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RECOVERY OF SODIUM FROM ALUMINA-EXTRACTED FLY ASH USING CONCENTRATED SODIUM CARBONATE SOLUTION

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Abstract

A novel method for the recovery of sodium from alumina-extracted fly ash (AEFA) using concentrated Na₂CO₃ solution is presented. Sodium was efficiently extracted from AEFA, which was mainly composed of NaCaHSiO₄. The factors influencing the process were systematically investigated, and the optimal conditions were determined to be: reaction temperature = 180 °C, Na₂CO₃ concentration = 170 g/L, liquid-to-solid ratio = 10 mL/g, and reaction time = 2 h. Under optimal conditions, a low Na₂O content of 1.02 wt% of the products, with Na₂O extraction rate of 93.79% was achieved. The results indicated that this process was more effective than the recovery of sodium from AEFA using a dilute NaOH solution. Furthermore, this process avoided the production of a dilute NaOH solution, therefore lowering the energy consumption during the concentration and recycling of sodium, when compared with the NaOH-based route. Therefore, the recovery of sodium from AEFA using concentrated Na₂CO₃ solution is more suitable for use in industrial applications.

Keywords: Fly ash; NaCaHSiO₄; Sodium carbonate; Sodium extraction

1. Introduction

Fly ash is an ultrafine solid residue generated by the combustion of coal in coal-fired power plants, and is the highest produced industrial solid waste in China, with an annual output of approximately 580 million tons by 2015 [1-2]. Large amounts of fly ash disposed in landfills, causing serious are environmental and social problems. High-alumina fly ash (HAFA) is a category of fly ash with an alumina content of 35-50% and with an annual output in Inner Mongolia and Shanxi province, China, of approximately 50 million tons [2-4]. Owing to its high alumina content and large annual output, HAFA is considered a promising resource for the extraction of alumina. A mild hydrochemical process [5], which can separate alumina from silica in an alkaline solution by generating NaAlO₂ and NaCaHSiO₄, has been reported to achieve the extraction of alumina from HAFA in a concentrated sodium hydroxide solution at 250–280 °C [2-4]. Remarkably, the Al₂O₂ extraction efficiency of this process was larger than 90%, and the process avoided the use of high temperatures (1200-1400 °C used in sintering processes [6-7]) and acid corrosion (concentrated sulfuric acid used in the pressure acid leaching method [8-10]). Therefore, this process demonstrates

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good applicability for use in industrial processes.

The main crystalline phase of alumina-extracted fly ash (AEFA) generated in the above hydrochemical process is NaCaHSiO₄, which contains a Na₂O content of ~20 wt% [2-3]. Due to its high alkalinity and negative effect on agricultural land and groundwater if used directly, AEFA is usually considered as hazardous industrial waste [11]. Therefore, recycling the alkali from AEFA is important in terms of utilizing the silicon component of the fly ash as well as diminishing its environmental damage. It is noteworthy that NaCaHSiO₄ can be converted into calcium silicate hydrate using a dilute NaOH solution [12-13]. The reactions taking place during the decomposition of NaCaHSiO₄ in a dilute NaOH solution can be expressed as follows:

$$NaCaHSiO_4 + NaOH \rightarrow Na_2SiO_3 + Ca(OH)_2$$
 (1)

$$Na_2SiO_3 + Ca(OH)_2 + H_2O \rightarrow CaO \cdot SiO_2 \cdot H_2O + 2NaOH$$
 (2)

During studies into the decomposition of NaCaHSiO₄ in dilute NaOH solution, Zhang et al. found that the optimal Na₂O concentration and reaction temperature were 40 g/L and 150 °C, respectively [13]. Recently, researchers investigated the recovery of sodium from AEFA using dilute NaOH solution (Na₂O concentration ~20 g/L) and



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successfully synthesized tobermorite insulation products from AEFA [14-15]. However, these processes generated large quantities of dilute NaOH solution, a by-product which is difficult to recycle in industry as the energy consumption of the evaporation process is too high to concentrate such large volumes of dilute NaOH solution. Therefore, it is necessary to develop a novel method for the recovery of sodium from AEFA, aiming at avoiding the production of such large volumes of dilute solutions and developing a more feasible and economical process for industrial applications. However, to date, there are few reports about the recovery of sodium from AEFA in other alkaline solutions.

