EFFECT OF USING TWO BINDERS ON THE AGGLOMERATION OF ZEOLITE TYPE 4A

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ABSTRACT

Zeolite 4A is agglomerated using 2,4,6,and 8 weight percentage water glass with different percentages of kaolin. The blended zeolite is agglomerated into cylindrical particles of 5 mm diameter and 4-7 mm length. Hardnees and adsorption capacity of the calcined blended zeolite were measured.

This research study showed that the hardnees of the particles decreased with the increasing in the water glass content. The increasing in the water glass content will cause increasing in the adsorption capacity of the blended Zeolite.

INTRODUCTION

Water glass is known to be used as adhesive material for papers and cartons and for other materials. This the first time that water glass has been used as a binder for the agglomeration of zeolite grains. Water glass contains $Na_2O.SiO_2$ which will combined with the structure of zeolite, because zeolite also contains the same oxides.

Zeolites are crystalline, hydrated aluminosilicate with a negative charge framework structure containing holes occupied by large ions and water molecules that have substantial freedom of movement. This leads to possibilities of ion exchange and reversible dehydration (Richardson ,J.T., 1989).

The structure of zeolite consists of a three-dimensional framework of $(SiO_4)^{-4}$ and $(AlO_4)^{-5}$ tetrahedral, each of which contains a silicon or aluminum atom in the center. The oxygen atoms are shared between adjoining tetrahedral, which can be present in various ratios and arranged in a variety of ways. Zeolites may be represented by the structural formulate:

$$M_{x/n}[(AlO_2)_x.(SiO_2)_y].wH_2O$$

where; (M) is a cation of valance (n) or proton, w is the number of water molecules, the sum (x+y) is the total number of tetrahedral in the unit cell, a change in M or y/x gives rise to a significant change in the pore size of the zeolite and hence its physio-chemical properties (Breck, D.W., 1964). The presence of (Al^{+3}) ion with smaller charge than (Si^{+4}) gives the lattice a negative charge, which compensated by exchangeable cation (M) (Satterfield, C.N., 1980).

Their significance as commercial adsorbents depends on the fact that each crystal contains interconnecting cavities of uniform size, separated by narrow openings, or pores of three-dimensional framework structure. When formed, this crystalline network is full of water. This moisture can be driven from the cavities with moderate heating without changing the crystalline structure (Behrens, P., 1993). After dehydration, the zeolite is termed activated and the pores or channels may be filled with water or other materials (Hersh, C.K., 1961).

Synthetic zeolites are widely used in industry as adsorbents of various gases and vapors and as a catalyst for many petroleum industries. Zeolite is a high capacity selective adsorbent (Breck, D.K., 1974) .

1- It separates molecules based upon the size and configuration of the molecule relative to the size and geometry of the main aperatures of the Zeolite structure.

2- Zeolite adsorbs molecules particularly those with a permanent dipole moment.

The objectives of agglomeration are (Perry, R.H. etal, 1973): A- reduce dust looses. B- reduce hazards. C- material is suitable to use and store. D- prevent caking and lump formation. E- create uniform blends.

Experimental work

Materials

The kaolin used in this investigation is available in AlDewkhala quarry in Alanbar region. Table (1) (Abdul Hady, A.A., 2001) shows the chemical analysis of this kaolin. Zeolite 4A is supplied from Alrayia State Company. The Chemical analysis of this molecular sieve is shown in Table(2) (Mahdi, S.M., 1997) .Water glass of 5 % SiO_2 and 95 % Na_2O (by wt) was supplied from the General State Company for Glass Manufacturing.

Experimental Steps

1- Iraqi zeolite and kaolin were sieved separately to get powder of particle size less than 45 micron.

2- The appropriate amounts of kaolin binder was mixed (for 5 minutes) in the rotating cylinder(centrifugal mill type Retch S2) to get homogeneous mixture.

3- Add a given amount of distilled water to a given weighted amount of the water glass and mix manually. Table(1) shows the experimental amounts used in this research.

