Improvement of the Mechanical and Dielectrical Properties of Kaolin Clay

Jassim Mohammed Yaseen
University of Mosul / College of Base Education

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Abstract:

This paper examines the influence of certain additives such as Sawdust ,CaO and quartz have been added with different proportions on Hardness and compression strength of the local kaolin .In general ,the additives used have increased the hardness and compression strength . The quantitative and qualitative analysis of the local kaolin before and after treatment with HCl acid solution was achieved using XRF technique . It has been found that the treatment of kaolin with HCl acid solution reduces the concentrations of Fe2O3 and alkali metals ,thus improving the dielectrical properties .

تحسين خصائص الميكانيكية والعزل الكهربائى لطين الكاولين

جاسم محمد ياسين
جامعة الموصل – كلية التربية الأساسية

ملخص البحث:

في هذا البحث تم دراسة تأثير بعض المضافات مثل نشارة الخشب وأوكسيد الكالسيوم CaO والكوارتز وبنسب مختلفة في خاصيتي متانة الانضغاط والصلادة للكاولين المحلي المستخدم. بشكل عام ادت هذه المضافات الى زيادة متانة الانضغاط والصلادة .كذلك تم اجراء التحليل الكمي والنوعي للكاولين المحلي قبل وبعد معاملته بمحلول حامض HCl باستخدام تقنية XRF . ان معاملة الكاؤلين مع محلول حامض HCl ادى الى تقليل تراكيز كل من Fe2O3 والمعادن القلوية مما ادى الى تحسين خواص العزل الكهربائي للكاولين.

Introduction

Kaolinate, the main constituent of kaolin,is formed by rock weathering.It is white, grayish_white,or coloured[1].The chemical formula of kaolinate is $Al_2O_3.2\ Si\ O_2.2\ H_2O$. Kaolin is a plastic raw material, crystal material having plane ,hexagonal crystals in grain size about (1-10 um) [2,3] All types of clays are used in many important industries in our life ,therefore many scientist and researchers were studied the subject of improving the different properties of clays . Most earlier studies treated the mechanical properties of clays under conditions before firing(wet, dry) [4,5,6]. Other studies treated the effect of adjusting the PH on sedimentation of kaolin minerals [7]. Reinforcing of clays was achieved by using fibers [8] . In this work , our aim was to improve the mechanical properties of kaolin using many types of reinforced materials to improve the ceramic industry in our country. In addition to that , we worked to improve the dielectric properties of kaolin by reducing the concentrations of iron oxide in kaolin . The ceramic industries have developed significantly because the ceramics have distinct properties not found in other materials and the industry of clay products is one of these industries, especially the clay brick in which suffers from many problems in Iraq .Fortunately, Iraq contains a variety of raw clays which compare favorably with those in china .

Experimental

A- Preparation of samples to mechanical properties

The used kaolin was grinded to fine powder by using agate grinding machine type (FRITSCH).Then groups of samples were prepared as following:

1- group of sawdust added to kaolin powder in three ratios (1,2,5 wt%). Big, small pieces of wood were eliminated from the sawdust, then it was Grinded to fragments in (0.1 mm) thickness , (0.5—1mm) length.
2- Group of calcium oxide, added to kaolin in three ratios (1,2,5 wt %).
3- group of quarts powder , added to matrix of kaolin in three ratios (1,3,6 wt %).

In all above groups, samples were prepared by using wet ,dry mixing to mixture of (kaolin –additives) by using electrical mixer for (48 hr) .Then, these Samples were pressed to discs in diameters and thickness between (2 -4 cm) ,(0.4—0.8 cm) by using hydraulic press with pressure (11 MN/M^2) after treated with distilled water .Then these discs sintered in electrical furnace at (1100 C) for (2 hr).

The mechanical properties tests were achieved in the control assurance office and the hardness was achieved by using vickers method .

B- Kaolin –HCl acid solution process .

Apart of used kaolin was immersed in diluted HCl acid solution (20 %) by using glass container (5 liter) for (7 days) .

After that, the HCl acid solution with dissolved substances were shed without residual kaolin . The residual kaolin was immersed again in diluted HCl acid solution (20 %) for (14 days) After that ,the HCl acid solution with dissolved substances were shed without residual kaolin . The residual kaolin was washed by distilled water several times to remove the HCl acid and the produced salts .

Afterwards , the washed kaolin was dried in (60 C) for (2 days) by using electrical oven.

C- Quantitative ,qualitative analysis .

HCl acid treated kaolin , crude kaolin were made the quantitative , qualitative analysis by using XRF technique (TWIN-X) in Ministry of Science and Technology (Baghdad)

D- The sampling for electrical properties test :

Several samples of HCl acid treated, crude kaolin were pressed into discs in 1 cm diameter ,0.3 cm thickness under pressure 6.5 MN/m^2 .

Afterwards, thes discs were sintered in (1100 C) for(2 hr) .Then, two surface of every discs were coated with aluminum layer by using CVD technique and copper electrodes were applied on surfaces of discs by using silver paste .

Dielectric constant ,electrical resistance were measured by using RCL – meter .The breakdown strength was measured by using power supply and glass chamber containing high breakdown strength oil .

Results and Discussion:

Table (1) shows the results of quantitative ,qualitative analysis of HCl acid treated , crude kaolin . This table shows that the compounds of Fe_2O_3 , Na_2O_3 ,K_2O , MgO in addition to Al_2O_3 were reduced in different ratios after treatment of crude kaolin with the diluted hydrochloric acid .