In this study, a novel method for recovery of sodium from AEFA (NaCaHSiO₄) using a concentrated Na₂CO₃ solution is presented. As outlined in the equations above, NaOH is both the reactant and the product; therefore, the reaction will be inhibited at high NaOH concentration. Conversely, a high Na₂CO₃ concentration will promote the decomposition reaction because Na₂CO₃ is only the reactant. Moreover, the solubility product (Ksp) of $CaCO_3$ (i.e., 2.8×10^{-9}) is lower than that of $CaSiO_3$ (i.e., 2.5×10^{-8}); therefore, the formation of CaCO₂ will promote the decomposition of NaCaHSiO₄ in a concentrated Na₂CO₂ solution. Therefore, the aim of this study was to investigate the recovery of sodium from AEFA using a concentrated Na₂CO₃ solution and to extract sodium from AEFA effectively without production of dilute solution. The effects of reaction temperature, Na₂CO₃ concentration, liquid-to-solid ratio, and reaction time were systematically investigated. Furthermore, the reaction mechanism and the incorporation of Al^{3+} in the products were also examined.

2. Experimental 2.1. Raw materials and apparatus

HAFA was obtained from a coal-fired power plant in Inner Mongolia, China, and the AEFA employed herein was obtained by extracting alumina from the HAFA in a hydrochemical process [2-3]. This process used a concentrated NaOH solution and the addition of CaO with a C/S ratio (i.e., the mass ratio of CaO to SiO₂) of 1.0 to leach alumina from HAFA at <1.6 MPa and 260 °C.

All chemicals used, including sodium hydroxide, calcium oxide and sodium carbonate, were of analytical grade and manufactured by China Xilong Chemical Co., Ltd. High-purity Milli-Q water was used for all experiments.

A custom-made 1L high-temperature autoclave used for the extraction of alumina from HAFA and the decomposition of AEFA was fitted with an external heater and an internal cooling system. The autoclave was protected from corrosion by a nickel vessel when the highly concentrated alkali solution was used.

2.2. Experimental and analytical methods

The recovery of sodium from AEFA was performed with stirring in a 1L high-temperature autoclave. Prior to carrying out the experiments, the AEFA was broken down using a high-speed universal pulverizer (FW177, Beijing Ever Light Medical Equipment Company Ltd., China) and sieved through a 200-mesh standard test sieve on an electric mechanical sieve shaker (GS-86, Shangyu Gauze Screen Factory, Zhejiang, China) to obtain particles measuring $0-74 \mu m$. The obtained AEFA sample (30 g) and concentrated Na₂CO₂ solution (85–255 g/L) at liquid-to-solid ratios of 6-20 mL/g were added to the autoclave, and the mixture heated to the desired temperature (140-220 °C) and digested for the desired reaction time (0-2h). Subsequently, the resulting slurry was filtered and washed with heated deionized water three times to reduce the adsorption of sodium ions on the product structures. Finally, the obtained samples were dried in an oven at 105°C over 12 h.

To identify the crystalline phases present, the dried samples were characterized by X-ray diffraction (XRD, X'Pert Pro MPD, PANalytical) at 40 kV, 30 mA, and $2\theta = 5-90^{\circ}$ using a Cu Ka X-ray source. In addition, to determine the morphology of the samples, scanning electron microscopy (SEM, JSM 7100F, JEOL, Japan) was employed. The chemical compositions of the samples were analyzed using inductively coupled plasma optical emission spectrometry (ICP-OES, Optimal 7300V, Perkin-Elmer Instruments, 1300 W, carrier gas flow = 0.08 L/min, peristaltic pump flow = 1.5 L/min). Solid–state 27Al magic-angle spinning nuclear magnetic resonance (MAS NMR) spectra were acquired at 104.0 MHz (Bruker AVANCE III 400 MHz, 9.4 T) using a 4 mm MAS probe at a spinning speed of 12.0 kHz. The 27Al spectra were accumulated with a 1 s recycle time and a 30° pulse width of 1 µs.

