), 65:5:25:5 (KIV), 70:0:25:5 (KV). All components were melted, then poured into hardness moulds (n=5). The carving wax properties were tested of their hardness by penetrometer (Setamatic, UK). Data were analyzed statistically by regression test and linearity by Anova. The results showed that regression linear significantly ($p<0.05$) and the regression of equation was $Y = 18.365\text{-}50.940\ X$ with coefficient regression of $(R) = 0.922$ ($p<0,05$) and determinant factor 84.9 percent. The conclusion of this study was the adding of Ca-bentonite on the composition of carving wax improved its hardness with the significant linearity ($p<0.05$).

Key words: carving wax, Ca-bentonite, linearity, hardness

INTRODUCTION

Knowledge of the anatomy of the teeth is essential in dentistry. Three approaches to study the tooth form are tooth drawing, wax block carving and tooth wax-up. Wax block carving is to produce a wax tooth by carving it from a rectangular piece of wax.[1] Carving wax consists of high quality waxes similar to inlay wax.[2]

The composition of inlay wax is complex, and it may contain five or six different waxes such as paraffin, carnauba, ceresin, and bees wax.[3] The paraffin in the composition of inlay wax may contain between 40 and 60%. Paraffin is composed mainly of complex mixture of hydrocarbon of the methane series, together with a minor amount of amorphous or microcrystalline phases. The wax can be obtained in wide melting range depending on the molecular weight and distribution of the constituents.[4] Carnauba wax composed of straight-chain ester, alcohol, acid and hydrocarbon. It has the characteristic of high hardness, brittleness, and high melting temperature. The adding of carnauba wax to paraffin wax increases its melting point.[5] Bees wax is originated from insect wax used in dentistry. It is a complex mixture of esters and unsaturated hydrocarbons and high molecular weight organic acid. It is a brittle material at room temperature but it becomes plastic at body temperature. The hardness is controlled by adjustment of the component.[3] The principal waxes used to inlay waxes are paraffin, microcrystalline wax, ceresin, carnauba, candelilla and bees wax. Inlay wax may contain 60% paraffin, 25% carnauba, 10% ceresin and 5% bees wax.[5] The research of carving wax with the composition of paraffin, carnauba and bees wax with ratio 60-80: 15-35:5, showed that improved paraffin concentration effect to decrease the melting point and hardness of carving wax.[6] Certain additives such as plasticizers and fillers can have a profound effect on properties of polymers. The inclusion of particulate or fibrous inorganic fillers has an equal significant effect on polymer properties. Particulate filler is often used to increase the hardness and improve its resistance to abrasion.[7] Filler is an innert substance added to a

polymer to improve or modify its properties. Kotsiomiti and McCabe found[8] that inorganic filler can act as an effective hardener for natural wax blends for dental applications. The findings were quite encouraging for suggesting the exact relationships, similar to those applied for alloy, between properties and constitutions.[8] Filler materials are the most often added to polymers to improve tensile and compressive strength, abrasion resistance, toughness, dimensional and thermal stability and other properties. Material used as particulate fillers include wood flour (finely powdered sawdust), silica flour and sand, glass, clay, talc, limestone and even some synthetic polymers.[9] When paraffin was blended with 2 to 10% filler, a trend of reducing flow with filler additions was noticed. The strongest material was mixture of paraffin with 8% filler. The influence of filler addition to natural waxes was quite significant.[8] Particulate inorganic filler is the seed function between paraffin and bees wax inter molecular position and the mixture becomes the gel texture.[10]

One of the inorganic filler is bentonite. It is an inorganic filler superaboundant in the minerals. Bentonite used to bleach, support, filler and mineral oil activities. Two bentonite types were a Wyoming bentonite type (Ca-bentonite) and meta bentonite (Na-bentonite, sub bentonite). In the acidic reaction activity of natural Ca-bentonite showed better properties application were adsorption, water dispersion, ion exchange prior to calcium and magnesium adding. Generally, calcium and magnesium atomic react with chemical binding with atomic hydrogen from paraffin hydrocarbon chain and enhanced physical mechanical properties caused salt calcium formation. In general, the aim of the filler added in one composition of substances is to improve hardness, toughness, voids-free, no flaking, glossy and no sticky on the models or instruments.[11] The objective of this study was to analyze the correlation between addition of Ca-bentonite on the composition and its hardness of carving wax.

MATERIALS AND METHODS

Five compositions of carving wax with ratio of paraffin (Pertamina, INA), Carnauba (Brataco Chemicals, INA), Ca-bentonite, inlay wax (GC, Japan), and bees wax (SEA, INA) summarized in Table 1.

Each composition of carving wax was prepared as many as 2000 grams. The constituents were prepared by melting together on the hot plate. This melt was poured into the mould and stored at room temperature for 24 hours before being tested.

Table 1. The composition of carving waxes

Ingrediens (% weight)	Groups				
	KI	KII	KIII	KIV	KV
Paraffin	50	55	60	65	70
Carnauba	25	25	25	25	25
Ca-bentonite	20	15	10	5	0
Bees wax	5	5	5	5	5

The hardness was measured based on ASTM D 1321 standards[12] by penetrometer (Setamatic, UK). Specimens were immersed in the water bath at 25°C for 1.5 hours. The hardness was measured by penetration of penetrator needle to the wax surface until the needle can not penetrate anymore. The penetration depth was measured by sliding caliper digital with the accuracy 0.01mm (Mitutoyo, Japan).

RESULTS

The results showed that the variation of data of hardness of the carving wax with the biggest penetration at 22.50 mm in groups KV (the lowest hardness) and the lowest 8.70 mm in groups KI (the highest hardness). Generally, descriptive data of this study in Table 1 tended to indicate that added Ca-bentonite in these compositions can enhance the hardness of carving wax from KV to KI.

