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دراسة الخواص الفيزيائية والتشكيلية للعازل السيراميكي

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الخلاصة

تم في هذا البحث تحضير عازل سيراميكي باستعمال مواد محلية عراقية (كاؤلين،سليكا،فلدسبار) وبنسب وزنية (30% ,25%,45%)على التوالي وبعد اجراء عملية التنقية،والغسل ،والتجفيف ،والطحن للاطيان العراقية بصورة انفرادية أضيفت نسب مختلفة من سليكات الصوديوم (0.1%,0.2%,0.5%,0.7%,1%)وبنسبة ثابتة من الماده المعدنة. كبست النماذج على شكل اقراص وحرّقت بدرجات حرارية ^{o}C(1250, 1350) على التوالي. استخدام المجهر الضوئي لدراسة سطوح النماذج ثم اجريت قياسات الكثافة الظاهريه والمسامية الظاهرية للنماذج كافة باستخدام طريقة آرخميدس .أوضحت الصور المجهرية لسطوح النماذج ارتفاع نسبة التفاعل الكيميائي الحاصل بين المواد الاولية مع ارتفاع درجة الحرق نتيجة للانصهار الحاصل الذي يعمل على زيادة التقارب الحبيبي على حساب المناطق عير المتفاعلة والفجوات وان افضل نسبة لفحوصات الكثافة والمسامية الظاهريه هي عند تركيز(0.5%) لسليكات الصوديوم.

الكلمات المفتاحية: العازل السيراميكي ، الكثافة ، المسامية .

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Study of the Physical and Morphological Properties of Ceramic Insulator

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Abstract

In this investigation insulator ceramic body was prepared by using iraqi local materials, these are kaolin, silica sand glass, feldspar with weight percentage (45%,25%, 30%)respectively. After the end of treating drying and milling of raw material mixing with different concentrations of sodium silicate(1%,0.7%,0.5%,0.2%,0.1%) while zinc oxide was added at fixed weight percentage. A disc samples was prepared after compaction and then fired by sintering temperatures (1250, 1350)^{o}C respectively.A surface morphology was studied by using optical microscope and measurements of apparent density and porosity was under taken to the sintered samples by using Archimedes method.The study showed that the microscopic images for samples surface showed that grains start in convergence with other and grain size increasing with firing temperature and the best result of apperant density and porosity at 0.5% concentration of sodium silicate .
Key words: ceramic insulator, density, porosity.

Introduction

Ceramic material can be defined as " in organic &non metallic materials that are artificially manufactured by high temperature reaction" and sometimes heat and pressure[1] . Ceramic materials have the following generalized materials properties, low density, low in toughness, high moduli, very hard , very high melting points, wear - resistance, brittle, good thermal shock résistance, excellent electrical and thermal insulation, good relation of properties at high temperatures, and chemically stable[2]. The field of ceramic science could be broadly classified as traditional and advanced ceramic. Traditional ceramic are those made from naturally occurring materials like clays and minerals without required much refinement characterized by mostly silicate - base porous microstructure that are quite coarse, non uniform and multiphase[3]Advanced ceramic are developed by chemical synthesis, there are man - made and can be made from high refined naturally occurring materials. The microstructures of these advanced ceramics were at least an order of magnitude finer and more homogenous and much less porous than those of their traditional counterpart [2]. Some material like zinc oxide used to improve the chemical durability of some composition , zinc oxide is produced by direct oxidation of zinc metal and it uses a mineralized[4,5]. Sodium silicate solution has some characteristic physical properties which make them suitable for certain industries purpose. It appears that solution preferentially wets supply of sodium silicates; ceramic is decorated with glaze in composition of which the silicate solution serves the double purpose supplying its share of sodium oxide and silica, and of keeping the other ingredients in position till the sintering temperature [6] sodium silicate are used as deflocculated in the processing of raw clay and other mineral slurries. Silicates reduce slurry viscosities making them easier to pump and process. This helps in the removal of impurities and provides saving in energy costs. Sodium silicate is also used in clay slip casting lower

viscosities improve casting time because less water is needed, firing times are reduces and final product is stronger and exhibits less shrinkage and low porosity [7].

Experimental procedure

- Raw material treatment:-

Kaolin and silica sand glass treated by washing them with HCl for time duration hour at room temperature. The washed materials separated using filter papers under sequence of operation for dilution and filtering until PH - value become 5. Then the separated material milled using ball mill of porcelain body for 7 hours and sieved to obtain powder with particle size about 75 μm.

