خصائص التقلص لجسم العازل السيراميكي البورسليني المشكل من مواد محلية

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الخلاصة

يهدف هذا البحث الى دراسة خصائص التقلص لجسم العازل السيراميكي ،وتأثير تغير نسب تركيز المحلول الإلكتروليتي في هذه الخصائص. جسم العازل الكهربائي حضر بأستعمال مواد عراقية محلية. هذه المواد هي :- كاؤلين دويخله،رمل زجاج أرضمه، فلدسبار وبنسب وزنية (45 %، 30% و 25%) على التوالي. تمت عمليات التصنيف ، والخلط، والتشكيل و الحرق خلال عملية خلط المحلول الالكتروليتي والمادة المعدنية التي تضاف بتراكيز مختلفة للمحلول الالكتروليتي (1% , 0.7%0.5%, 0.2% , 0.1%). المحلول الالكتروليتي حضر بخلط كاربونات الصوديوم وسليكات الصوديوم بنسبة(2/1) ، بينما المادة المعدنية ،أوكسيد الزنك ، تضاف بنسبة وزنية ثابتة.

القياسات أخذت لنماذج مستطيلة لبدت بدرجات حرارة تلبيد (1350،1300،1250) ْم. النتيجة التي حصلنا عليها انه لتركيزالمحلول الالكتروليتي (0.5%) اعلى تقلص كلي في (1350،1300) ْم وكذلك على اعلى تقلص حرق . وبذلك فان هذا التركيز هو الافضل لاعطاء المادة صفة العزل الكهربائي.

Shrinkage Properties of Insulator Ceramic Body Porcelain Formed Using Local Material

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Abstract

This work was carried out to investigate the shrinkage properties of insulator ceramic body, and the effect of changing the ratio of concentration of electrolyte solution on these properties. The electrical insulator body was prepared by using Iraqi local materials. These are :- kaolin Duakhla, Arudhuma Sand glass, and potash feldspar with weight percentage (45%, 25%,and 30%) respectively. The processes of milling, classification, mixing, forming and firing, through the process of mixing electrolyte solution and mineralizer were added at different concentrations for electrolyte solution, (1%, 0.7%, 0.5%, 0.2%, and 0.1%). The electrolyte solution was prepared by mixing sodium carbonate and sodium silicate by (2:1) ratio, while the mineralize, Zinc Oxide, was added at fixed weight percentage. The measurements were undertaken on rectangular sample burnt at sintering temperatures of (1250, 1300,and 1350) ^{o}C. The result was obtained at (0.5%) electrolyte solution concentration has highest total shrinkage at (1300,1350) ^{o}C sintering temperature and also highest firing shrinkage .So that, it is the best concentration to get material property of insulating.

Introduction

The structure and properties of crystalline ceramic material can be interpreted in terms of their complex structures and phase diagram because of their brittle behavior, they are normally manufactured into useful component by pressing moist aggregated or powders into shapes. Following by drying and firing. This permits the particles to shrinkage and sintering to become solid, the crystalline ceramics typically have high melting temperatures, high hardness and are suitable for many high - temperature or corrosion – resistant applications [1,2].

Kaolin has numerous industrial applications and new uses continued to be discovered. They are unique industrial applications and new uses including chemical inertness over a wide range of acid/alkaline conditions [3].

It has been shown that cracking resulting from shrinkage processes occurs especially if the material is homogenized and close to its saturation point[4]. The shrinkage process has been divided into normal shrinkage phase and residual shrinking phase[5]. Horn *et al* [6] showed normal shrinkage properties while compaction at water contents below the optimum resulted in residual shrinkage behavior. Bauer *et al* [7] and Wysocka *et al* [8] found that the shrinkage potential for Kaolin increased with water content during compaction.

Shrinkage processes

The major mechanical properties for ceramic insulator are the shrinkage processes. Shrinkage and drying are of profound concern to the structure clay products industry. Since clay minerals are responsible for shrinkage, the amounts percentage and their particle sizes determine the shrinkage potential, then the amount of water present in the plastic clay is proportional to, but not equal to shrinkage [2].