3. Results and discussion 3.1. Characterization of raw materials

The chemical composition of the raw HAFA is shown in Table 1. Al_2O_3 and SiO_2 are the main compositions of the HAFA, with an A/S ratio (i.e., mass ratio of Al_2O_3 to SiO_2) of 1.33. As shown in Table 2, the resulting AEFA was composed mainly of SiO₂, CaO, and Na₂O.

Table 1. Chemical composition of the raw HAFA

Composition	Al ₂ O ₃	SiO ₂	CaO	Na ₂ O	A/S
Content (wt%)	52.37	39.34	1.35	0.48	1.33



Table 2. Chemical composition of the AEFA Page 1 Page 2 Page 2 Page 3 Page 3							
Composition	Al ₂ O ₃	SiO_2	CaO	Na ₂ O	A/S	C/S	
Content (wt%)	1.96	33.54	30.55	16.49	0.06	0.91	

Analysis by XRD indicated that the main crystal phase of the AEFA was NaCaHSiO₄, as indexed by JCPDS card no. 00-025-1319 (Fig. 1). The SEM image indicates that the AEFA particles adopted a rod-like microstructure with lengths in the order of dozens of micrometers and widths of several micrometers (Fig. 2).



Figure 1. XRD pattern of the AEFA



Figure 2. SEM image of the AEFA

3.2. Effect of reaction variables and reaction optimization

3.2.1. Effect of reaction temperature

Fig. 3 shows the XRD patterns of the products at reaction temperatures ranging from 140 to 220 °C. The experiments were performed using a Na_2CO_3



Figure 3. XRD patterns of the products obtained at reaction temperatures of 140–220 °C, a Na₂CO₃ concentration of 170 g/L, liquid-to-solid ratio of 10 mL/g, and reaction time of 2 h

concentration of 170 g/L, liquid-to-solid ratio of 10 mL/g, and reaction time of 2 h. The main crystal phases of the products were determined to be tobermorite and calcite, as indexed by JCPDS card nos. 00-019-1364 and 01-086-2334, respectively. It is found that the temperature has an important effect on the crystallization of the product. As shown, with an increase in reaction temperature, the diffraction peaks of tobermorite gradually become more intense. The identified peaks of NaCaHSiO4 in AEFA disappear after the AEFA is decomposed in 170 g/L Na₂CO₃ solution at 140 °C for 2 h. In contrast, NaCaHSiO₄ still exists in the products obtained from the recovery of sodium from AEFA using 20 g/L NaOH solution at 180 °C for 4h [14-15]. This indicates that the recovery of sodium from AEFA using concentrated Na₂CO₃ solution was more effective. In addition, at a reaction temperature of 220 °C, signals corresponding to calcium sodium aluminum oxide were also observed (c.f., JCPDS card no. 01-083-1358).

The Na₂O content and Na₂O extraction rate of the products at reaction temperatures ranging from 140 to 220 °C are shown in Fig. 4. Upon increasing the reaction temperature from 140 to 180 °C, the Na₂O content in the products decreased gradually along with an increase in the Na₂O extraction rate. In contrast, upon increasing the temperature further from 180 to 220 °C, the Na₂O content of the products increased sharply, accompanied by the expected decrease in Na₂O extraction rate. In addition, at a reaction temperature of 220 °C, the Na₂O content in the product reached its highest value, due to the crystallization of calcium sodium aluminum oxide, as indicated in the XRD pattern. Thus, at a reaction temperature of 180 °C, the lowest Na₂O content (i.e., 1.02 wt%) and highest Na₂O extraction rate (i.e., 93.79 %) were recorded. This contrasts with previous



studies by Ding and Wang, where the Na₂O content in the product obtained from the recovery of sodium from AEFA using a dilute NaOH solution was higher than 2 wt% [14-15]. These results indicate that the recovery of sodium from AEFA using concentrated Na₂CO₂ solution is a more effective process than that using the NaOH-based system. This is ascribed to the higher crystallinity of calcite, which prevents the accommodation of Na⁺ [13]. Moreover, a wider range of operating temperatures from 140 to 200 °C can be chose for the process involving the concentrated Na₂CO₃ solution, compared to the narrow range of reaction temperature when using dilute NaOH solution, which demonstrates the potential of using concentrated Na₂CO₃ solution for this process in industry.