- Sample preparation: -

The raw materials used for the preparation are kaolin, silica sand glass,and feldspar with percentage (45%, 25%, 30%) respectively. 2%of zinc oxide was added to the mixture following by mixing for 2 hours. The final mixture then divided into five groups related to concentration of sodium silicate (1%, 0.7%, 0.5%, 0.2%, and 0.1%). PVA binder was prepared and applied with 1%wt for each group. The mixture process was carried under heating 80 ^{o}C until get a slurry form, and then dried at 60 ^{o}C with continuous mixing for four hours until obtain agglomerated powder.

- Sintering process:-

The final powder was milled for 2 hour and sieved to size of 250 μm. These samples were dried after pressed with pressure of 8MPa as disc form, the prepared samples sintered using different temperatures(1250, 1350)^{o}C with sinter time hours.

- Optical microscope tests:-

The optical microscopy was provided with digital camera and computer system (model Nikon ME600, attached with digital camera DXM/200F).This system is used for photographing the samples, before photographing, the surface of samples must be grinded.

- Measurement of apparent density and apparent porosity.

Apparent density and porosity of sintered samples were determined by using Archimedes Method [8].According to ASTM C20-18T,(American Standard Test Methods)[9],which cover the determination of the following properties of sintered samples.

1 -Dry weight (wd):
Samples dried or sintered by heating them for 2 hour at 100^{o}c, to insure that residual moisture must be removed, and determined the dry weight (wd) for the samples.

2 -Saturation:
Place the samples in a beaker of distilled water and boil it for 2 hour. During the boiling period , keep them entirely covered with water, allow no contact with the heated botton of the container , keep the samples immerse in water for 12-24 hours before weighting .

3 -Suspended weight W_{su}:
This weighting is accomplished by connecting a copper wire end at the downside of the balance and the other end of the terminals of the meshwork immersed in distilled water, the balance should be previously counter-blace. Place the saturated samples on the suspending meshwork for determining the suspended weight W_{su} .

4 -Saturated weight $W_{sa:}$
After determining the suspended weight, blot the sample lightly with moistened smooth linen or cotton cloth to remove all drops of water from the surface and determine the saturated weight (W_{sa}). Excessive blotting or (pressing) will induce error by withdrawing water from the pores of the sample.

5 -Bulk density (ρ_B)
The bulk density (ρ_B)or apperant density of the sample is determined by using rhe following equation

$$\rho_B = \frac{Dryweigh}{apperantvdume} = \frac{W_d}{W_d - W_{SU} / \rho_{water}}$$

Where the volume of the liquid displace, which is identical to the volume of the sample.

6 - Apparent porosity

The apparent porosity expresses as percentage by using the expression

$$\text{Apparent porosity\%} = \frac{openporevdume}{totalvolume} \times 100\%$$

$$\text{Apparent porosity\%} = \frac{w_{sa} - w_d}{w_{sa} - w_{su}} \times 100$$

Result and Discussion

Figures 1 and 2 revel the surface morphology of sample taken by the optical microscope; it is known that ceramic color is typically gray, brownish or colorless with vitreous luster. Figure(1)shows the image taken to samples fired at 1250 ^oC for 2 hours have different surface structure and color than sample firing at 1350 ^oC in figure (2). The images show in fig.(1) include the existence of white spot beside a small amount of gray region through a flux which refers to uncompleted melting of stating materials and the reduction amount of energy required to follow complete reaction between the composition with respect of time of firing.

For samples firing 1350 ^oC the image explain white and brown agglomerate which indicate present more than one phase and increase of the rate of reaction between melted material in composition firing at 1350 ^oC and decrease in prose especially when at sample (d_1) which contains a concentration of sodium silicate as table (1).

Physical characteristic parameters (Apparent density and apparent porosity):

Apparent density and porosity were calculated from the data, that measured by using Archimed method from samples fired at temperature 1250 ^oC, 1350 ^oC.The results of these groups are listed in table (1).

Fig (2) shows the images taken to samples surface that are fired at 1350 ^oC, the melt rate for the material in composition increases the chemical reaction and phase transformation to the major crystalline phase cordierite.

It is well known that the powder density is an indirect measure of the degree of the firing reaction compound formation that takes place when a powder mixture is reacted during firing. It is related to the amount of particle growth [10]. Figures (3, 4) illustrate the behaviors of density and porosity for samples with respect to firing temperatures (1250, 1350) ^oC.

Conclusion

In conclusion , this paper describes the possibility of manufacturing a good ceramic body from local material and obtain agood properties (density &porosity)by adding 0.5% concentration of sodium silicate.