The high dissolubility of alkalizes in hydrochloric acid ,whereas ,the reaction of hydrochloric acid with alkaline minerals is simple ionic reaction lead to forming salts [9,10] . Therefore ,the hydrochloric acid treatment kaolin must be washed with distilled water many times after finish this process .

Table (1) : Results of the quantitative ,qualitative analysis of kaolin by XRF technique.

Crude kaolin		HCl acid Treated kaolin
Compound	Concentration %	Concentration %
Al_2O_3	27.94	27.46
SiO_2	53.89	51.21
Fe_2O_3	3.81	2.63
MgO	2.31	1.85
K_2O	1.91	0.87
Na_2O_3	2.73	1.11
U.D.L	8.41	14.77

Table (2) shows values of compressive strength ,hardness of kaolin samples with additives . In this table ,the compressive strength and hardness of crude kaolin are 7.2 MN/m^2 , 17.3 HV respectively .

On addition of (1 wt % CaO) to crude kaolin ,the compressive strength increased to 8.93 MN/m^2 while, the hardness decreased to 16.9 HV .

On addition (2 wt % CaO) , the compressive strength reach to maximum value among prepared samples in which is 10.8 MN/m^2 ,in same time, the hardness increased to 17.6 HV .

On addition of (5 wt % CaO) ,the compressive strength decreased to 10.51 MN/m^2 but ,the hardness was increased to 18.2 HV .

On addition (1 wt % sawdust) ,compressive strength ,hardness were increased to 8.45 MN/m^2 , 19.1 HV respectively . But ,at increasing the reinforcement ratio to (2 wt % sawdust) the compressive strength increased to 9.15 MN/m^2 ,another side ,the hardness decreased to 18 HV

,in which the hardness strongly depend on the chemical affection of the reacted components[11].

On increasing reinforcement ratio to (5 wt % sawdust) ,the compressive strength and hardness were decreased to 7.07 MN/m^2 , 17.0 HV respectively

Table (2) : Results of the mechanical properties of kaolin .

Sample	Compressive strength MN/m^2	Hardness HV
Crude kaolin	7.20	17.3
With 1wt % sawdust	8.45	19.1
With 2wt % sawdust	9.15	18.0
With 5wt % sawdust	7.07	17.0
With 1wt % calcium oxide	8.93	16.9
With 2wt % calcium oxide	10.80	17. 6
With 5wt% calcium oxide	10.51	18.2
With 1wt % quarts	7.22	17.3
With 3wt % quarts	7.40	17.7
With 6wt % quarts	9.41	18.4

On addition (1 wt % quarts) , we did not find any effect on compressive strength ,hardness as shown in table (2) . But addition the quarts in the ratios

(3 wt %) ,(6 wt %) to lead to increasing compressive strength to 7.4 MN/m^2 9.41 MN/m^2 respectively, also with increasing in hardness to 17.7 HV,18.4 HV respectively . With simple analysis to table (2) ,we find that the maximum two values of compressive strength belong to the samples (2wt% Cao), (5 wt%Cao) respectively .While the maximum value of hardness belong to the sample of (1 wt% sawdust) .In this

situation ,we can say ,that the physical reaction (composite) between kaolin and sawdust in this ratio to work toward increasing the tensile strength that is caused increasing in hardness .While the chemical reaction between (CaO -kaolin) with relative high ratios of CaO to work toward increasing the compressive strength .

The interpretation of the mechanical behavior of ceramic materials prepared at high temperature is a complex due to The mechanical behavior of these materials not depends only on the physical reaction between the matrix and the reinforcement the foundation as is the case with the reinforcement of metallic materials and polymers but also depends on the chemical interaction between the components of composite which occurs at high temperatures .

In table (2) ,as an example, the compression strength of kaolin was increased with increasing the sawdust ratio from (0.1wt%) to (0.2wt%) .But on addition (5wt%)sawdust , the compression strength was decreased as a result of overcoming the impact of the chemical reaction on the physical reaction which lead to the generation of pores by the gas free in the kaolin composite in which the compression strength depends largely on the porosity and grain size [11] .

Table (3) ,shows the results of electrical measurements for untreated , HCl acid treated kaolin. In this table , we find that treatment of crude kaolin with HCl acid to lead to increasing the dielectric constant from (673) to (721) at

1 KHz , 27 C .Also , increasing in electrical resistance from ($3*10^{12}$ Ohm) to $3.6*10^{12}$ Ohm at 30 C . In addition to increasing the dielectric strength (breakdown) from 17 KV /mm to 19 KV/mm at 35 C .

Table (3): Results of the dielectric properties of kaolin with frequency (40 Hz) and (32 C) .

Crude kaolin			HCl acid treated kaolin		
Dielectric Constant	**Resistance Ohm**	**Breakdown KV/mm**	**Dielectric Constant**	**Resistance Ohm**	**Breakdown KV/mm**
673	$3 * 10^{12}$	17	721	$3.6 * 10^{12}$	19

Conclusions

Based on the data from literature ,the hydrochloric acid dissolving the alkaline substances especially K_2O , Na_2O_3 , Fe_2O_3 , while is very weak in the dissolving Al_2O_3 ,SiO_2 .Therefore ,its very active in purifying of kaolin from Fe_2O_3 . The sawdust is good material for increasing the hardness of kaolin in ratio (1 wt%) . While , the calcium oxide is good additive to increasing the compressive strength of kaolin in ratio (2 wt%) . The effect of quarts on mechanical properties of kaolin is weak when it have added in. low ratios .Therefore , adding the quarts to kaolin in relatively high ratios especially above (6 wt%) .Decreasing the Fe_2O_3 alkaline substances ratios lead to the improvement of the dielectric properties of kaolin observably

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