Figure 4. Na₂O content and Na₂O extraction rate of the products at reaction temperatures of 140–220 °C, a Na₂CO₃ concentration of 170 g/L, liquid-tosolid ratio of 10 mL/g, and reaction time of 2 h

3.2.2. Effect of Na₂CO₃ concentration

Fig. 5 shows the XRD patterns of the products obtained from the recovery of sodium from AEFA at Na_2CO_3 concentrations between 85 and 225 g/L. All experiments were performed at 180 °C over 2 h with a liquid-to-solid ratio of 10 mL/g. The main crystal phases of the products obtained in this case were tobermorite and calcite, with aragonite (c.f., JCPDS card no. 01-076-0606) also being present in the product when a Na_2CO_3 concentration of 255 g/L was employed.

Furthermore, the Na₂O content and Na₂O extraction rate of the products at Na₂CO₃ concentrations of 85–255 g/L are shown in Fig. 6. Upon increasing the Na₂CO₃ concentration from 85 to 170 g/L, the Na₂O content in the products decreased gradually, accompanied by an increase in the Na₂O extraction rate. This is ascribed to the faster decomposition of NaCaHSiO₄ at higher CO₃⁻² concentration due to the formation of CaCO₃. In



Figure 5. XRD patterns of the products obtained at Na_2CO_3 concentrations of 85–225 g/L, a reaction temperature of 180 °C, liquid-to-solid ratio of 10 mL/g, and reaction time of 2 h



Figure 6. Na₂O content and Na₂O extraction rate of the decomposition products at Na₂CO₃ concentrations of 85–255 g/L, a reaction temperature of 180 °C, liquid-to-solid ratio of 10 mL/g, and reaction time of 2 h

contrast, a further increase in the Na₂CO₃ concentration to 255 g/L led to an increase in Na2O content and a decrease in the Na₂O extraction rate. Excess Na⁺ ions could hinder both the decomposition of NaCaHSiO₄ and the conversion of amorphous calcium silicate hydrate into well-developed final phases, thereby causing many Na⁺ ions be adsorbed or incorporated in the structure of the calcium silicate hydrate, which is difficult to wash off [13]. These results indicate that the optimal Na₂CO₂ concentration is 170 g/L (Na₂O concentration of 100 g/L). In contrast, in studies reported by Ding and Wang, the optimal Na₂O concentration for the recovery of sodium from AEFA using a dilute NaOH solution was ~ 20 g/L [14-15]. This therefore confirms that a high Na₂CO₂ concentration promotes the reaction, because the Ksp of CaCO₃ (i.e., 2.8×10^{-9}) is lower than that of $CaSiO_3$ (i.e., 2.5×10^{-8}). It is noteworthy that the Na₂O concentration of the process with the concentrated Na₂CO₃ solution is five times higher than that using the dilute NaOH solution. Thus, the recovery of sodium from AEFA using a concentrated Na₂CO₃ solution avoids the use and production of dilute NaOH solutions, resulting in a lower energy consumption for the concentration and recycling of recovered sodium, compared to that of the NaOH-based sodium recovery process. Therefore, the proposed process will be more suitable for use in industrial processes.

3.2.3. Effect of the liquid-to-solid ratio

Fig. 7 shows the XRD patterns of the products obtained at liquid-to-solid ratios of 6–20 mL/g. The experiments were performed at 180 °C for 2h, with a Na₂CO₃ concentration of 170 g/L. In this case, the main crystal phases observed in the products were tobermorite and calcite, with tobermorite being more abundant at lower liquid-to-solid ratios (i.e., \leq 10 mL/g) and calcite being more abundant at higher liquid-to-solid ratios (i.e. 20 mL/g).