Reference

1.Choudhary, S.K.H.(1985), material science and processes“ndian book,distributing co.

2. Michel, W.B. (1997), fundamentals of cermics” international edition,the MC Graw - Hill companies, Inc.newyork.

3. Romasesho S. (1999), sience and technology of ceramic,part 1, resonance , 4(8) ,part 2, resonance,december

4.Singer,F.and Signer,S.S. (1963) industrial ceramic”chapman and hall Ltd,London.

5.Toylor,J.R.and Bull,A.C. (1986) Ceramic glaze technology,by pergamon press, newyork,.

6.Seligman and Williams.J. (1977) , Low densily ceramics produced from paper recyclirg residuals ,inst.Metals,28,297, 51-58 .

7.Forge,V. (2004), Advanceing the art of silicate chemistry p.9, by PQ corporation

8.Blythe, A.R. (1982) Advance in physics31(5): 24-28.

9. Gray, A.G. (1972) introduction to material science Mc.Graw - Hill

10. She, J.H., J. (2002) Preparation of porous cordierte ceramic using Silica Secondary resource (Silican fumrs)fordust filtration purposes,Mater.sci., 37,125-131

Table (1):Apparent density (g/cm^3) and apparent porosity for these groups at different firing temperature

Samples	Concentration of sodium silicate	Apparent density		Apparent porosity	
		1250 ^{0}C	1350 ^{0}C	1250 ^{0}C	1350 ^{0}C
A	zero	1.179	1.339	9.3	0. 35
B	1%	1.194	1.51	11.6	0. 341
C	0.7%	1.205	1.398	13.9	0. 312
D	0.5%	1.462	1.37	17.1	0. 3
E	0.2%	1.6	1.63	13.8	1.1
F	0.1%	1.2	1.50	10.2	0. 7

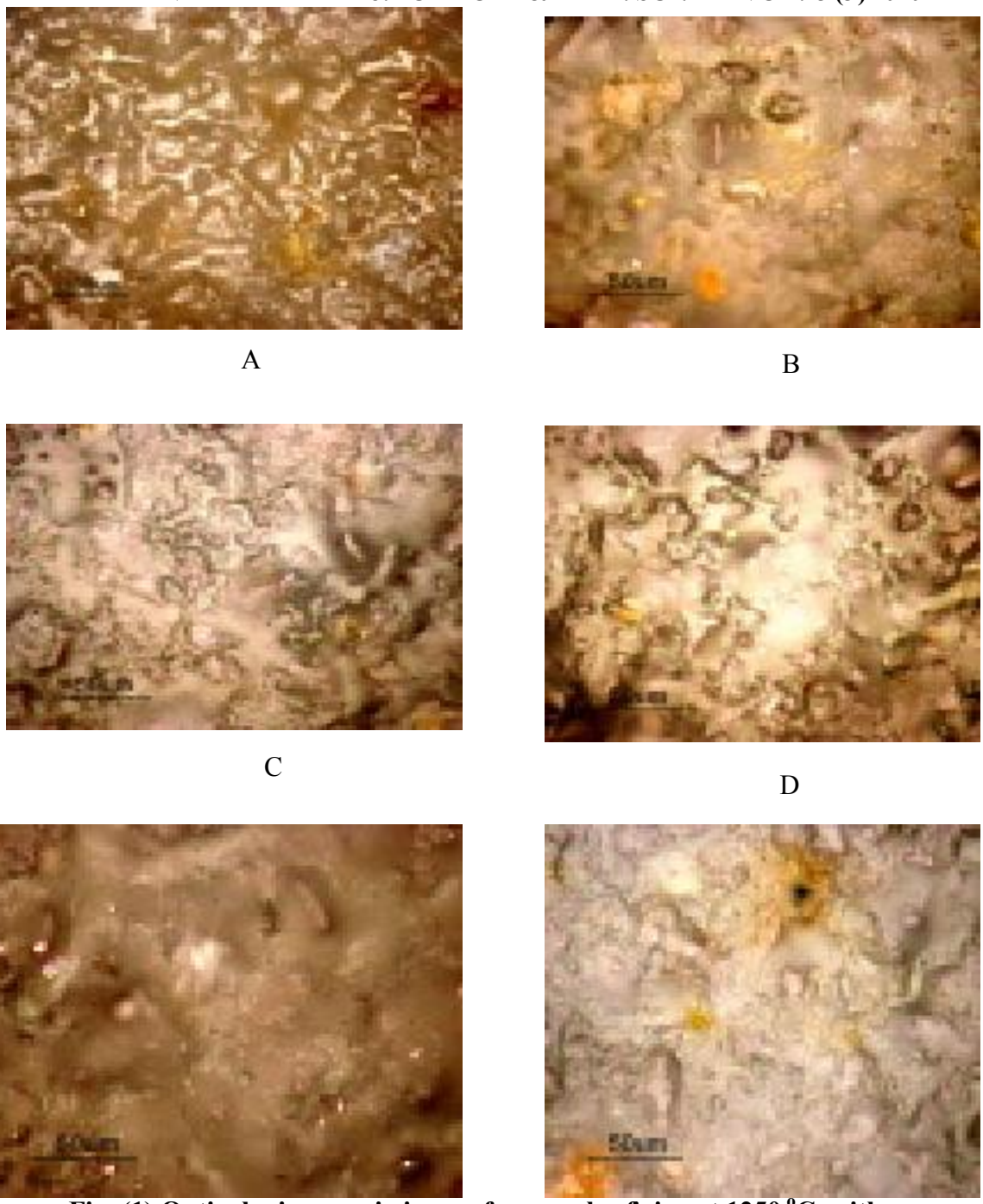
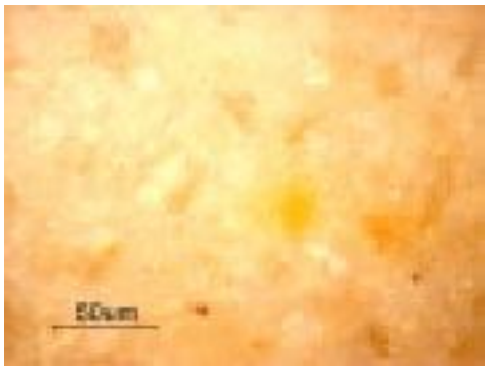
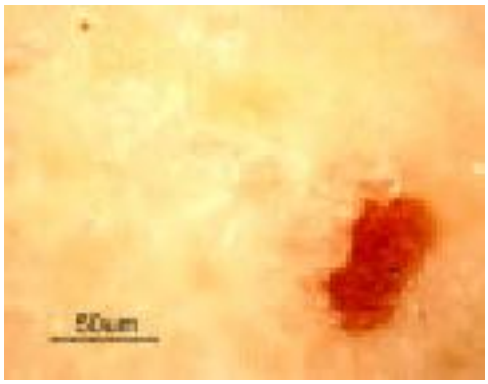