The values of liner firing shrinkage in the percent of shrinkage are due to variation in the size and shape of sample particle , the liner shrinkage is approximately proportional to the inverse of partial radius but is not greatly affected sintering time [9,10].

Electrolyte solution

Electrolytes are class of solid solutions that exhibit special behavior compared to non–electrolytes. The distinction arises both because electrolytes dissociate upon dissolution and because the ions produced interact through much large distances than uncharged solutions [11]. It is well known that many substances– inorganic salts in particular–dissociate to form ions in aqueous solutions. The most direct evidence of this is the large electrical conductivity of such solution; in fact, the solution is called electrolytes because it conduct electricity readily [12]. The electrical double layer is formed at interfaces of charged objects and electrolyte solutions composed of ions and solvent molecules [13]. The ions with the charge of the opposite sign than the charged object (counterions) are accumulated close to the charged object, while the ions with the charge of the same sign as the charged object (coions) are depleted from the vicinity of the charged object. Well known examples of planar electrical double layer are biological membranes, liquid crystals and metals in contact with the electrolyte solution [2,14] . Clay minerals have the property of sorting certain anions and cations, retaining these in an exchangeable state; i.e. they are exchangeable for other anions or cations by treatment with such ions in a water solution (the exchange reaction also takes place sometimes in a non -aqueous environment). The exchangeable ions are held around the outside of silica–alumina clay mineral structural units, and the exchange reaction generally does not affect the structure of silica–alumina clay packet. In clay minerals ,the common exchangeable cations are calcium, magnesium, hydrogen, potassium, and sodium, frequently in about that order of general relative abundance [15].

The aim of the work

One of additives, which are used in the produce of Porcelain bodies, is the electrolyte solution. Our study was carried out to optimize the required weight percentage of these additives to be applicable to Porcelain body, which is prepared from Iraqi local material, to be used as an insulator ceramic body from the study of the shrinkage properties.

Samples preparation

Samples were prepared with affixed percentage of raw material. 2%wt of Zinc oxide was added to the mixture followed by mixing for 2hours. A polyvinyl alcohol binder was prepared and applied with 1%wt for each group. The mixing process was done under heating (80 ^{o}C) until it gets a slurry form, and then dried at 70^{o}C with continuous mixing for 3 hours, until obtaining agglomerated powders.

Electrolyte solution preparation

Electrolyte solution is prepared by using Na_2CO_3 & Na_2SiO_3 by ratio 2: 1 respectively. From this mixture, we determine the amount of adding distilled water to obtain electrolyte solution with concentration 5 %. So the amount of distilled water added was 114 ml. Mixing 4 gram of Na_2CO_3 with 2gm of Na_2SiO_3 and solving these massed in 50 ml distilled water, with continues mixing process for half hour using magnetic stirrer (model (Great Britain, serial 11750)). After that we carried on adding distilled water to obtain a final volume 114 ml. The preparation of electrolyte solutions with the concentrations (1%, 0.7 %, 0.5 %, 0.2 %, and 0.1 %) from mentioned above 5 % done by using dilution equation given by [16]:-

$$M_i V_i = M_j V_J \qquad \text{---------- (1)}$$

Where M_i is the percentage of solution before dilution, Vi is the volume of solution before dilution, M_j is the percentage of solution after dilution, V_j is the volume of solution after dilution.

Sintering Processes

The final powder was milled for about one hour, and then sieved by using a sieve of size 250 μm. The sieved powders then were pressed by using press (model (38888.4D10A00, made in USA)), with pressure 7MPa for 5 min., a rectangular form of length 50mm. These samples were dried in a furnace at a temperature 70 ^{o}C for two hours. The prepared samples were burnt by a furnace (model (Hi 62, Ti7, 1700, Nabertherm)) by using different temperatures 1250, 1300, and 1350^{o}C, with sintering time 2 hr. and sintering rate 100 ^{o}C/ hr.

