Perlites – attractive low cost raw materials for synthesis of microporous molecular sieves with useful properties

Перлитът – евтина природна суровина за синтез на микропорести молекулни сита с полезни свойства

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Introduction

Perlite is abundant raw material in Bulgaria (Yanev, 1987). Large perlite deposits are also found in Australia. It is an attractive low-cost source of Si and Al for synthesis of molecular sieves possessing high potential for various applications. Perlite as a starting material for synthesis of micrporous phases have already been applied by Barth-Wirching et al. (1985), Khodabandeh and Devis (1997), and others.

The purpose of the present work is to verify the possibility for hydrothermal transformation of two perlite samples from different deposits with different phase compositions into highly added value microporous materials. Perlites from Schupenata Planina deposit (East Rhodopes, Bulgaria) and Numinbah deposit (Qeensland, Australia) were used and the properties of the obtained crystalline phases were inspected.

Materials and methods

Naturally occurring rhyolitic glass (perlite, kindly supplied by Y. Yanev) was used as a starting material (chemical composition in wt%) – 80.44 SiO_2, 11.83 Al_2O_3, 5.68 K_2O, 1.60 Fe_2O_3, 0.39 TiO_2, and 0.06 MnO_2). The used perlite was crushed and milled to a fraction less than 0.25 mm. The Numinbah perlite appears black and after been milled in agate mortar becomes gray. The samples were used as received, not dried and thermally expanded.

Merlinoite was reproducibly synthesized from the Bulgarian perlite in the presence of 2N KOH solution at different solid /liquid ratios and temperatures from 100 to 140 °C. At higher temperature (140 °C) and solid/liquid ratio = 0.5 and 43 h hydrothermal treatment merlinoite is obtained with the yield of about 85 wt%. A supplementary method was elaborated to

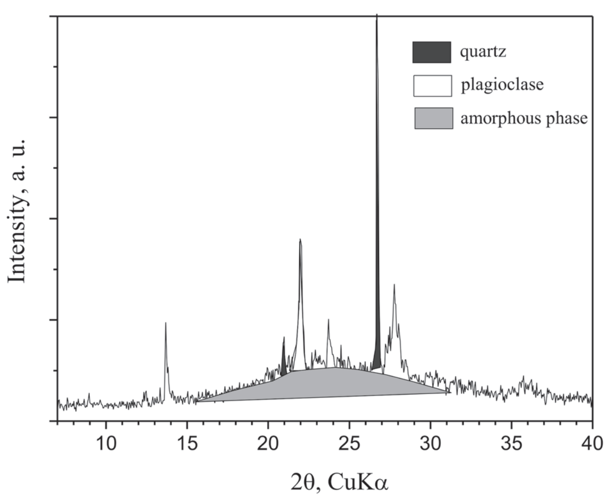

Fig. 1. Powder XRD patterns of perlite from Schupenata Planina

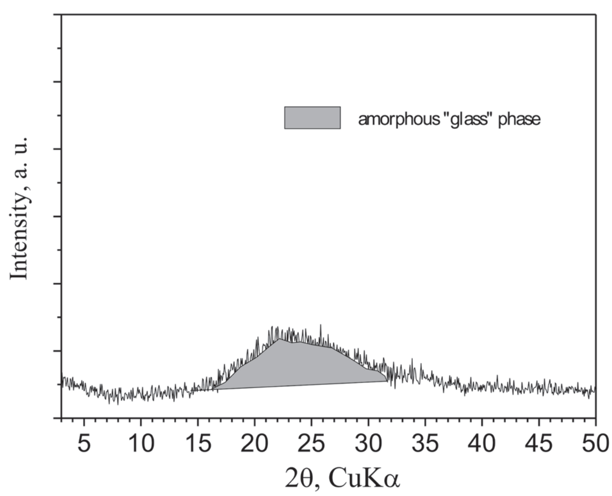

Fig. 2. Powder XRD patterns of perlite from Numinbah

nano-sized zeolite EMT preparation, which utilizes the waste mother waters from this synthesis for transformation of Numinbah perlite into phillipsite. The method is reproducible and cheap.