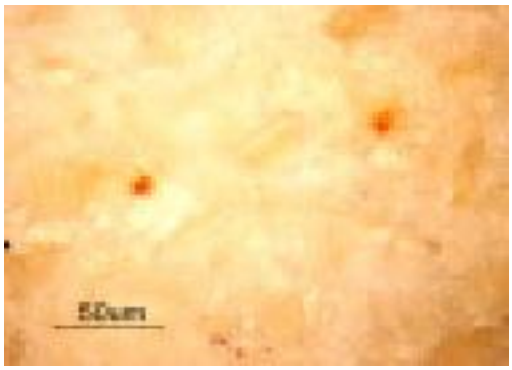
Fig. (1) Optical microscopic image for samples firing at 1250 ^{o}C with concentrations of sodium silicate show in table (1)



A1

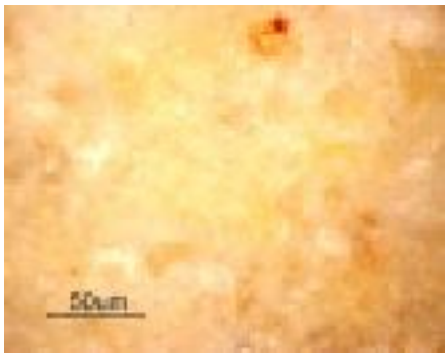


B1

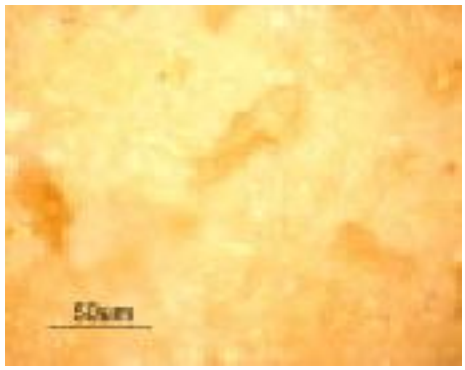


C1

D1



E1



F1

Fig.(2) Optical microscopic image for samples firing at 1350 ^{o}C with concentrations of sodium silicate show in table (1)

