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Preparation and Characterization of Dental Porcelain

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Abstract

Feldspar and quart from the local source is used as a base material for dental porcelain. The physical and chemical properties have been performed. The x-rays fluorescence is used to analyze the chemical composition. The composition of material and temperature preparation of dental porcelain contributes to shrink of burning and hardness, which is increased along with the increasing of treatment temperature.

KEYWORDS: dental porcelain, feldspar, quartz, hardness

I. INTRODUCTION

South Sulawesi as well as another region of Indonesia has feldspar, quartz, kaolin and many other mineral compounds. All of these materials need to be developes. Feldspar, quartz, kaolin are the base materials of porcelain.[1–3] It can be used to produce an artificial dental porcelain, and it will increase its economical value. Porcelain has an esthetic value, strong, easy to form, low thermal conductivity, resistance from chemical reaction. [4]

Heat treatment of dental porcelain is at 1200°C - 1400°C for a high fusing, 1050°C - 1200°C for medium fusing, and 800°C - 1050°C for low fusing. The low fusing method is used for restoration of all porcelain. The chemical content of dental porcelain is SiO_2, Al_2O_3, CaO, and K_2O. Further, physical properties of dental porcelain are grain size of material: 0.18 mm - 0.075 mm, shrink of burn is less than 30%, hardness: 68 kg/mm^2, and coefficient of thermal expansion 83 x 10^{-6}/°C to 114 x 10^{-6}/°C.[2, 5]. In this paper the study on physical and chemical properties of dental porcelain is presented.

II. EXPERIMENTAL METHOD

The sample of dental porcelain used feldspar from Tanjung Bira and quartz from Tonasa, the South Sulawesi region. The chemical composition of material is determined by X-ray flourescence. The fineness of grain size is determined by filtering it on different size of mesh. There are 5 types mixture of feldspar, quartz and kaolin for the experiment. Each composition of the base material is determined its chemical composition.

TABLE I: Chemical composition of dental porcelain material.

Material	Percentage (%)							
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	SO_3	Cl
Feldspar	2.75	0.37	0.20	50.46	0.42	0.54	40.12	94.91
Quartz	70.24	13.59	5.62	0.02	0.37	0.96	0.07	0.42
Kaolin	43.08	44.01	1.91	0.60	0.22	1.96	0.05	0.72

TABLE II: Composition of base materials.

Composition	Total mass material (5 grams)		
	Feldspar (g)	Quartz (g)	Kaolin (g)
1 : 4 : 4	0.556	2.223	2.223
1 : 4 : 3	0.625	2.500	1.875
1 : 4 : 2	0.714	2.857	1.429
1 : 5 : 3	0.556	2.778	1.667
1 : 5 : 2	0.625	3.125	1.875

The low fusing temperature (800°C, 900°C, and 1000°C) is used in vacuum fired porcelain (*Vita Vacumat 40*) to prepare the samples of dental porcelain. The physical properties of the samples are determined by shrinkage percentage, and hardness.

III. RESULT AND DISCUSSION

Feldspar, quartz, and kaolin are determined its chemical composition by x-ray fluorescence. Dental porcelain materials need high percentage of SiO_2, Al_2O_3, CaO, but low percentage of Fe_2O_3, MgO.

Feldspar is non elastic material; it used to reduction the shrinkage and increases the hardness of the product. Feldspar has high concentration of CaO but low concentration of SiO_2 and Al_2O_3. It will be suitable by mixture with quartz and kaolin, which have high concentration of SiO_2 and Al_2O_3, as show on Table 1. All the base material has low concentration of MgO and Fe_2O_3 and it will not give an effect on color, specially for dental porcelain.

This experiment used 5 types mixture of feldspar (F), quartz (Q), and kaolin (K), see Table 2. Combination on certain amount of the three base materials could get a good chemical composition, high percentage of SiO_2, Al_2O_3, and CaO.

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TABLE III: Chemical composition of dental porcelain, depend on its composition.

