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Improving physical properties for insulator ceramics using local materials

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Kaolinitic claystone, silica sand, and Bauxite are used to produce the raw materials, with additional locally available materials being added. Also utilized are Pura Silica, Rice husk ash produces Silica, as well as $MgCo_3$, and $Mg(OH)_2$. The raw materials listed earlier are pulverized and crushed into a size of lower than 45 microns. The raw materials underwent physical and chemical analysis. The samples are dryers add fired in 1300,1350,1400 and 1450°C according fire program 50°C /hour in socking time 2 hours. Physical evaluated tests are done to the samples. From the results of these testes, we saw that 1300°C firing temperature is not enough to get the sintering between mullite and the addition of cordierite. The evaluations given by the samples fired in 1400°C are the most favorable. Samples that fired in 1450°C have not good physical, specifications because the samples containing 50%, 60% and 70% cordierite are melted. Samples containing 30% and 40% cordierite are the best in our current study because they have good physical specifications, their mixtures could be used in production Ceramic insulators.

Keywords: Cordierite, Mullite, Ceramic, Bauxite, Physical Properties, Local materials.

1. INTRODUCTION

The main ingredients of porcelain are minerals like kaolinite, ball clay, feldspar, and quartz., which is a highly important composite ceramic. Porcelain is mostly made from Kaolin, despite clay minerals making up only a small portion of the total. Porcelain's composition can be very varied, but kaolinite, a mud mineral, is commonly a crude material [1-3]. When not fired, clay serves the function of providing malleability that Maintains its shape and serves as a binding agent for others components [4-6]. Fabrication takes place during sintering at between 1200 °C and 1400 °C. Porcelain, unlike other ceramics materials, is known for its Good thermal stability, high mechanical strength, and a high dielectric constant are unique properties. It stands out from other ceramic composite materials due to its The electrical conductivity is low and the resistance is high [7-10]. The speed at which porcelain-based materials, have been developed in everyday life all over the world has increased over the past decade, such as stoneware tiles, The superior mechanical properties and stylish execution of Construction of buildings, photoelectric supports, and dielectric. make them better than other ceramics items. It's environment-friendly because it doesn't cause pollution, and it's inexpensive because it's readily accessible [11-12]. In engineering, the use of porcelain and other ceramic materials have a plethora of application, particularly in ceramic engineer. In outdoor applications, porcelains are an exceptional High voltage requires the use of insulating materials, specifically brushes for power transformers and high-voltage cables and Providing insulation for high-frequency antennas, etc. Tiles or large rectangular panels are common structural materials made of porcelain [13-15].

The dimensions of a crystal structure that is orthorhombic a=7.5456, b=7.689, and c=2.88 is formed by mullite that has ($3Al_2O_3.2SiO_2$) as its chemical structure. Its metallic traits include colorlessness, The density is 3.2 g/cm^2, the specific weight is 3.03, and the hardness is 7.5 on the Mohs's hardness chart. Mullite's high strength is attributed to its needle shape [16]. Magnesium and aluminum silicate compose, The (MgO-SiO_2-Al_2O_3) system is present in Cordierite ($2MgO.2Al_2O_3.5SiO_2$). 13.8% is composed of MgO, 34.8% is composed of Al_2O_3, and 51.4% is composed of SiO_2% [17], as show in Fig. 1. The hardness of cordierite ranges from 7 to 7.5 and it has a specific weight of 2.3. The hardness of cordierite ranges from 7 to 7.5 and it has a specific weight of 2.3. Three types of cordierites are available at low temperatures. Upon crystallization, it forms -cordierite, which is also known as low temperature orthorhombic cordierite. As temperatures increase, it changes into -cordierite. Hexagonal high-temperature cordierite, also known as Indialite, is a mineral that has a hexagonal structure. Cordierite's -cordierite is another unstable phase that can be crystallized using either melt or fine materials. At temperatures of up to 1460 °C, cordierite can be formed by melting incongruously, resulting in mullite and glass [18-19].