Shrinkage test:

The drying shrinkage, firing shrinkage and the total shrinkage were calculated for each test specimen by using the following formula stated in [17,18]:-

$$\%AverageDryingShrinkage = \frac{OL - DL}{OL} \times 100\% \quad .....(2)$$

$$\%AverageFiringShrinkage = \frac{DL - FL}{DL} \times 100\% \quad .....(3)$$

$$\%TotalShrinkage = \frac{OL - FL}{OL} \times 100\% \quad .....(4)$$

Where OL means Original Length, DL stands for Dry Length and FL is Fired Length.

Result and Discussion

The results obtained for the shrinkage tests are presented in table 1. The relation between drying shrinkage and concentration of electrolyte solution at different sintering temperatures (1250, 1300, and 1350) ^{o}C was shown in fig{3}. It shows that the behavior of curves at (1250 and 1300) ^{o}C is nearly similar. It reaches the maximum drying shrinkage at 0.2% concentration of electrolyte solution. While at 1350 ^{o}C the drying shrinkage reaches maximum at 0.5%. The large drying shrinkage indicates to some degree the plasticity of the mixture. So, the highest drying shrinkage led to absorb much water which in turn indicates fine mixture particles. This is in agreement with the work of B.I.Ugheoke *et al* [3].

The relation between firing shrinkage and concentration of electrolyte solution is shown in fig. {4}. At (1250 and 1300) ^{o}C, the firing shrinkage reaches maximum at 0.5% concentration. While 0.2% concentration of electrolyte solution represents maximum firing shrinkage at 1350 ^{o}C. Fig. {5} and table 1, show that at 1350 ^{o}C the sample of 0.5% concentration of electrolyte solution has the highest total shrinkage 30.667. The least total shrinkage of 20.833 was for sample without electrolyte solution. At 1300 ^{o}C, the highest value of total shrinkage was 28 at 0.5% concentration of electrolyte solution. While, at 1250 ^{o}C, the value of total shrinkage is changeable from lowest to highest at 0.01% concentration of electrolyte solution. The firing shrinkage indicates how fusible the mixture is. A high shrinkage normally means a lower melting point. The total shrinkage of refractory bodies tells us how much bigger we should make our moulds. From our study there is an agreement that temperature increases lead to higher shrinking of pores, which subsequently leads to disappearing of the many pores, the result of this is that less water is absorbed by moulds[8,18]. The behavior clearly shows that there is a highly variation and non– linear phenomena. This can be explained, because each group have the same percentage of the raw material (kaolin Duekhla, Aruthma Sand Glass and feldspar) impling to the ability of the results depending on the mechanism of reaction between $SiO_2 - Na_2O$, as shown in figures

{1} and, {2}. From all of the results, we can say that the highly porous structure of sample would make them suitable for back up insulation since the air which fills the pores acts as an insulator.

Conclusion

Based on the shrinkage properties of the samples tasted and analysed in this study, it can be concluded that the Porcelain which was preformed from local material is suitable for the production of insulating materials. From the result, that the samples with 0.5% electrolyte solution have the best result at 1300, and 1350 ^{o}C that have high total shrinkage.

References

1.Ewsuk,K. G. (1999)"Ceramic processing",Entry for Encycloped of chemical physics and physical chemistry, ,version 9;13-99.

2.Askeland,D.R. (1988)"The science and engineering of materials", Van nostrand reinhold international co. Ltd, Hong Kong.

3.Ugheoke,B.I.; Onche, E.O.; Namessau, O.N. and Asikpo, G.A. (2006)"Property optimization of Kaolin-Rice Husk insulating Fire- Briks", Leonardo Electronic Journal of Practices and Technologies, ISSUE 9, July-December, P.167-178.

4.Hartge, K.H. and. Horn, R. E.(1999)In fuchrung in die Boden physik, 3rd edition, Stuttgart,.

5.Junkersfeld ,L. and . Horn, R.(1997)"Variability of fixed water content on the example of soil aggregates", Z.Planzen Bodenk., 159:137-142.

6.Horn, R. and Stepniewski, W. (2004)" Modification of mineral liner to improve its long term stability", Int. Agrophysics, 18 : 317-323.

