ZEOLITE FOR DRYING OF ETHANOL-WATER AND METHANOL-WATER SYSTEMS FROM A NIGERIAN CLAY RESOURCE

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ABSTRACT

Synthetic zeolite (Zeolite A) was produced from local kaolinitic clay mineral obtained from Ukpor, Anambra state, by treating pulverised kaolin calcined at 700°C with sodium hydroxide. Following further activation at 400-550°C, the zeolite was used to dry ethanol-water and methanol-water systems. A comparison was made of the drying capacities and intensities of the zeolite and untreated kaolinite clay. Breakthrough curves of water content against time for the two solvent systems using the zeolite and activated clay were obtained and compared. Results showed that the zeolite was more effective than untreated clay for the uptake of water in both systems.

Keywords: adsorbents, breakthrough curves, zeolite, kaolinite clay.

INTRODUCTION

The choice of desiccants or adsorbents for drying organic liquids is restricted because of the need to avoid all substances likely to react with liquid. In some cases, direct distillation of organic liquids has been used as a suitable method of drying especially if low-boiling azeotropes are formed. On the other hand, addition of extractive solvents such as benzene can be used to facilitate distillation in azeotropic distillation. In addition, distillations intended to yield anhydrous products substances such as calcium chloride, silica gel are fitted to the apparatus in guard – tubes to prevent entry of moist air into the system as many anhydrous organic liquids are appreciably hygroscopic. At present zeolites (molecular sieves) have found application in many areas including as adsorbents for the uptake of water from organic solvents [1, 2]. The up-take of water or other species in zeolites is called adsorption and functions on the basis of physical adsorption contrary to chemisorption. The main driving force for adsorption is the highly polar surface within the pores. This unique characteristic distinguishes zeolites from other commercially available adsorbents, enabling an extremely high adsorption capacity for water and other polar components even at very low concentrations [3]. In addition, the pore size plays a significant role, allowing or prohibiting the entrance of molecules to the pore system. The adsorption on molecular sieves is therefore dependent on physical molecular properties such as size and shape and molecular polarity. Molecules larger than the pore opening of the molecular sieve can not be adsorbed whereas
smaller molecules can. Molecules with large polarity or polarisability can be adsorbed preferentially under identical conditions. The adsorption process is fully reversible and of purely physical nature. The structure of the zeolite remains intact during the adsorption process (and its subsequent regeneration), and dissolution effects such as occur with other drying agents like calcium compounds can not happen. Thus, this work investigates the drying of organic liquids, ethanol and methanol, using zeolites produced from Ukpor kaolinite clay obtained from Ukpor in Anambra state, Nigeria. The work is part of a series of on-going research and development on the production of catalysts, supports and zeolites from Nigerian clay resources. The Ukpor clay resource is estimated at about 12 million tonnes [4] and has been largely unexploited. Its exploitation would be beneficial to the nation’s economy in the area of conservation of foreign exchange and development of raw materials from local resources.

EXPERIMENTAL

Materials

Materials and chemicals used include sodium hydroxide, ethanol, methanol, deionised water and Ukpor kaolinite clay sample. The chemicals were analytical grade and used without further purification. Equipment used in this work includes common glassware, electric furnace, oven and Abbe refractometer and IR spectrophotometer (ATI Mattson genesis series).

Method

Pulverised clay was calcined at 700°C in a furnace for two hours to produce metakaolin. The calcined clay was mixed with sodium hydroxide solution and left at ambient temperature for 16 hours to age. The mixture was then refluxed in a steam bath for 8 hours with intermittent stirring, a procedure used in previous unpublished research by the authors. The product obtained was washed in deionised water and dried in an oven and characterised using IR spectroscopy. The zeolite product was formed into pellets stored in a desiccator prior to use in the percolating column. The zeolite pellets were activated at 500°C prior to use in the percolating column. Ethanol-water and methanol-water mixtures of known compositions were passed through the column and effluents collected at time intervals for the two solvents, respectively. The refractive indices of the samples were used to obtain their water content from the calibration curves. Breakthrough curves of water content against time were obtained for the two systems using both zeolite sample prepared and untreated clay.

RESULTS AND DISCUSSION

Fig. 1 shows the IR spectra of the zeolite produced. The IR spectrum corresponds to that for zeolite A as obtained in literature [6]. This validates the use of this kaolinite for production of Zeolite A molecular sieve. Figs. 2-5 show the breakthrough curves for the uptake of water from ethanol-water and methanol-water mixtures using the zeolite produced and raw untreated kaolin. It can be seen that bimodal or double step curves were obtained. This would indicate that crystalline or micropores (about 8 Å in diameter) as well as

![Fig. 1. IR spectra of the zeolite produced.](image-url)
CONCLUSIONS

It has been shown in this work that zeolite produced from Ukpor kaolinite clay is an effective water adsorbent for the ethanol-water and methanol-water systems. The Ukpor kaolinite clay resources can be fully exploited for the production of adsorbents and even catalysts. Nigeria therefore stands to benefit immensely from the development of this raw material for use in many areas of its fledgling chemical industry. In addition, the ease of regeneration adds to both the economic impetus and environmental friendliness.

REFERENCES