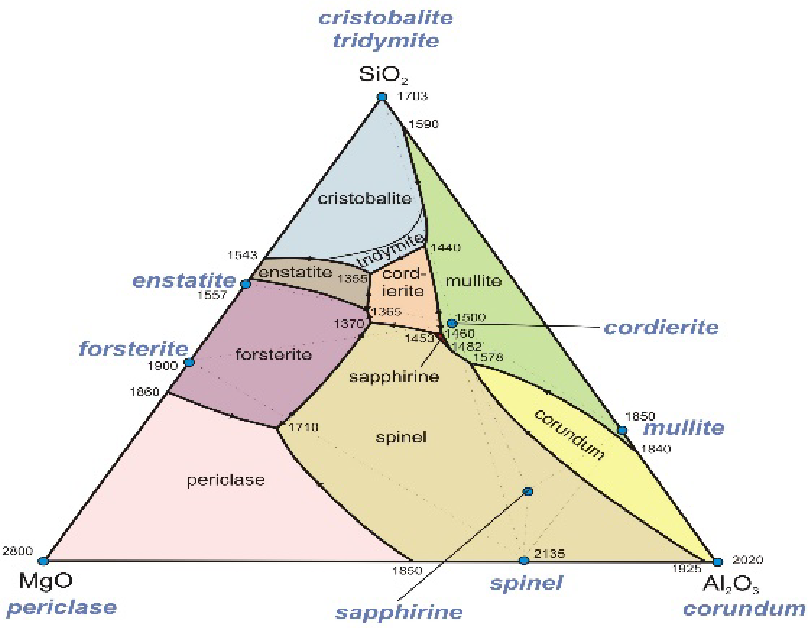


Figure 1 Silica-alumina-magnesia system [20].

2. MATERIALS AND METHODS

2.1 Preparation of the Mixes

2.1.1 Steps to prepare mullite metal

For mullite metal ($3Al_2O_3.2SiO_2$) Mixing is configured with weight (1kg) Consisting of (91% bauxite, 9% silica from burning rice crusts, 0.5% $MgCO_3$), Ingredients (bauxite and silica are mixed from Burning rice crusts) and ground dryly previously and well and passed from sieve (1mm); So, for the best homogenization. Grinded for (5) hours using a grinder Porcelain balls, the ratio of weight of porcelain balls to the weight of the mixture (1500g: 500g), then added magnesium carbonate ($MgCO_3$) by 0.5% (as mineral material) to the mixture, then blended well and re grinded for (5) Other hours, after the completion of the grinding process moisturized the mixture by adding water to it by 8%. then put in a nylon bag and closed tightly and left for more than (24 hours); To completing moisture homogenization in the mixture.

2.1.2 Steps to Prepare Cordierite Metal

Use both white kaolin and silicon sand folds in two beloved sizes: (45 microns or 25 microns). The rest of the raw materials are used the size of one sweetheart is (45 microns), after completing the weighing process for the components of each of the previously ground raw materials, they are well mixed, then each mixture is milled separately by the porcelain ball mill and for a period of time (5) hours, and moisturized each mixture separately by adding water to it by (8%), and re-grinded again for (5) hours. After completion of the grinding process, each mixture is consistently homogenized by the grinded sieve (2 mm) and then sieve (1 mm) and kept in nylon bags tightly for 24 hours for the purpose of completing moisture homogenization.

2.2 Forming of Samples

Formed sample in the form of cylindrical tablets with diameter (4cm) and thickness (0.5cm), weight (8g) per sample, using a single axis hydraulic piston type (HERZOG) and by shedding pressure of 1000kg/cm2; So, to get higher Convergence of granules facilitating the process of sintering and the acquisition of chemical reactions Granules with each other during the burning process, as well as to reduce longitudinal contraction [21].