7.Bauer, B. and Taubner, H. and Tippkoetter,R. (2001)"Measurement of mechanical and hydraulic compression susceptibility of clay substrates with an improved proctor test", Wasserund Boden, , 53:27-30.

8.Wysocka,A. and Stephiewski,W. and Horn,R. (2006)"Shrinkage properties of three clay materials at different temperatures", Int. Agrophysics, , 20:255-260.

9.Petrzzelli,G. and Guldi,G. and Sequi,P. (1976)"Electro-Optical measurement of clay shrinkage", Clay minerals, , 11:81-84.

10. Norsker, H. (1987)"The self reliant potter: refractories and kilns", Vieweg& Sohn.

11. McDonald ,J. A and . Rennie, A.R. (1995)Progress in colloid and polymer science, , 98:75-78.

12.Berry, R.S. and Flynn, G.P. (1995)"Physical chemistry" by John Wiely &Sons, Inc. New York.

13.Bohinc,K. (2003)"Effect of ion size in planar, cylindrical and spherical electrical double layers", , 10(4):167-171.

14.Mclaughlin,S. (1989)"The electrostatic properties of membranes, Ann. Rev. Biophys. Chem, , 18:113.

15.Grim,R. (1962)"Applied clay mineralogy"McGraw-Hill book company, Inc. NewYork and lLondon.

16.Skoog, D.A. and West, D.M. (1986) "Analytical chemistry and introduction", , 4th edition, by CBS college publishing, Chicago.

17.Chesters, J.H. (1973)"Refractories: Production and properties,Iron and Steel institute", , London, P.P.24-25.

18. Onche, E.O. and Ugheoke,B.I.and Lawl, S.A. and Dickson,U.M. (2007)"Effect of rice husk and diatomite on the insulating properties of Kaolin-Clay firebriks",

Leonardo Electronic Journal of Practices and Technologies ISSUE 11, July-December, P.P.81-90.
19- Grimshaw,R.W. (1971) "The Chemistry and Physical of Clays and Allied Ceramic Materials"4th by Rex, W. Grimshaw

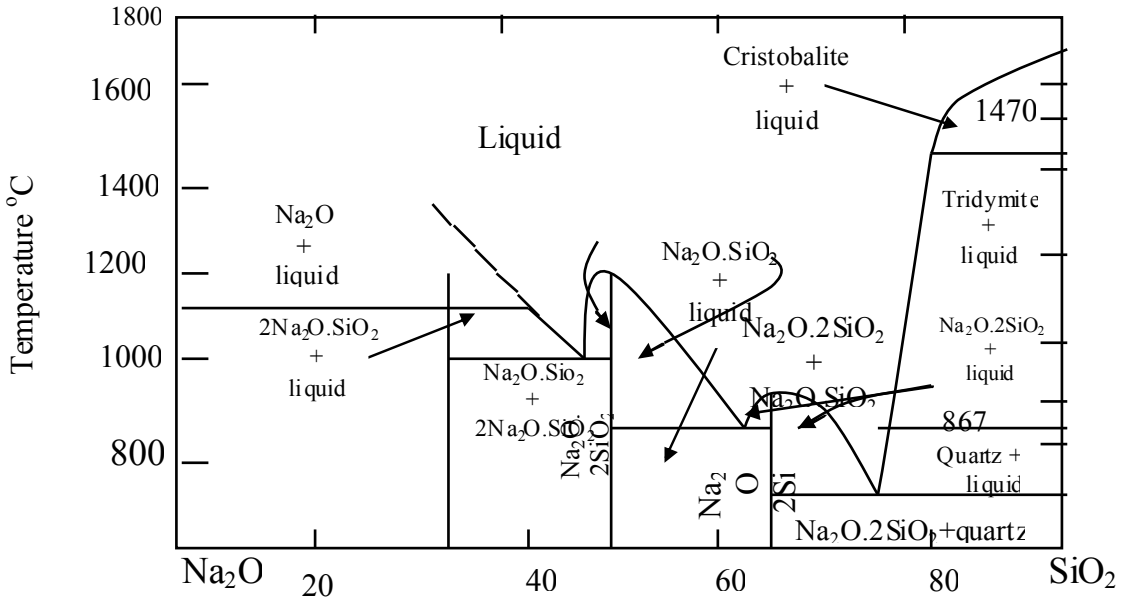

Fig.(1):The Sodium oxide / silica phase diagram.[19]