4- This diluted water glass was added to the blended Zeolite (obtained from step 2). The mixture was mixed manually to get a homogeneous past that can be extruded by a medical syringe into cylindrical rods.

5- The obtained rods were dried at 110 ° C overnight in an electrical oven(Tecnoformal Ltd.).

6- The dry cylindrical pellets were calcined at 650 ° C for 3 hours [(2)] in a programmable electrical furnace(Model N2O/H).

Physical properties

1- Adsorption capacity:

The adsorption capacity measurements were carried out in the apparatus shown in Fig. (1). The particles (before the test) must be kept in a diskkater. The blended Zeolite particles were placed in a small basket hung to an electronic balance (Metler type). Air flow rate was measured by a calibrated rotameter. The sample was weighted before and after saturation with water vapor.

Table (1) Experimental amounts of blended materials

Sample No.	Zeolite wt %	Kaolin wt %	Water glass wt %
1	70	22	8
2	70	24	6
3	70	26	4
4	70	28	2
5	80	12	8
6	80	14	6
7	80	16	4
8	80	18	2
9	90	2	8
10	90	4	6
11	90	6	4
12	90	8	2

2- Hardness of particles:

The hardness of the blended Zeolite was measured in Alrayia State Company using Erweka apparatus.The experimental results are recorded in Table (2).

Table (2) Experimental Results

Sample No.	Adsorption Capacity (kg water/kg adsorbent) X 10^2	Hardness (N)
1	7.6	37
2	6.9	42
3	6.6	47
4	5.9	52
5	10.1	19
6	9.5	21
7	9.0	27
8	8.5	33
9	15.5	8
10	13.4	10
11	12.5	13
12	12.0	15

RESULTS AND DISCUSSION

1- Adsorption Capacity

- Effect of kaolin content: The binding power present in kaolin clay enables it to act as a cement or binding agent in uniting non-plastic zeolite particles to produce mixtures which possess plastic properties. The binding power is an extremely important property of kaolin clay, as it affords a simple and excellent means of reducing the shrinkage by drying or calcining. This research used different weight percentages of kaolin binder (2 – 28 wt %) accompanied with various weight percentages of water glass (2 – 8 wt %).From Fig(2) ,it is obvious that adsorption capacity of the blended zeolite will decrease as the kaolin content increases. This can be explained as follows: the addition of kaolin to zeolite causes the grains to be closer during agglomeration and calcining, which means more resistance for the molecules of water to diffuse into the particles. Also increasing the binder content means less quantity of zeolite available for adsorption. The importance of the binder came when the particles need to be hard for using in adsorption beds.

- Effect of water glass content: Water glass contains sodium silicate which acts as an adhesive for various substrates. For a given zeolite content, the increase in water glass content will cause an increase in the adsorption capacity of the blended zeolite, this is shown in Fig.(3). This slight increase in the adsorption capacity is due the decrease in the kaolin content of the particles, which means less resistance for the water molecules to diffuse into the particle.

2 - Hardness of Particles

- Effect of kaolin content: Figure (4) shows that the hardness of the blended zeolite particles will increase with the increase in the kaolin content. This is due to the excessive binding effect for the increasing content of kaolin, which causes high binding (more adhesion), resulted in more resistance for the particle to crack..

- Effect of water glass content: Noting Fig.(5), the hardness of the particles will decrease as the water glass content increases (for a given zeolite content). It is well known that kaolin will act as cementing agent during the calcinations step, but with the water glass the silicate will act as adhesion during agglomeration, but no further change during the calcination step. As seen previously the increase in the weight percentage of the water glass means lower kaolin content, thus the hardness will decrease with the increase in the water glass content.

CONCLUSIONS

1- The adsorption capacity of the blended zeolite will increase with the decrease in the kaolin content, or with the increase in the water glass content.

2- The hardness of the particles increases with the increase in the kaolin content of the zeolite, or with decrease in the water glass content.