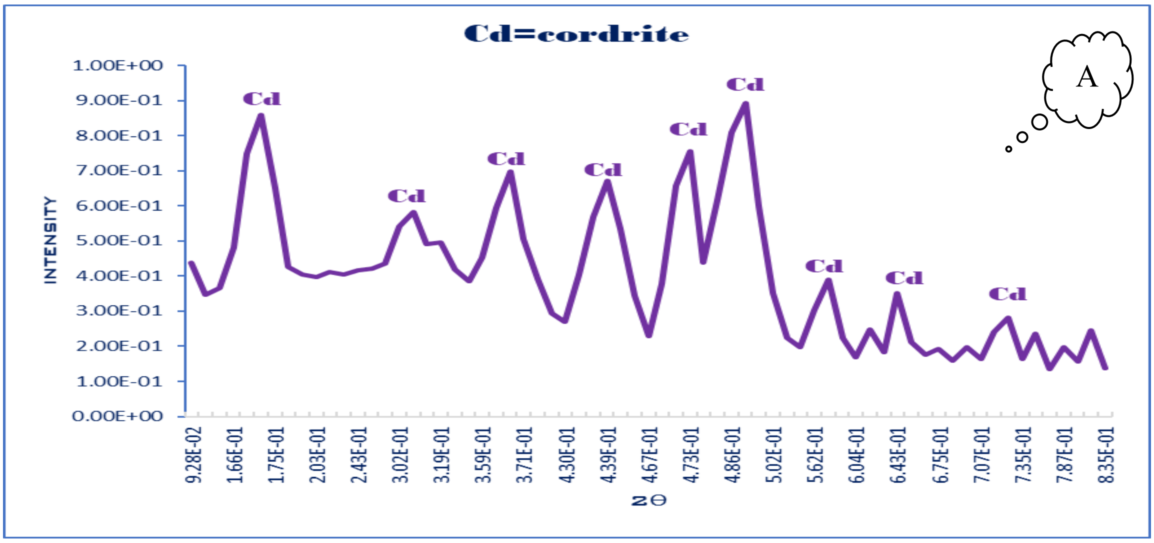
2.3 Drying and Firing

The samples are drained at a temperature of 105°C and for a period of 24 hours; To remove water Addendum; To perform the formation process slowly, so that no cracks occur as a result of the contraction Sudden, which may occur if water is quickly expelled during the burning process; the samples are then burned at a temperature of (1300°C) by oven mediation Electrician at the rate of temperature increase is (50) per minute and mature time is 2 hours. By closing off the furnace, the metallic phases will have ample time to react and crystallize. The ceramic body's strength and toughness is attributed to the physical and chemical processes that occur during the firing stage, which is considered the most difficult and significant stage.

3. RESULTS AND DISCUSSIONS

3.1 Cordierite and Mullite Preparation

The first stage of the research project involved the preparation of Raw materials obtained from Iraq are used to make cordierite and mullite ceramics. Fig. 2 presents The pattern of x-ray diffraction in mullite and cordierite. A porcelain ball crusher is used to crush Mullite and cordierite separately, then each powder is sieved with a 45µ-degree sieve, before being stored in bags secured with nylon.