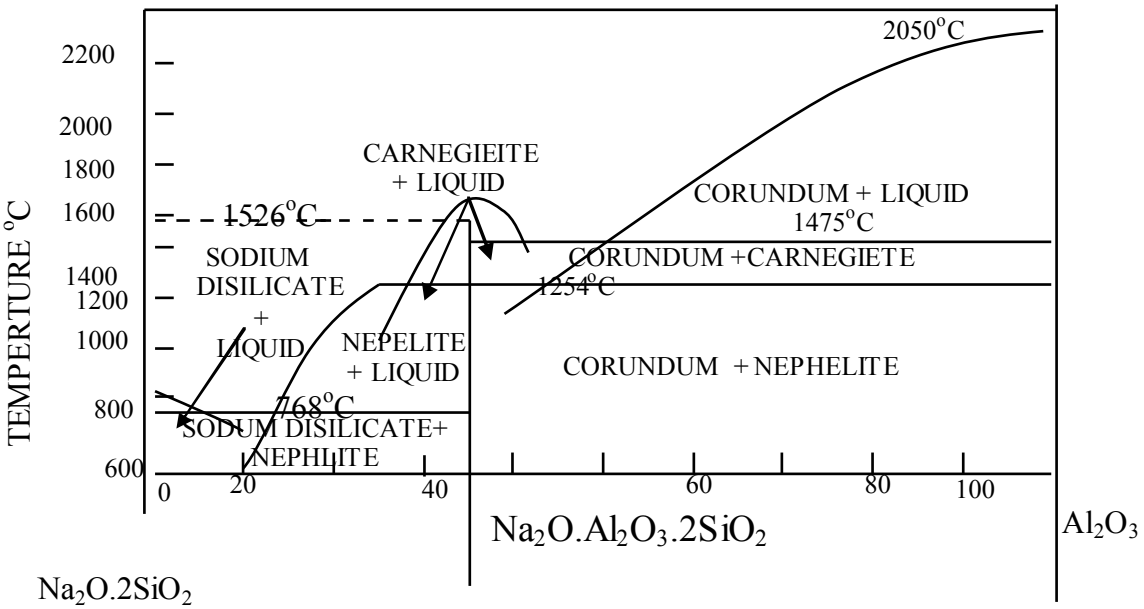

Fig. (2): The phase relationships between Sodium Disilicate and Corundum[19].

Table (1).The result of shrinkage tests

Concentration of electrolyte solution	Length of samples							Shrinkage of sa				
	Original state	1250°C		1300°C		1350°C		1250°C			1300°C	
		Drying state	Firing state	Drying state	Firing state	Drying state	Firing state	Drying state	Firing state	Total state	Drying state	Firing state
0	6	4.87	4.64	4.75	4.62	4.89	4.75	18.833	4.723	22.661	20.833	2.7368
0.1%	6	5.4	4.68	5.6	4.64	5.16	4.63	10	13.33	22	6.6667	17.143
0.2%	6	5.1	4.69	4.6	4.57	5.7	4.69	15	8.039	21.833	23.333	0.6522
0.5%	6	5.63	4.9	5.4	4.32	4.54	4.16	6.1667	12.97	18.333	10	20
0.7%	6	4.54	4.49	5.4	4.48	5.2	4.59	24.333	1.101	25.167	10	17.037
1%	6	4.58	4.4	4.7	4.62	4.76	4.32	23.667	3.93	26.667	21.667	1.7021

