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Optimization of Uranium (VI) Adsorption Parameters Using Commercial Nay Zeolite: A Factorial Experimental Design Approach

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ABSTRACT

This study focuses on two main aspects. Firstly, it engages in the activation of a commercial NaY zeolite through a cationic exchange process. Activation is performed on three particle size levels of the zeolite, achieved through grinding and sieving. The primary goal of this process is to release the active sites of the zeolite. Secondly, the application of crushed and exchanged materials in uranium recovery was investigated using 2^4 factorial experimental design. The kinetic study of uranium adsorption by three different granulometries of exchanged zeolites (0.4 mm, 1 mm, and 1.6 mm) revealed an equilibrium time of 120 minutes and an enhancement in yields from 19.52% to 80.83% as the zeolite diameter decreased fom 1.6 mm to 0.4 mm, confirming that grinding has increased the zeolite's specific area and subsequently improved the adsorption yields. Factorial design experiments on uranium adsorption by exchanged zeolites allowed understanding the effects of considered factors. The pH, the zeolite diameter and the concentration were found to be highly significant, while the solid-liquid ratio was determined to be non significant. The optimized parameters are:pH= 4.56; [U] =78.86ppm; S/L=16.43g /L; d_I =0, 47mm.

Keywords: Uranium VI, NaY Zeolite, Exchanged zeolite, Factorial design experiments, Statagraphics.

1 Introduction

While the uranium industry plays a crucial role in the nuclear fuel cycle, it, like other industrial sectors, generates liquid effluents throughout processes ranging from uranium ore extraction to the decommissioning of nuclear power plants. These effluents require treatment before discharge into the environment to meet acceptable standards. Activated carbons, clays, and zeolites are frequently utilized porous materials, with zeolites standing out due to their crystalline structure and distinctive physico-chemical properties, particularly in adsorbing pollutants. This study focuses on investigating the potential enhancement of uranium adsorption yields using a commercial zeolite of the NaY type. The approach involves grinding the zeolite to release active sites and subsequently activating it through a cationic exchange process. The uranium adsorption by exchanged zeolites is examined through factorial design experiments[1], utilizing the STATGRAPHICS® computer tool to analyze the results

2 Experimental

a commercial Y Faujasite zeolite (FAU), designated as NaY1.6 with a diameter of 1.6 mm, undergoes a thermochemical treatment to enhance its reactivity. The treatment involves suspending 10g of the zeolite in a concentrated 1M solution of ammonium nitrate (NH_4NO_3) and heating the mixture to 80 °C for 2 hours under reflux. This process is repeated three times to replace sodium cations with ammonium cations in the zeolite. The resulting zeolite, referred to as $NH_4Y1.6$, is filtered, rinsed with hot distilled water, and then dried in an oven at 80 °C for 24 hours [2].. The chemical exchange is depicted in reaction (1):

$$(NH_4^+ NO_3^-) + NaY \rightarrow NH_4Y + NaNO_3 \quad (1)$$

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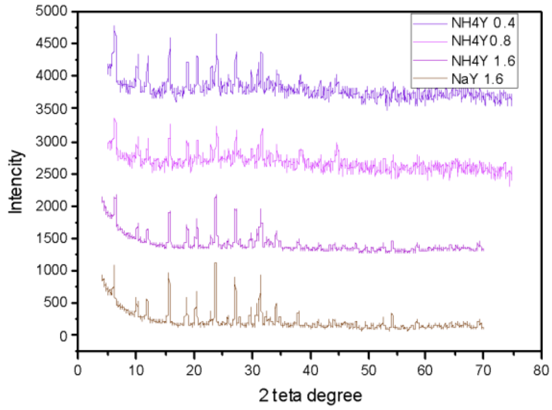
3 Results and Discussion

The X-ray diffraction analysis of NaY zeolite and NH_4Y zeolite (exchanged form) in Figure 1 reveals distinctive patterns. The commercial NaY zeolite shows diffraction lines corresponding to zeolite Y form. The exchanged zeolite exhibits characteristic peaks with a noticeable rightward shift. This shift, observed in various reflections, provides strong evidence of cationic exchange, in line with findings from previous studies [3].

Comparisons between diffractograms of different zeolites (NH4Y1, NH4Y0.4, NH4Y1.6, and NaY1.6) further emphasize the rightward shift in peak positions, particularly in the basal reflection d (001). Thermal and FTIR analyses confirm the occurrence of cation exchange between sodium cations (Na^+) in NaY zeolite and ammonium cations ($NH4^+$) from the NH_4NO_3 solution.



Additionally, factorial design experiments identify pH and zeolite diameter as highly significant factors influencing uranium adsorption yields. On the other hand, the solid-liquid ratio and concentration are deemed less influential. The mathematical model expressing the relationship between the experimental factors and uranium adsorption is provided, allowing for a quantitative understanding of the process.

4 Conclusions

A clear improvement in yield is observed with the decrease in the diameter of the zeolites, confirming that the grinding of zeolites enhances the adsorption yield. The factorial planning of the experiments proved to be highly useful and effective for the study of uranium adsorption by NH4Y zeolites. This method allowed us to understand the effects of the considered factors, with pH and diameter proving to be very significant, while the solid-liquid ratio was not significant and the concentration was only mildly significant. The optimal parameters obtained through factorial planning are: pH = 4.56; [U] = 78.86 ppm; S/L = 16.43 g/L; Diameter (di) = 0.47 mm.

References

[1] J .GOUPY: Pratiquer les plans d'expérience :Ed Dunod,Paris,France,2005 .

[2] M.S. Aghakhani, A.A. Khodadadi, Sh. Najafi, Y. Mortazavi, Enhanced triisopropylbenzene cracking and suppressed coking on tailored composite of Y-zeolite/amorphous silica–alumina catalyst, Journal of Industrial and Engineering Chemistry, Volume 20, Issue 5, 2014, Pages 3037-3045, ISSN 1226-086X, https://doi.org/10.1016/j.jiec.2013.11.040.

[3] Wang, L. Crystal-chemical studies of cation-exchanged zeolite A. 2016.

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