Table 2. Measurement the hardness of carving wax (the penetration in: mm)

	KI	KII	KIII	KIV	KV
Penetration	9.17	10.17	11.33	14.50	18.16
	9.30	11.33	12.00	14.33	20.33
	8.80	9.17	13.16	13.50	20.00
	8.70	11.66	12.00	14.00	22.50
	9.67	10.67	13.66	14.00	19.66
Mean ± SD	9.12 ± 0.39	10.60 ± 0.98	12.43 ± 0.95	14.06 ± 0.38	20.13 ± 1.56

Table 3. Summaries of Anova the effect of carving wax composition to hardness

	Sums square	df	Mean square	F	Sig.
Between groups	363.419	4	90.855	98.246	0.000
	18.495	20	0.925		
Total	381.915	24	0.925		

Statistical analysis with regression test showed regression line was: Y = 18.365-50.940 X with coefficient regression (R) 0.922 and factor determinant (R^2) 84.9%. The linearity of enhanced hardness carving wax tested by Anova showed different significance ($p<0.05$).

Table 4. Summaries of the LSD of hardness of carving wax

	KI	KII	KIII	KIV	KV
KI	-	1.4720*	3.3020*	4.9380*	11.0020*
KII		-	1.8300*	3.4660*	9.5300*
KIII			-	1.6360*	7.7000*
KIV				-	6.0640*
KV					-

*: significantly ($p<0.05$)

DISCUSSION

The function of bees wax constituent is a brittle material at room temperature but it becomes plastic at body temperature or with other means such a bees wax as functional plasticizer. The Carnauba wax has been characterized by high hardness, brittleness, and high melting temperatures.[5] The amount of carnauba wax and bees wax constituent in this research were the same with the composition carving wax. The constituent concentrate paraffin and Ca-bentonite were different and influenced to carving wax hardness. Generally, adding filler inorganic Ca-bentonite enhanced the hardness of carving wax. The hardness was controlled by adjustment of the component. The addition of fillers decreases the flow of the materials caused by the absence of slippage of the long-chained wax molecules with each other.[3] In this case hardness of carving wax caused by added filler inorganic Ca-bentonite and it tended to indicate that added Ca-bentonite in these compositions can be enhanced by the hardness of carving wax.

The comparative Dyah-Irnawati's research result means the penetration of carving wax. This research showed the increasement in group KV (20.13 mm versus 14.12 mm), but it was decreased on filler with Ca-bentonite in group KI, the highest hardness was 9.12 mm. The addition of Ca-bentonite 5% in this research was caused different significance on the mean of hardness carving wax, and this different from Kotsiomiti & McCabe's result[8], where its filler concentration addition up to 10% increased the hardness of mixture waxes. Ca-bentonite is a particulate inorganic filler, it is the seeds function between paraffin and bees wax at intermolecular position and the mixture becomes the gel texture.[10] The natural of Ca-bentonite when its acid activated has a good absorption, water dispersion and ion exchanged, especially to the calcium and magnesium mineral. The reaction between calcium and magnesium in the Ca-bento-nite and hydrogen atomic from hydrocarbon compounds in the paraffin are chemically bounded to salt calcium or magnesium formed and im-proved its physics mechanically to carving wax.[13] The chemical bound to salt calcium caused enhan-ced hardness of carving wax. The added Ca-bentonite has risen so the mechanical physics and hardness of carving wax were enhanced. The enhanced hardness of carving wax followed the regression equals and linear.

The conclusion of this research was the adding of Ca-bentonite on the composition of carving wax improved its hardness with the significant linearity.

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References

1. Benson HJ, Kipp RE. Dental science laboratory guide. 4th ed. Iowa: WMC Brow Company Publisher, 1973: 74-9.
2. Anonymous. Metrodent carving wax. <http:// www.metrodent. com/pdfs/modelling.pdf> (January 15, 2005)
3. Craig RG, Powers JM, Wataha JC. Dental materials properties and manipulation. 7th ed. St Louis: Mosby Inc, 2000: 209-20.
4. Anusavice KJ, Phillips'. Science of dental materials. 11st ed. St Louis: Elsever Science. 2003: 283-93.
5. Craig RG. Powers JM, Restorative dental materials. 11th ed. St Louis: Mosby Co, 2002: 436.
6. Dyah-Irnawati. Pengaruh rasio malam parafin dengan malam Carnauba terhadap titik leleh dan kekerasan malam ukir, FKG-UGM, 2007.
7. McCabe JM. Applied dental materials, 7thed. New York: Blackwell Scientifict Pub, 1990: 85
8. Kotsiomiti E. McCabe JF, Experimental wax mixtures for dental use. J Oral Rehabilitation 1997; 24: 517-21.
9. Callister Jr WD. Materials science and engineering an introduction. New York: John Wiley & Sons Inc, 1991: 508.
10. Nuryono. Hydrocarbon and ester bonding (personal approach), 2007.
11. Arifin M, Sudrajat A. Bentonite. Dalam: Suhala S, Arifin M (Ed). Bahan Galian Industri. Bandung: Pusat Penelitian & Pengembangan Teknologi Mineral, 1997: 124-6.

12. ASTM (American Society for Testing Materials). Annual book of ASTM Standards Section 5. Petroleum Products, lubricants and fossil fuels. Petroleum Products and Lubricants (1) D56-D2596. Baltimore: ASTM. 2001; 05: 504-6.

13. Anonymous. MDM Corporation expanding dealership, network, inquiries, solicited. <http://indiamart.com> (February 28, 2007).

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