ADSORPTION AND ION EXCHANGE PROPERTIES OF ZEOLITE MATERIALS PRODUCED FROM FLY ASH USING SIMPLE METHODS OF SYNTHESIS

DERKOWSKI, A.,[1] FRANUS, W.[2]

[1] Institute of Geological Sciences PAS [Instytut Nauk Geologicznyh PAN], Senacka 1, Kraków, 31 002, Poland
[2] Department of Geotechnics, Lublin University of Technology [Katedra Geotechniki, Politechnika Lubelska], Nadbystrzycka 40, Lublin, 20 618, Poland
E-mail: ndderkow@cyf-kr.edu.pl

The production of zeolites by treatment of coal fly ash with alkaline solutions, was tested using various procedures of hydrothermal synthesis. The F class fly ash (classification: see Manz, 1999) is a good substrate for zeolite synthesis reaction because of its composition dominated by aluminosilicate and silicate phases. Based on previous work (Derkowski and Michalik, 2004), the most effective reactions of synthesis were chosen to produce three types of zeolite materials, rich in three zeolite phases: Na-X (FAU), NaP1 (GIS) and sodalite (SOD; nomenclature and classification after Baerlocher et al., 2001). The fly ash collected from Kraków power plant ($SiO_2 + Al_2O_3 = 72.5\%$; $SiO_2 / Al_2O_3 = 1.88$) was used as substrate for the reactions.

10 g of homogenised fly ash was mixed with NaOH and NaCl solutions, stored 24 hours in various temperatures (see below), under atmospheric pressure, then washed and dried. The reactions were carried out in the following conditions:

- the Na-X-rich material: 200 ml of 3 M NaOH, temperature 75°C;
- the NaP1-rich material: 200 ml of 1M NaOH + 100 ml of 3 M NaCl, temperature 150°C;
- the sodalite-rich material: 400 ml of 5M NaOH + 200 ml of 3 M NaCl, temperature 150°C.

The mineral and chemical composition of the raw fly ash and the products were determined using XRD, IR and EDS methods and SEM observations and their various properties were tested:

1. CEC (determined using Mn^{2+} ions, desorbed with 1 M CH_3COONa solution): fly ash 10 meq/100g; sodalite 63; Na-P1 154; Na-X 187.

2. Specific surface (SBET), specific surface and volume of mesopores (S_{mez}, V_{mez}) and micropores (V_{mic}) were measured applying adsorption and desorption of argon gas in liquid nitrogen temperature, and then calculation using Dubinin and Dubinin-Radushkievitsh equations (Brunauer et al., 1938; Ościk, 1979).

3. Thermal stability of zeolite materials was checked by heating in three ranges of temperature and then analysing their structures by XRD. Zeolite structures are stable: NaP1 < 300°C; Na-X ≈ 700°C, sodalite > 700°C.

Determined properties of zeolite materials suggest a broad range of possible applications. Na-P1 and Na-X materials show very high capacity for removing heavy metal ions from water solutions, due to their high CEC. Because of the wide micropore dimensions of 0.74 nm (Breck, 1974), significant micropore volume and the high thermal stability, Na-X may be an appropriate material for gas purification from SO_x, CO_x and Hg. NaP1 and sodalite have too small effective pore dimensions for accepting bigger gas molecules, but can be good adsorbents for water vapor.

References

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Table 1:

Material	S_{BET} [m²/g]	V_{mic} [mm³/g]	S_{mez} [m²/g]	V_{mez} [mm³/g]
fly ash	10	5	9	15
sodalite	28	11	18	29
NaP1	39	15	33	49
Na-X	231	90	46	71