김일성종합대학학보 JOURNAL OF KIM IL SUNG UNIVERSITY
(자연과학) (NATURAL SCIENCE)
주체103(2014)년 제60권 제6호 Vol. 60 No. 6 JUCHE 103(2014).

The Effect of Some Factors on the Solubility of Silicon in Fly-Ash

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The great leader Kim Jong Il said:

"Only when it is organically combined with production can scientific research render a tangible contribution to finding solutions to urgent problems arising in the revolution and construction, and its achievements prove their great worth in promoting the technological revolution and people's living standards."

Today a lot of studies are being undertaken to gain both economic and environmental benefits by recycling various wastes from production and life. Ongoing, in particular, are studies to make effective absorbent by treating silicic materials in various methods including fly-ash from thermal power stations and domestic coal ash, and to use them in various fields [1－4].

On the basis of clarifying some properties of the fly-ash from thermal power stations that constitutes a large amount of industrial waste, it was studied to establish conditions for manufacturing materials of high adsorption in ammonium.

1. Materials and Methods

The material for study was the fly-ash from the Pyongyang Thermal Power Complex and the bentonite (from Kumya County, South Hamgyong Province) passed through a sieve (1mm). NaOH solutions of various concentrations were used as alkali for treatment.

The texture of materials was determined by sieving method.

The concentration of silicon in the solution treated with NaOH was measured as follows:

Fly-ash and NaOH solution were put in stainless-steel vessel in a ratio of 1:5 and then treated in an autoclave(TOMY ES-315) under different conditions (in concentration of NaOH, temperature and time). And then the treated solution was soon filtrated and the concentration of silicon in filterate was analyzed by silicon-molybden blue colorimetry.

2. Results and Consideration

2.1. Some physical and chemical properties of fly-ash

The fly-ash from the Pyongyang Thermal Power Complex is light gray. Its density is 1.82 g/cm^3 and its bulk density is 1.33 g/cm^3 and the total porosity is about 26.9%.

Table 1. Particle size composition of fly-ash

Particle size/mm	<0.06	0.06~0.125	0.125~0.16	0.16~0.315	0.315~0.40	>0.40
Content/%	20.6	63.8	11.3	3.7	0.2	0.4

As shown in Table 1, fly-ash is comparatively heavy material in which particles of less than 0.125mm account for 84.4%.

Fly-ash is alumosilicate mineral material, nearly 74.3% of which is silicon and aluminium as its main components (Table 2).

Table 2. Chemical composition of fly-ash (%)

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	TiO_2	K_2O	Na_2O
Content/%	51.9	22.4	5.74	1.72	1.06	1.05	3.24	0.59

What is particular about fly-ash is that it exists in the form in which silicon is easily soluble unlike other natural crystal silicate mineral (Fig. 1).

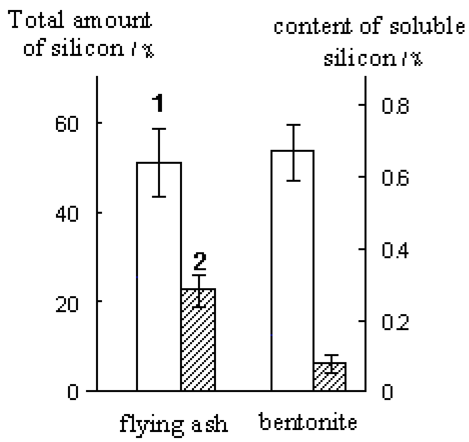

Fig. 1. The difference of silicon content in silic material
1—Total amount of silicon(%),
2—Content of soluble silicon(%)

There is little difference in the total content of silicon in fly-ash and montmorilonite (natural silicate material) as 51.9% and 53.7% respectively whereas the content of soluble silicon in them greatly differs as that in the bentonite is 0.05% (about 25.7% of that in the fly-ash). This is attributed to the fact that, unlike bentonite, noncrystal alumosilicate mineral formed in the condition of high combustion temperature is dominant in coal ash and fly-ash.

Therefore, fly-ash, the industrial waste from thermal power stations but high in its content of soluble silicon can be used as raw material with which to manufacture materials of high absorbability.

2. The Effect of Alkali Treatment Condition on Solubility of Silicon in Fly-Ash

The fact that NaOH, as alkali material, greatly dissolves silicon that constitutes main component of fly-ash becomes the main precondition for synthesizing the mineral with high ability of adsorption. Therefore, this paper made clear the effect of some conditions for the change in the concentration of silicon in extraction solution of fly-ash when treated by alkali.

2.1. The effect of NaOH concentration

Generally silicon concentration in extraction solution of fly-ash increased as NaOH concentration increased (Fig. 2).

The concentration of silicon increased rapidly when NaOH concentration was 0～0.1 mol/L and gradually when it was 0.1～0.5 mol/L. When it became higher, the solubility of silicon increased rapidly. The concentration of silicon in the solution treated with 2 mol/L of NaOH in the reaction temperature of 60℃ and 105℃ was respectively 5.9 times and 17.9 times higher compared with 0.1 mol/L of NaOH.