Figure 7. XRD patterns of the products obtained at liquidto-solid ratios of 6–20 mL/g, a reaction temperature of 180 °C, Na₂CO₃ concentration of 170 g/L, and reaction time of 2 h

The Na₂O content and Na₂O extraction rate of the products at liquid-to-solid ratios of 6–20 mL/g are shown in Fig. 8. Upon increasing the liquid-to-solid ratio from 6 to 10 mL/g, the Na₂O content in the products decreases gradually, while the Na₂O extraction rate increases. In contrast, the Na₂O content in the products begins to increase with a corresponding decrease in Na₂O extraction rate as the liquid-to-solid ratio is increased beyond 10 mL/g. Therefore 10 mL/g was selected as the optimal liquid-to-solid ratio for the process of concentrated Na₂CO₃ solution, which is 1/2-1/3 of that of the process of

dilute NaOH solution [14-15]. Therefore, the sizes of the instruments in the process using concentrated Na_2CO_3 solution can be 1/2-1/3 of that in the process using the dilute NaOH solution, which can significantly lower investment on instruments for industrial applications.



Figure 8. Na₂O content and Na₂O extraction rate of the products at liquid-to-solid ratios of 6–20 mL/g, a reaction temperature of 180 °C, Na₂CO₃ concentration of 170 g/L, and reaction time of 2

3.2.4. Effect of reaction time

Fig. 9 shows XRD patterns of the products obtained from the recovery of sodium from AEFA at reaction times of 0–2h. All experiments were performed at 180 °C, with a Na₂CO₃ concentration of 170 g/L and a liquid-to-solid ratio of 10 mL/g. As observed previously, at a reaction temperature of 180 °C and a reaction time of 2h, no diffraction peaks corresponding to NaCaHSiO₄ were observed. In this case, a reaction time of 0h yielded calcite as the main crystal phase of the product, with traces of



Figure 9. XRD patterns of the products obtained at reaction times of 0–2 h, a reaction temperature of 180 °C, Na₂CO₃ concentration of 170 g/L, and liquid-to-solid ratio of 10 mL/g



tobermorite also being observed. However, upon increasing the reaction time up to 2 h, the diffraction peaks corresponding to the tobermorite crystal phase gradually strengthened, giving products containing crystal phases of both tobermorite and calcite. Once again, no diffraction peaks corresponding to NaCaHSiO₄ were present.

Finally, the Na₂O content and Na₂O extraction rate of the products obtained at reaction times between 0 and 2 h are shown in Fig. 10. In this case, with a reaction time of 0 h, the Na₂O content in the products was 1.86 wt%, indicating that the decomposition reaction of AEFA in the concentrated Na₂CO₃ solution occurred during the heating process and the reaction rate was high, with the high Na₂CO₃ concentration and the low Ksp of CaCO₃ promoting the reaction. Upon increasing the reaction time, the Na₂O content in the products decreased gradually, due to the increase in Na₂O extraction rate. Indeed, at a reaction time of 2 h, the lowest Na₂O content was recorded (1.02 wt%); therefore, this reaction time was selected as the optimal value for our system.



Figure 10. Na₂O content and Na₂O extraction rate of the products at reaction times of 0–2 h, a reaction temperature of 180 °C, Na₂CO₃ concentration of 170 g/L, and liquid-to-solid ratio of 10 mL/g

In conclusion, the optimal reaction conditions for the recovery of sodium from of AEFA using Na₂CO₂ solution are as follows: reaction temperature = 180°C, Na_2CO_3 concentration = 170 g/L, liquid-to-solid ratio = 10 mL/g, and reaction time = 2 h. The SEM images of the products obtained under these optimal conditions are shown in Fig. 11. The morphology of the product particles was irregular, with aggregations consisting of fragments and fibers being observed. This differs from the rod-like morphology of AEFA shown previously in Fig. 2. In addition, Table 3 shows the composition of the products obtained under optimal conditions, where SiO₂ and CaO were the main components. Furthermore, a C/S ratio (mass ratio of CaO to SiO₂) of 1.18 was calculated, which is higher than that of tobermorite (5CaO•6SiO₂•5H₂O, C/S ratio = 0.78), due to the presence of calcite (CaCO₃) in the decomposition products.