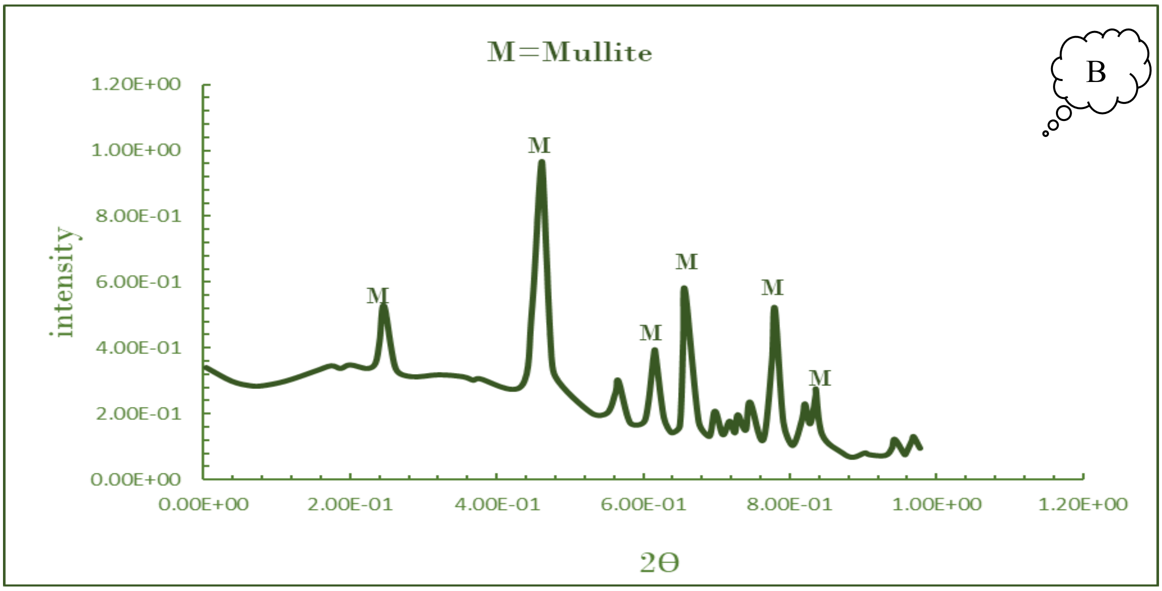


Figure 2 X-Ray Diffractograms (A) Cordierite and (B) Mullite.

3.2 Physical Properties (Volume shrinkage)

Table 1 and Fig. 3 shows Five groups can be identified for volume shrinkage tests on samples fired at 1300, 1350, 1400, and 1450 °C: A, B, C, D, and E. Figure 3 shows the relationship of volume contraction with the constant change in burning temperatures of cordierite metal additives, and based on these ratios the study samples can be divided into five groups: (A), (B), (C), (D) and (E). The results showed that the samples of all these aggregates, characterized by the relatively low volumetric diminishment of their samples when burned at a temperature. (1300°C), where it is between (6.26-5.51%) because of the burning temperature (1300°C) is the grade used in the current study to prepare cordierite metals and mullite main components of the samples, resulting in no sinter process (Sintering), in addition the non-emergence of the liquid glass stage between the grains of the minerals that works to bring them closer together.

And when the burning temperature of the two groups' samples (A) and (B) From (1300-1400°C) an enhance in the rate of volumetric contraction of its samples is observed, ranging from (6.26-12.00%) For group samples (A), and between (6.20-11.90%) for group samples (B), and with high burning temperature to (1450°C) A small decrease in the volume contraction rate of the two groups' samples is equal to (11.00%) for group (A) samples, and equal to (11.53%) for group (B) samples; This is due to the fact that as the burning temperature rises to more than 1350°C, the synthetic structure of the cordierite metal begins to break down and partially help the sintering process, as does the appearance of the liquid glass phase, which reduces and blocks the pores; This increases the volume contraction of ceramic samples.

Table 1 Volume shrinkage values for samples fired at 1300, 1350, 1400, and 150 °C.

Sample	Firing temperature °C			
	1300	1350	1400	1450
A	6.26	11.97	12.00	11.00
B	6.20	11.80	11.90	11.54
C	6.15	11.68	11.62	12.00
D	6.00	11.49	11.43	14.32
E	5.51	11.09	12.12	15.40