Type	F : Q : K	Percentage (%)							
		SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	SO_3	Cl
I	1 : 4 : 4	51.01	22.25	0.58	9.49	0.32	1.26	0.01	7.81
II	1 : 4 : 3	52.00	23.79	2.24	6.43	0.32	1.29	0.03	5.40
III	1 : 4 : 2	54.05	20.41	2.03	7.67	0.32	1.19	0.04	6.38
IV	1 : 5 : 3	55.34	23.09	1.92	5.52	0.32	1.27	0.05	4.69
V	1 : 5 : 2	56.44	20.61	2.44	6.76	0.34	1.18	0.04	5.68

TABLE IV: Grains size of Feldspar from Tanjung Bira - South Sulawesi.

Mesh no.	Diameter (mm)	Fineness (%)
50	0.35	96.79
80	0.18	93.51
100	0.15	85.18
120	0.13	73.39
170	0.09	58.94
200	0.075	41.16

X-ray fluorescence is used to determine its chemical composition of 5 types of combination material as show on Table 3.

All the sample type has 50 - 60 percentage of $Si2O$, close to 62.2% for dental porcelain [6]. Concentration of Al_2O_3 is 20 - 24 percent; it is higher than 18.7 percent. The Fe_2O_3, MgO, K_2O, SO_3, and Cl have a small concentration, and it will give a good effect on color quality.

The dental porcelain material has to have a fineness grain size in order 0.075 mm - 0.18 mm. The grain size of the base material (feldspar, quartz and kaolin) was determined by filtering it on different size of mesh.

The grain size of the base materials (feldspar, quartz, and kaolin) have a good order and suitable for dental porcelain. It has more than 93% of the grain size 0.18 mm, as show on Table 4, 5 and 6. The refinement of grain size will effect on elasticity during preparation.

Feldspar, quartz, and kaolin were pre-drying at 100°C, to eliminate its water content. The dental porcelain was then baked in vacuum fired porcelain at temperature of 800°C, 900°C, and 1000°C. The shrinkage of the sample is determined by measuring the reduction of its size after baked it in vacuum fired porcelain. The maximum shrinkage is 30% for dental porcelain.

The experiment has shown that it shrank in a good range, less than 30% [7]. The shrinkage increases as increasing the temperature of preparation. Some mineral oxides are melting on high temperature. It will affect the increasing shrinkage and hardness.

The acrylic is used as comparison with dental porcelain material for the hardness test. The acrylic is used as artificial dental material because it is cheap, like a gums color, elastic, and easy to form [8, 9].

The hardness of sample increases as temperature of furnace increase. The hardness of dental porcelain is 8 - 14 kg/mm^2. The dental porcelain is better than acrylic artificial dental. The hardness is higher than that of acrylic artificial dental (7 kg/mm^2). The sample's hardness is less than that of standard sample [2]. It may probably be as an effect of concentration of SiO_2 which was found to be less than the standard.

TABLE V: Grains size of quartz from Tonasa - South Sulawesi.

Mesh no.	Diameter (mm)	Fineness (%)
50	0.35	98.75
80	0.18	95.61
100	0.15	88.42
120	0.13	78.91
170	0.09	65.64
200	0.07	63.59

TABLE VI: The grains size of kaolin.

Mesh no.	Diameter (mm)	Fineness (%)
50	0.35	98.35
80	0.18	96.23
100	0.15	92.26
120	0.13	87.25
170	0.09	79.93
200	0.07	71.19

TABLE VII: Shrinkage on temperature 800°C, 900°C, and 1000°C.

Sample	Shrinkage (%)		
	800°C	900°C	1000°C
I	14.75	22.15	31.12
II	11.32	15.44	30.46
III	7.41	11.31	26.05
IV	7.00	10.67	21.68
V	6.74	9.54	15.80

IV. CONCLUSION

The local feldspar and quartz are promising material for dental porcelain. Its grain size are suitable for prepare the dental porcelain. The composition of material and temperature preparation of dental porcelain influences the shrinkage and hardness. The shrinkage is compatible with standard. The hardness is increase as temperature of preparation-increase.

TABLE VIII: The hardness of dental porcelain.

No. Sample	Hardness (kg/mm^2)			
	type	800°C	900°C	1000°C
1	I	10	11	13
2	II	8	11	13
3	III	8	11	12
4	IV	10	12	14
5	V	11	13	14
6	Acrylic	7		

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