Figure 11. SEM images of the products obtained under optimal conditions: reaction temperature of 180 °C, Na₂CO₃ concentration of 170 g/L, liquid-tosolid ratio of 10 mL/g, and reaction time of 2 h

 Table 3. Chemical composition of the products obtained under optimal conditions

Composition	Al ₂ O ₃	SiO ₂	CaO	Na ₂ O	A/S	C/S
Content (wt%)	1.19	28.76	33.85	1.02	0.04	1.18

The various reactions taking place during the recovery of sodium from AEFA in concentrated Na₂CO₃ solution can be expressed as follows:

$$\begin{aligned} &NaCaHSiO_4 + Na_2CO_3 \rightarrow CaCO_3 + NaOH + Na_2SiO_3 \qquad (3)\\ &NaCaHSiO_4 + NaOH \rightarrow Na_2SiO_3 + Ca(OH)_2 \qquad (4) \end{aligned}$$

$$Na_2SiO_3 + Ca(OH)_2 + H_2O \rightarrow CaO \cdot SiO_2 \cdot H_2O + 2NaOH$$
 (5)



Initially, NaCaHSiO₄ is decomposed by Na₂CO₃, to yield CaCO₃, NaOH, and Na₂SiO₃. Subsequently, NaCaHSiO₄ can be decomposed into Na₂SiO₂ and Ca(OH), by the NaOH formed in the initial reaction. Finally, the produced Na₂SiO₃ and Ca(OH)₂ react in the presence of water to form CaO•SiO₂•H₂O. Thus, the final crystal phases of the products are tobermorite (5CaO•6SiO,•5H,O) and calcite $(CaCO_{2}).$ Meanwhile, the final liquids are composed of Na_2CO_2 , NaOH, and H₂O, which were quantified by titrimetry according to the national standard (DZ/T 0064.49-93) [16]. The concentration of Na₂CO₃ and NaOH in the final liquid is 137 g/L and 35 g/L, respectively. The mixture solution is suitable for causticizing by the Ca(OH), to form NaOH and CaCO₃, which is widely used to recover NaOH in the Bayer process of alumina production [12], and the recovered concentrated NaOH solution can be reused in the hydrochemical process for alumina extraction.

3.3. Incorporation of Al^{3+} into the products

Under the optimal reaction conditions, the final crystal phases of the products were identified to be tobermorite and calcite, and the Al₂O₂ and Na₂O contents were 1.19 and 1.02 wt%, respectively. A number of research groups have reported that Al³⁺ can be incorporated into the tobermorite structure, with the charge deficit from the replacement of Si⁴⁺ by Al³⁺ being balanced by the adsorption of alkaline ions [17-21]. To further investigate the incorporation of Al³⁺ into the tobermorite structure of our products, ²⁷Al MAS NMR spectroscopy was carried out on the products obtained under optimal conditions (see Fig. 12). The assignment of ²⁷Al chemical shifts reported in previous studies described that the tetrahedrally coordinated Al(IV) resonates at 50-70 ppm, pentahedrally coordinated Al(V) at resonates 33-39 ppm, and octahedrally coordinated Al(VI) resonates at 0-10 ppm [22]. Furthermore, the tetrahedrally coordinated Al(IV) is often present in a bridging position or cross-linking site of the tobermorite structure, while the pentahedrally coordinated Al(V) has been assigned to Al^{3+} substituting Ca^{2+} in the interlayer space of the tobermorite, and the octahedrally coordinated Al(VI) has been suggested to represent either an amorphous aluminum hydroxide or a calcium aluminate hydrate structure on the tobermorite surface or in the octahedral CaO₂ layer of the tobermorite structure [20-22]. For our product mixture obtained under optimal conditions, only two Al(IV) peaks with maxima at 63.7 and 51.7 ppm were present, with no traces of signals corresponding to Al(V) or Al(VI) being observed, thereby confirming that all Al atoms were incorporated into the silicate chains of the tobermorite structure. This results in the adsorption of Na⁺ to compensate for the charge deficit

due to the replacement of Si^{4+} by Al^{3+} ions in the tobermorite structure [17-21].