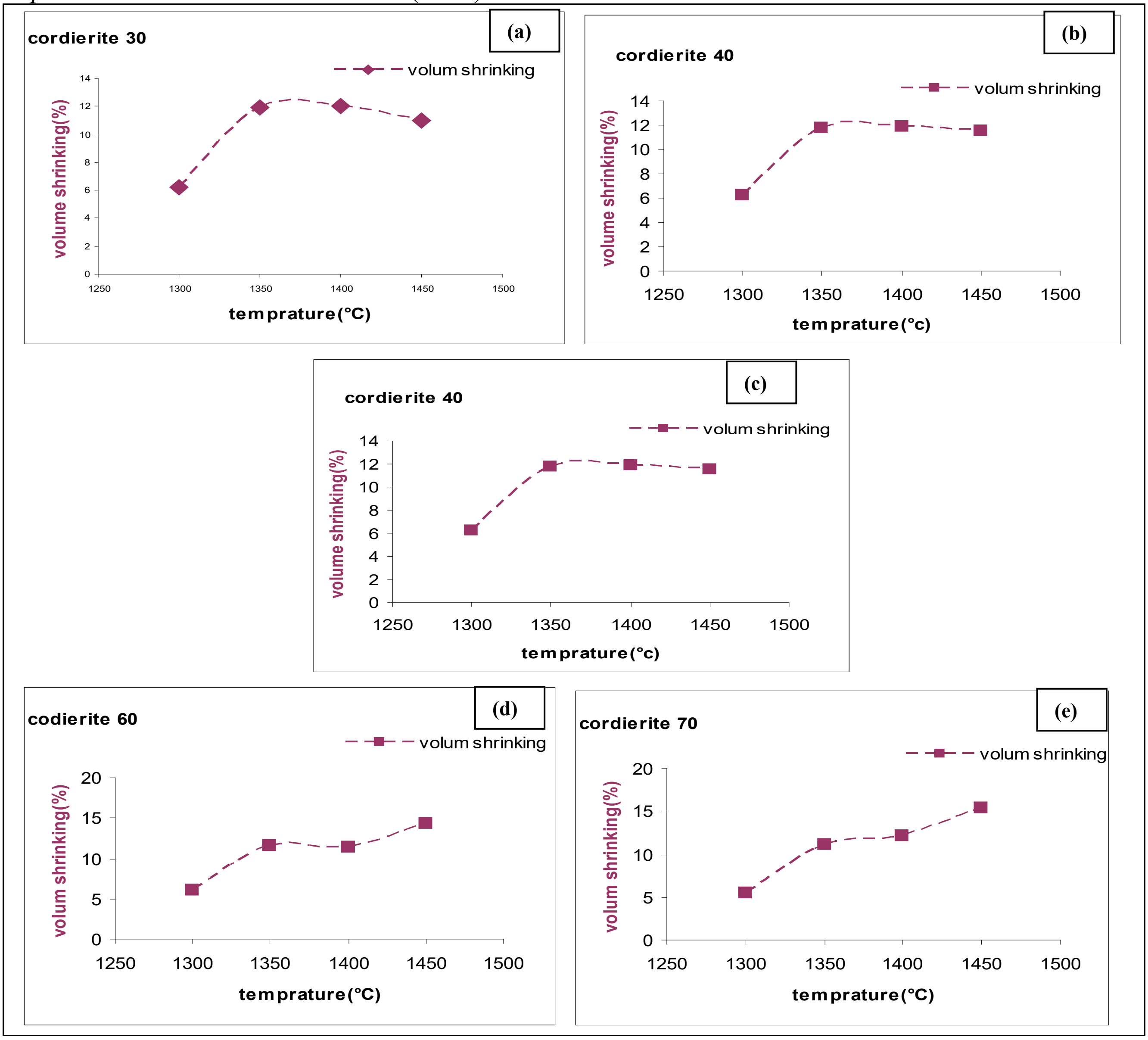


Figure 3 (a), (b), (c), (d) and (e) Show Shrinkage with the firing temperature change.

3.3 Apparent Porosity and Water Absorption

Fig. (4), Table 2, and Table 3 Presents the correlation between water absorption and apparent porosity at various firing temperatures, with the percentage of cordierite remaining constant. Note that all samples of aggregates (A), (B) and (C), (D) and (E) containers on (30, 40, 50, 60 and 70%) Cordierite metal, respectively, when the burn temperature rises from (1300-1400 °C). High and abrupt reductions in phenomenal porosity and water absorption of total samples (A), (B) and (C) are observed, ranging from (22.30-2.03%) to (9.86-0.90%) respectively for group A samples and between (22.42-2.03%) and (10.05-1.05%) respectively for group B samples and between (22.61-2.44%) and (10.46-1.10%) for group C samples. Then it is observed that there is a small increase in the apparent porosity and water absorption of the above group samples with an increase in burning temperature to (1450°C) which is equal to (2.42%) and (1.20%) respectively for group samples (A), equal to (2.42%) and (1.25%) respectively for group samples (B). This is attributable to the fact that, as the burning temperature of the above collections' samples increases in convergence of granules due to the sintering process, as well as the effect of the liquid glass phase factor, which fills the pores in the ceramic samples causing a decrease in their ratio [22,23], and the decrease in porosity will directly result in a decrease in the water absorption ratio. With a high burning temperature of 1450 °C, the cordierite metal begins to fuse; This causes an increase in the proportion of pores (closed and open); This directly increases the proportion of water absorption of samples.