The SEM and EDS analyses were performed at 20 kV accelerating voltage on a ZEISS EVO 25LS with an EDAX Trident system. The powder XRD patterns were recorded on diffractometer D2 Phaser (Bruker) with CuK_α radiation (30 kV, 10 mA).

Cation exchange was studied at 298 K by a bath-exchange method inspecting the K^+, Cs^+ and Sr^{2+} cations removal from the model water solution.

Results and discussion

The performed phase analyses on both perlites are based on the powder XRD patterns demonstrated on Figs. 1 and 2.

Apart from the glassy material (~75%), the Bulgarian perlite contains quartz (~10–15%), sanidine (~5–10%), and plagioclase (<5%). The Numinbah perlite is totally glassy.

The successfully synthesized merlinoite from Schupenata Planina perlite is demonstrated on Fig. 3 (powder XRD pattern and Fig. 4 (SEM morphology).

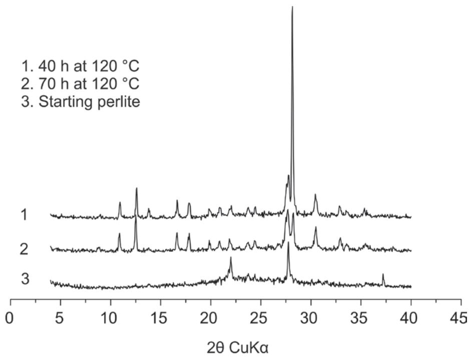

Fig. 3. Powder XRD patterns of perlite and the as-synthesized merlinoite at 120 °C for 40 and 70 h

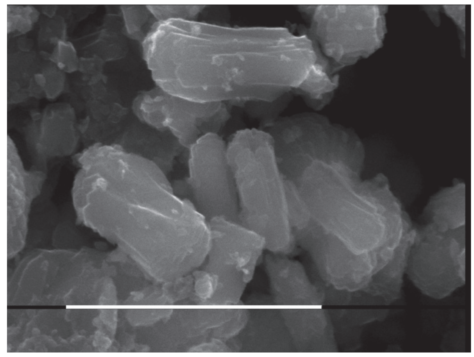

Fig. 4. SEM image of merlinoite crystal intergrowths obtained at 120 °C for 40 h; bar – 10 μm

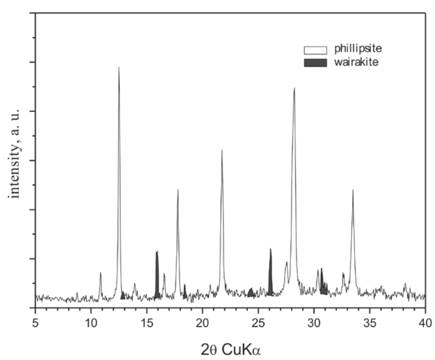

Fig. 5. Powder XRD pattern of microporous phase(s) synthesized from Numinbah perlite

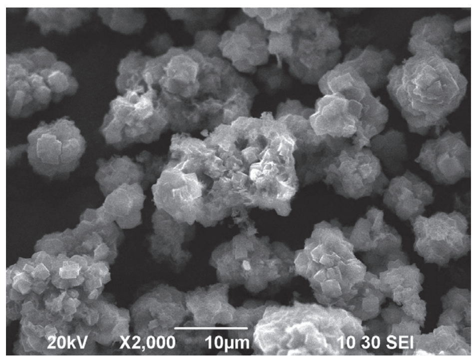

Fig. 6. SEM image of phillipsite obtained via hydrothermal treatment of Numinbah perlite

Phillipsite was obtained from Numinbah perlite after 72 h of hydrothermal treatment at 90 °C (Figs. 5 and 6). The XRD phase analysis gives: phillipsite as major component and wairakite as subordinate one.

The phillipsite sample was tested as ion-exchanger with solutions containing K^+, Cs^+ and Sr^{2+} for simulated fixation of radioactive analogues of these ions. Cation-exchange effectiveness was also tested for Cs^+ and Sr^{2+} solutions, contaminated with nonionic surfactant Pluronic 123. The obtained distribution coefficients for K^+, Cs^+ and Sr^{2+} ions for the phillipsite sample are comparable or better than the ones, reported in the literature for synthetic titanium octahedral molecular sieve.

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