Figure 12. ²⁷Al MAS NMR spectrum of the products obtained under optimal conditions: reaction temperature of 180 °C, Na₂CO₃ concentration of 170 g/L, liquid-to-solid ratio of 10 mL/g, and reaction time of 2 h

4. Conclusions

A novel method for the recovery of sodium from alumina-extracted fly ash (AEFA) using concentrated Na₂CO₃ solution was systematically studied. The optimal reaction conditions were determined to be as follows: reaction temperature = 180 °C, Na₂CO₂ concentration = 170 g/L, liquid-to-solid ratio = 10mL/g, and reaction time = 2 h. Under these optimal conditions, the Na₂O extraction rate was 93.79 %, and the Na₂O content of the products was 1.02 wt% which is lower than that of the products obtained from the recovery of sodium from AEFA using a dilute NaOH solution (i.e., ~ 2 wt%). This indicates that the process of recovery of sodium from AEFA using concentrated Na₂CO₃ solution is more effective. Furthermore, the high Na₂CO₃ concentration promotes the decomposition reaction, due to the formation of CaCO₂ with lower Ksp (i.e., 2.8×10^{-9}), compared with that of CaSiO₃ (i.e., 2.5×10^{-8}). This process avoids the production of a dilute solution, resulting in a lower energy consumption for the concentration and recycling of recovered sodium, thus, making it more suitable for industrial applications.

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DOBIJANJE NATRIJUMA IZ ALUMINIJUM-OKSIDA (GLINICE) DOBIJENOG IZ LETEĆEG PEPELA (POLETINE) UZ PRISUSTVO KONCENTROVANOG RASTVORA NATRIJUM KARBONATA

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Apstrakt

U ovom radu je predstavljen novi metod za dobijanje natrijuma iz aluminijum oksida (glinice) dobijenog iz letećeg pepela (poletine) uz prisustvo koncentrovanog rastvora Na_2CO_3 . Natrijum koji je na efikasan način dobijen iz aluminijum oksida (glinice) dobijenog iz letećeg pepela (poletine) se uglavnom sastojao od NaCaHSiO₄. Faktori koji su uticali na postupak su sistematično ispitani, a zatim su ustanovljeni sledeći optimalni uslovi: temperatura reakcije = 180 °C, koncentracija $Na_2CO_3 = 170 \text{ g/L}$, odnos Č:T (čvrsto:tečno) = 10 mL/g, i vreme reakcije= 2h. Pod optimalnim uslovima, stopa dobijenog Na_2O iz proizvoda sa niskim sadržajem Na_2O od 1,02 wt%, iznosi 93,79%. Dobijeni rezultati ukazuju na to da je ovaj postupak efikasniji od postupka dobijanja natrijuma iz aluminijum oksida (glinice) dobijenog iz letećeg pepela (poletine) uz prisustvo razblaženog NaOH rastvora. Takođe se ovim postupkom izbeglo dobijanje razblaženog NaOH rastvora, i samim tim se smanjio utrošak energije prilikom postupka koncentrovanja i recikliranja natrijuma, u poređenju sa postupkom koji se zasniva na NaOH osnovi. Stoga, dobijanje natrijuma iz aluminijum oksida (glinice) dobijenog iz letećeg pepela (poletine) uz prisustvo koncentrovanog rastvora Na_2CO_3 predstavlja bolje rešenje za uptrebu u industriji.

Ključne reči: Leteći pepeo; NaCaHSiO₄; Natrijum karbonat; Dobijanje natrijuma