Groups (D) and (E) have a high decrease in phenomenal porosity and water absorption with increased burning temperature from (1300-1450°C) ranging from (23.11-2.15%) to (11.39-1.02%) respectively for group (D) samples and between (24.15-2.00%) and (11.71-1.02); This is due to the increased convergence of granules due to the process of sintering, as well as the appearance of the liquid phase (Cordierite glass + glass), which fills the pores and reduces their proportion, and then exposes them to vitrification at high temperatures, which increases surface tightness and reduces apparent porosity, directly resulting in a decrease in water absorption.

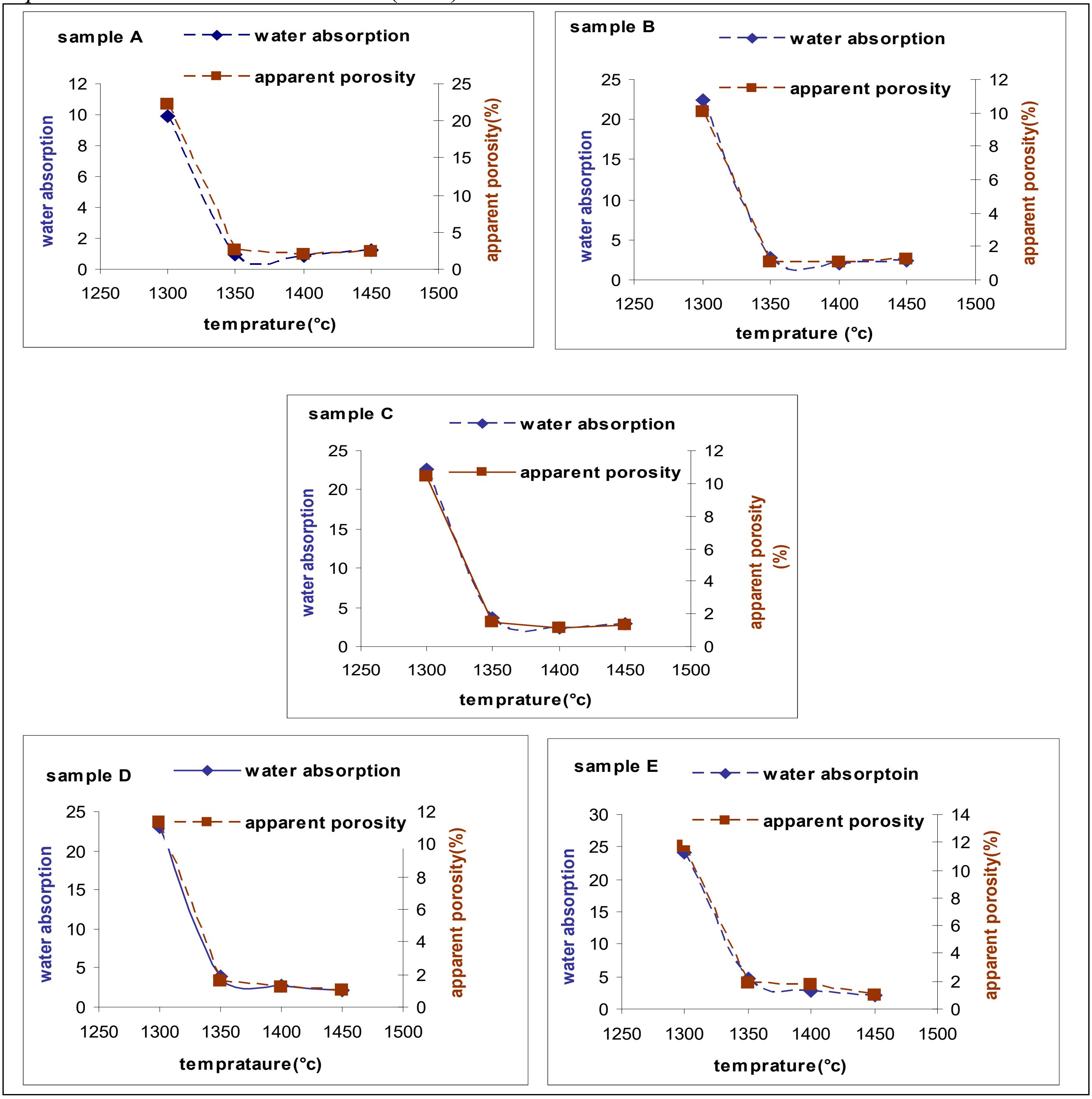


Figure 4 (A), (B), (C), (D) and (E) Show Water absorption and apparent porosity.