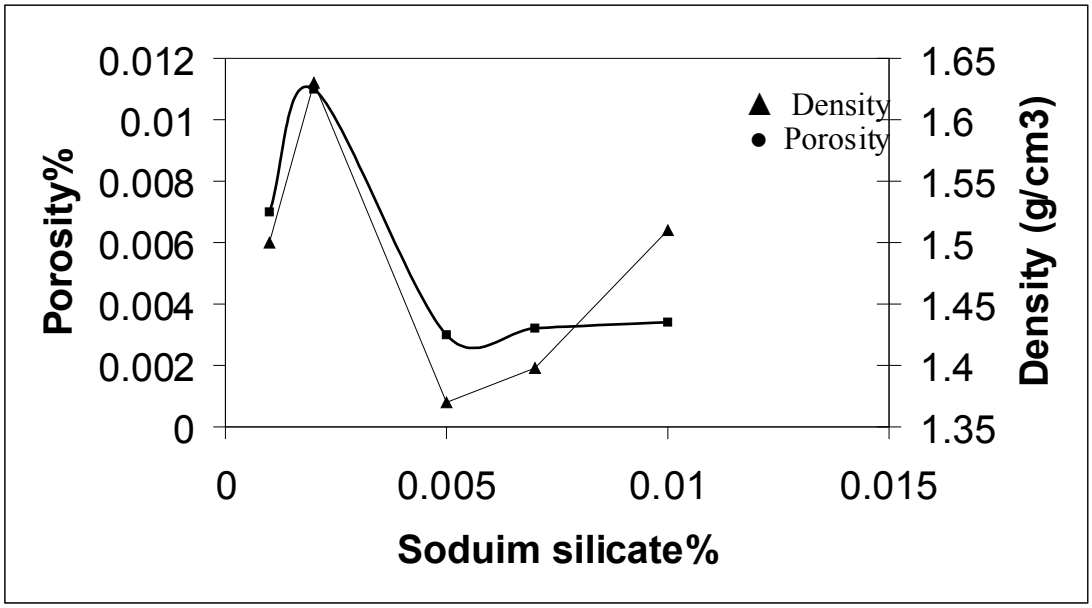


Fig.(3) The apparent density and porosity with concentration of sodium silicate for samples firing at 1350 °C

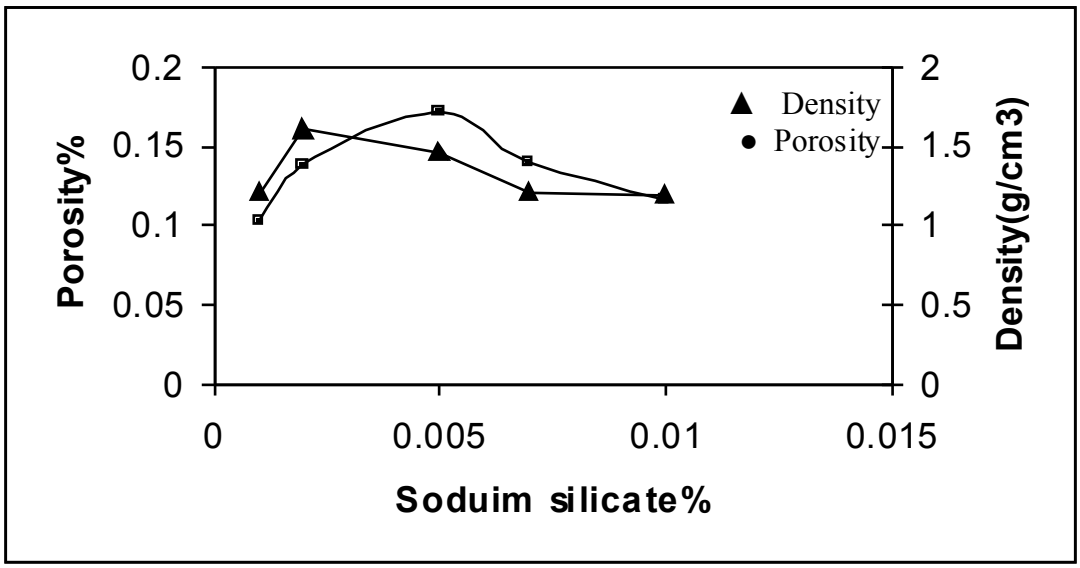


Fig.(4) The apparent density and porosity with concentration of sodium silicate for samples firing at 1250 °C