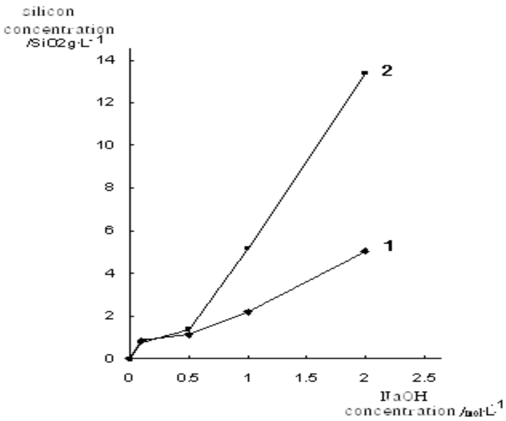

Fig. 2. The change in silicon concentration according to NaOH concentration
1—treated for 4 hours in 60℃, 2—treated for 4 hours in 105℃

2.2. The effect of treatment time

The concentration of silicon in extraction solution changed according to the time of treating NaOH (Fig. 3).

As shown in Figure 3, the concentration of silicon in extraction solution increased to its maximum with the time and decreased again. When treated in 105℃, the concentration of silicon increased rapidly from 0.5 hour after the treatment started to reach its maximum of 7.77 SiO_2 g/L after one hour and decreased rapidly until two hours' time of its treatment and then slowly until four hours' time. When treated in 60℃, the concentration of silicon increased rapidly from one hour after it began to be treated to reach its maximum of 5.99 SiO_2 g/L after two hours and decreased rapidly until four hours' time of treatment and then slowly till eight hours' time.

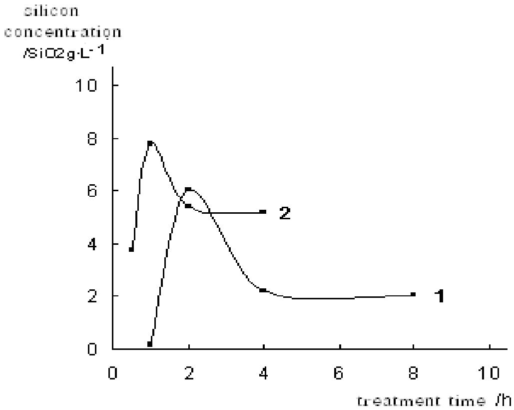

Fig. 3. The change in silicon concentration with the time of treating NaOH
1—treated with 1mol/L of NaOH in 60℃,
2—treated with 1mol/L of NaOH in 105℃

The maximum concentration (7.77 SiO_2 g/L) of silicon in the solution treated in 105℃ was nearly twice that in NaOH treated for 0.5 hour and the maximal concentration (5.99 SiO_2 g/L) of silicon in the solution treated in 60℃ was nearly 44 times of the solubility of silicon (0.14 SiO_2 g/L) in NaOH treated for one hour.

The increase for a certain period of time and the subsequent decrease of silicon concentration in extraction solution can be attributed to the formation from the dissolved silicon of a new mineral of high adsorption.

2.3. The effect of treatment temperature

As treatment temperature went up, the concentration of silicon in extraction solution increased (Fig. 4).

The concentration of silicon in 121℃ (25.0 SiO_2 g/L) increased 131 times as high as that in 60℃ (0.19 SiO_2 g/L), 10 times as high as that in 80℃ (0.25 SiO_2 g/L) and 1.6 times as high as that in 105℃ (15.6 SiO_2 g/L).

In this way the concentration of silicon greatly differs according to concentration of NaOH, treatment time and temperature, and the formation of minerals with high ability of adsorption might be different.

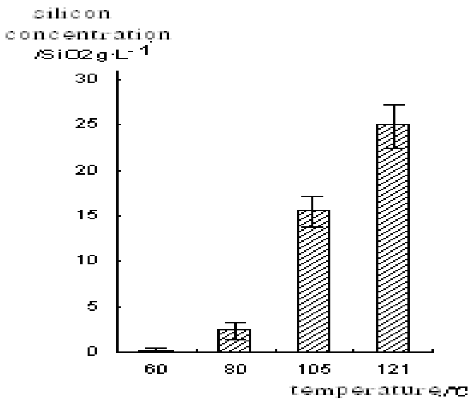

Fig. 4. The change of silicon concentration according to treatment temperature
Treated for one hour with NaOH solution of 2 mol/L

Conclusion

The fly-ash consisting of noncrystal alumosilicate has high content of soluble silicon in it so it can be changed into material with high ability of adsorption by treatment of NaOH.

When treating fly-ash with NaOH, the amount of dissolved silicon greatly differs according to the concentration of NaOH, treatment time and temperature, and thus, the minerals with high ability of adsorption can be formed in certain circumstances.

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