Table 2 Water absorption values for samples fired at 1300, 1350, 1400, and 1450 °C.

Sample	Firing temperature °C			
	1300	1350	1400	1450
A	9.86	0.98	0.90	1.20
B	10.05	1.05	1.05	1.25
C	10.46	1.46	1.10	1.31
D	11.39	1.56	1.19	1.02
E	11.71	1.87	1.71	1.02

Table 3 Apparent porosity values for samples fired at 1300, 1350, 1400, and 1450 °C.

Sample	Firing temperature °C			
	1300	1350	1400	1450
A	22.30	2.63	2.03	2.42
B	22.42	2.76	2.03	2.42
C	22.61	3.73	2.44	2.86
D	23.11	3.90	2.75	2.15
E	24.15	4.73	2.90	2.00

3.4 Bulk density

Table 4 and Fig. (5) The bulk density tests for samples fired at 1300, 1350, 1400, and 1450 °C are shown. Each sample can be divided into five groups: A, B, C, D, and E. Fig. 5 shows the total density relationship with flaring temperatures constantly changing the added proportions of cordierite metal. Note that all samples with code (A), (B), (C), (D) and (E) are characterized by a gradual increase in the total density of their samples with an increase in the burning temperature from (1300-1400°C) ranging from (2.25-2.69g/cm3 for samples (A) to (2.25-2.6gm)/cm2, -2.55g/cm3) for (D) samples, and between (2.05-2.58g/cm3) for (E) samples.

This is because as the burning temperature rises to more than. (1350 °C) The synthetic structure of the Cordierite metal begins to break down (tilting), and this works for the sintering process. (Sintering) between cordierite metal granules and mullite metal main components of samples, in addition to boosting the quantity of liquid glass phase. Some of the pores in those samples are sealed by cordierite glass. (Depends on the ratio of cordierite metal in the samples), depending on the quantity of the glass substance formed which in turn depends on the quantity and type of ingredients of the burning substance, the size of its granules and the degree of burning. [24-27]. The liquid glass phase hardens when these samples are cooled, connecting the granules to each other, reducing their porosity, increasing the total density of the samples, and increasing the burning temperature to 1450 °C for total samples (A), (B), (C), (D) and (E). There is a decrease in the total density of the above total samples, which is equal to. (2.49 g/cm3) for group samples (A), (B) and equal (2.18 g/cm3) for group samples. (C), equal to (2.09 g/cm3) for the samples of the two groups (D), equal to (1.95 g/cm3) For E samples, this is due to the fact that at burning temperature. (1450 °C), increased cordierite metal ratios in samples from (30-70%) The number of pores increases. (Open and closed) resulting from cordierite metal melting, the quantity of liquid phase. (Cordierite Glass and Glass) is insufficient to fill all of these pores, increasing the porosity of the samples resulting in a decrease in their total density; Therefore, the lowest value for the total density of the study samples is for samples containing (70%) cordierite metal burned at a temperature of (1450 °C).

Table 4 Bulk density values for samples fired at 1300, 1350, 1400, and 1450 °C.

Sample	Firing temperature °C			
	1300	1350	1400	1450
A	2.25	2.66	2.69	2.49
B	2.25	2.60	2.69	2.49
C	2.15	2.55	2.60	2.18
D	2.11	2.55	2.55	2.09
E	2.05	2.46	2.53	1.95