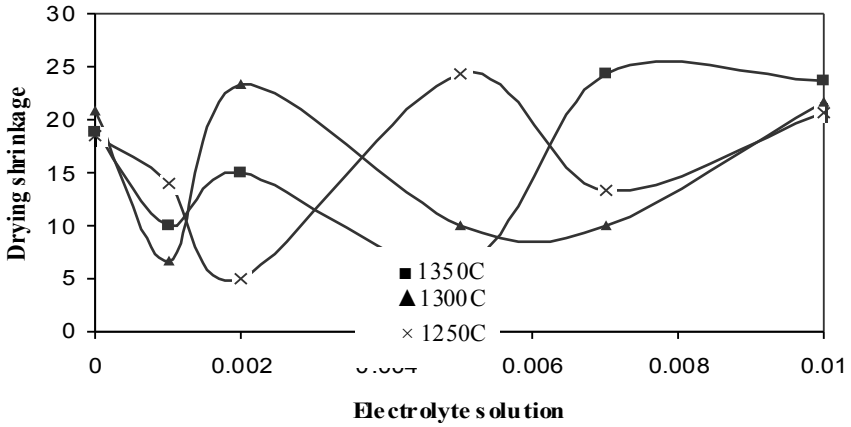

Fig. (3)The change of drying shrinkage with concentration of electrolyte solution

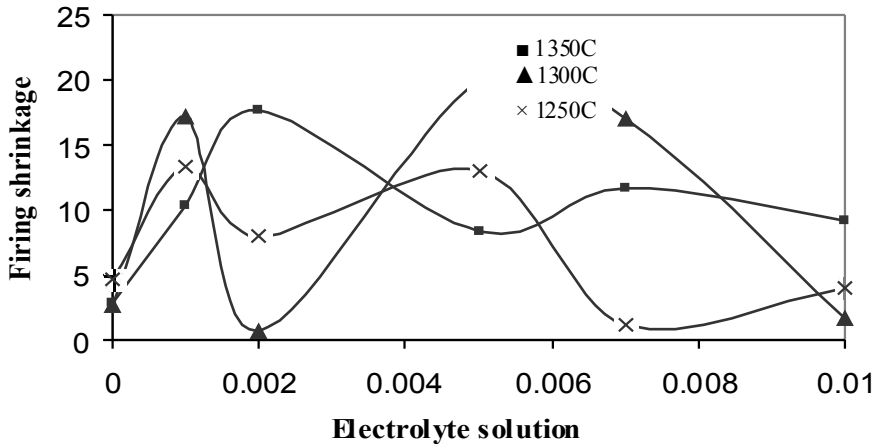

Fig.(4):The change of firing shrinkage with concentration of electrolyte solution

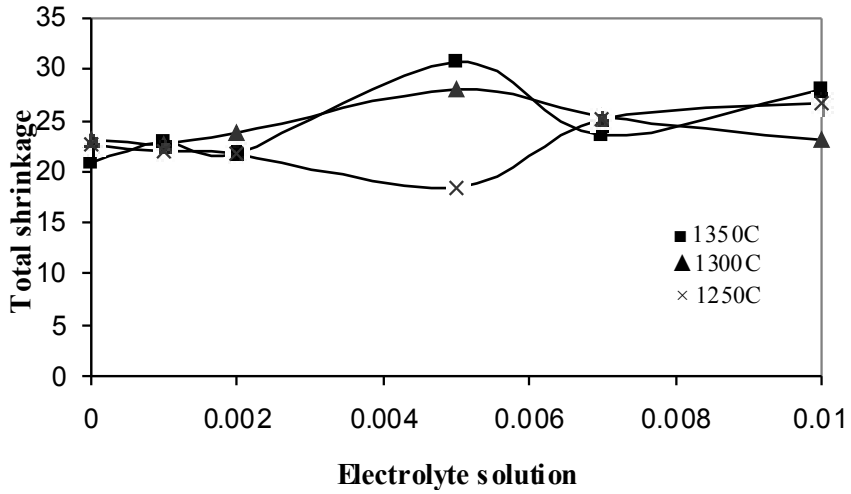

Fig. (5):The change of total shrinkage with concentration of electrolyte solution