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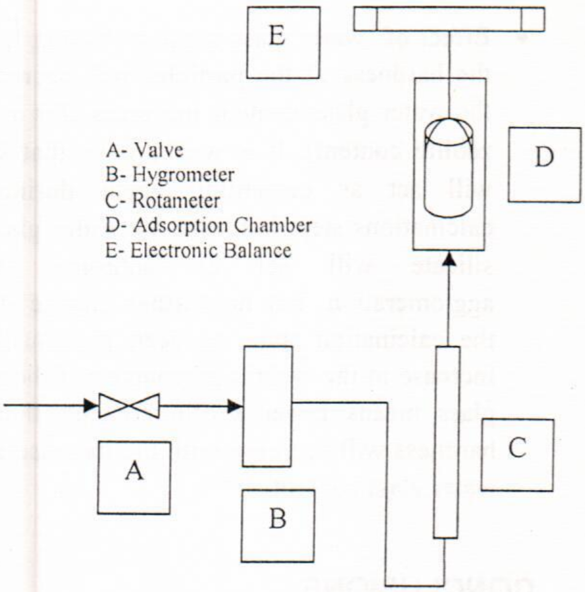

Fig. (1) Adsorption system

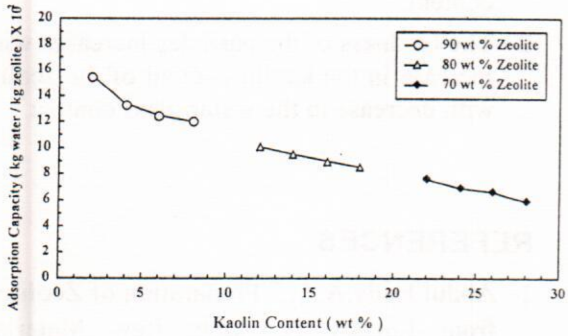

Fig. (2) Effect of the kaolin content on the adsorption capacity

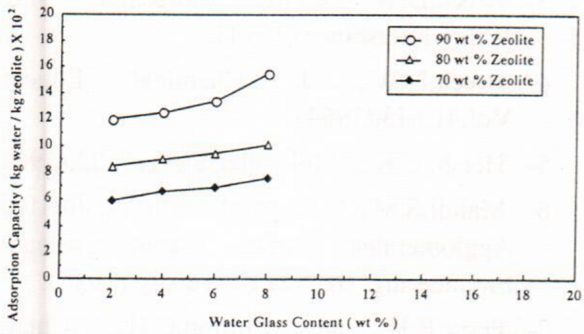

Fig. (3) Effect of water glass content on the adsorption capacity

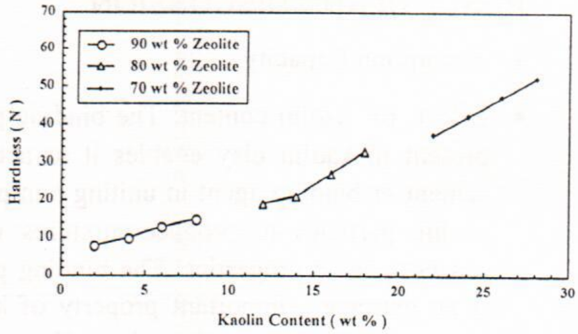

Fig. (4) Effect of the kaolin content on the hardness of the particles

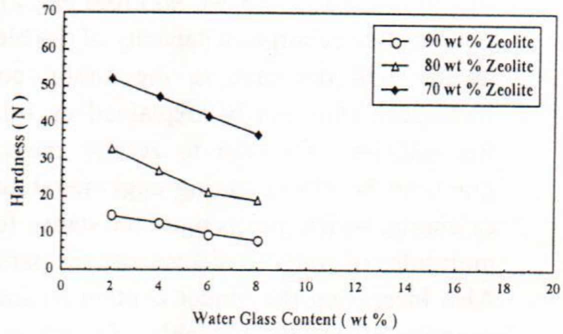

Fig. (5) Effect of the water glass content on the hardness of the particles