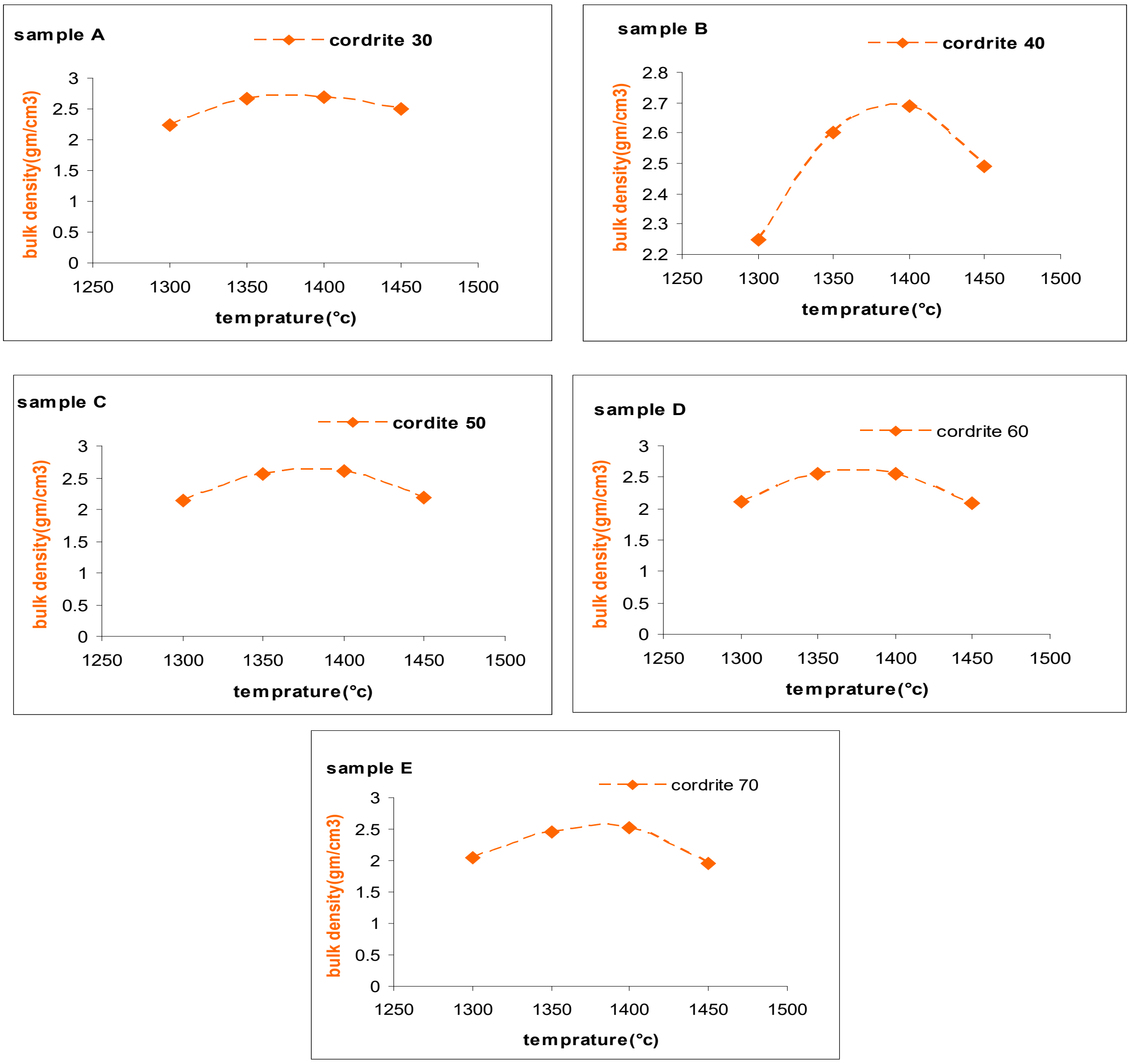


Figure 5 (A), (B), (C) (D)and (E) Show bulk density with the firing temperature change.

4. CONCLUSIONS

1. At a temperature of 1450 °C, the burned samples exhibit an Volumetric shrinkage increases, porosity decreases, and water absorption decreases.
2. Increase the burning temperature to 1450 degrees Celsius if the percentage of cordierite in the samples stays the same. According to the samples, there was a drop in apparent porosity and water absorption, a rise in the density, and a decrease in volumetric shrinkage ratio.
3. The physical properties of the samples may be compromised using cordierite that is in the range of 50, 60, and 70% in the samples.
4. The samples' physical characteristics can be improved mullite can be burned at temperatures of 1350 and 1400°C by adding 30% and 40% cordierite to it.

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