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Influence of Axial Impeller Off-Bottom Clearance on Copper Exchange Kinetics on Zeolite NaX in Batch Reactor

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Highlights

- The effect of impeller off-bottom clearance and zeolite mass concentration was investigated.
- Critical impeller speed increases with impeller position and zeolite mass concentration.
- Rate of copper exchange is affected by impeller position and zeolite mass concentration.
- Amount of copper exchanged is affected only by zeolite mass concentration.

1. Introduction

In heterogeneous solid-liquid systems, mixing need not only to ensure complete solid suspension but also the optimal hydrodynamic conditions regarding product properties and power consumption. Process of ion exchange in a batch reactor could be limited by film diffusion, particle diffusion and chemical reaction. In that case, hydrodynamics could play an important role in minimization of the diffusion layer thickness. The focus of this work was to analyze the influence of hydrodynamic conditions generated by pitched blade turbine at different impeller off-bottom clearances (C/H) on the kinetics of copper exchange on zeolite NaX. Also, the effect of mass concentration of zeolite on ion exchange rate and amount of copper exchanged was determined. Blanchard kinetic model was used to test the experimental kinetic data.

2. Methods

Experiments in this research were conducted in a baffled glass reactor of 2.14 dm^3. Reactor diameter, d_T, was 0.14 m and was equal to suspension height, H. Mixing was performed using four blade 45°- pitched blade turbine (D=0.065 m). Solution containing Cu^{2+} was prepared by dissolving $Cu(NO_3)_2 \cdot 3H_2O$. The initial concentration (7 mmol/dm^3) was checked by *Perkin Elmer Lambda 25 UV/VIS* spectrophotometer. Size of zeolite particles was in range from 0.071-0.09 mm. In the first part of this investigation the impeller speed which ensured the state of complete suspension (N_{JS}) was determined by Zwietering's visual method [1] for three impeller off-bottom clearances (C/H=0.1 - 0.5) and four zeolite mass concentrations (γ=5-8.75 g/dm^3). Also, at all examined mixing conditions torque was measured by *Lightnin LabMaster LB2* and the power consumption per unit mass of suspension was determined. In the second part of the investigation, kinetics experiments were carried out at just suspended impeller speed (N_{JS}) for all impeller positions and zeolite mass concentrations used. Solution temperature was kept constant (T=300K). Obtained experimental rate data, were fitted using the Blanchard model [2] and Blanchard rate constant, for all experiments was calculated.

3. Results and discussion

When a process is carried out in an agitated reactor at the state of complete suspension, characterized by N_{JS}, all particles are in motion and no particle remains on the tank base for more than a short period of time. Figure 1a. shows that N_{JS} increases with an increase of zeolite mass concentration and impeller off-bottom clearance. But the influence of the latter is more pronounced. This is a consequence of hydrodynamic conditions which change with impeller position (Figure 2.). This eventually reflected on the values of power consumption (Figure 1b.) and rate of copper exchange (Figure 3.) which, also, follow this trend. Both are highest at C/H=0.5 and γ=8.75 g/dm^3. Unlike the mentioned parameters, the amount of copper exchanged does not depend on impeller off-bottom clearance (Figure 3.) but it decreases with an increase of zeolite mass concentration.

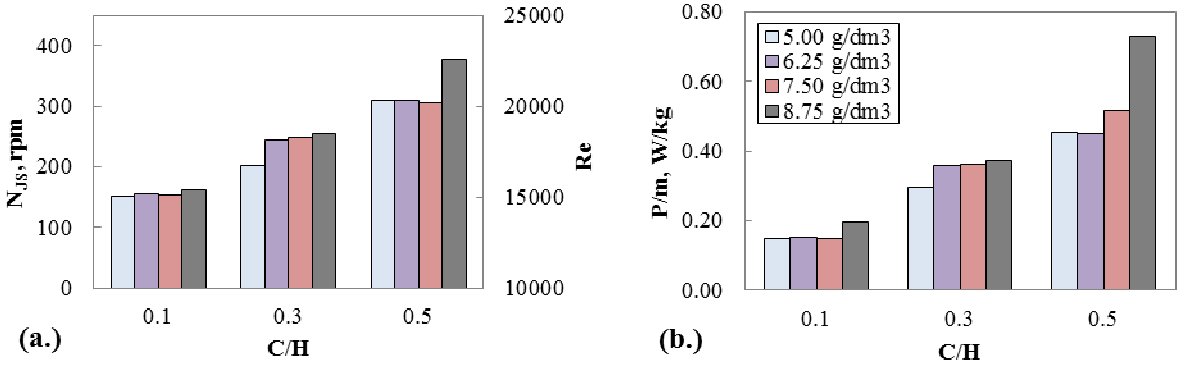

Figure 1. Dependence of N_{JS} (a.) and P/m on impeller off-bottom clearance at different zeolite mass concentrations.

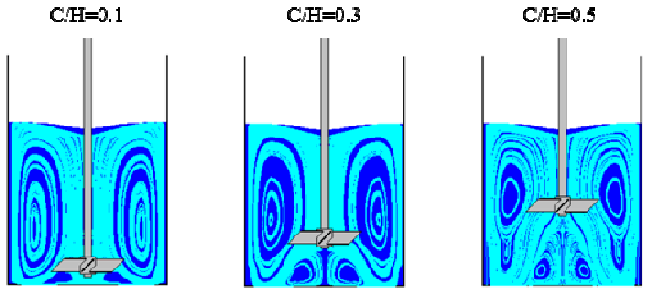

Figure 2. Simulation of hydrodynamic conditions generated by PBT impeller at different impeller off-bottom clearances.

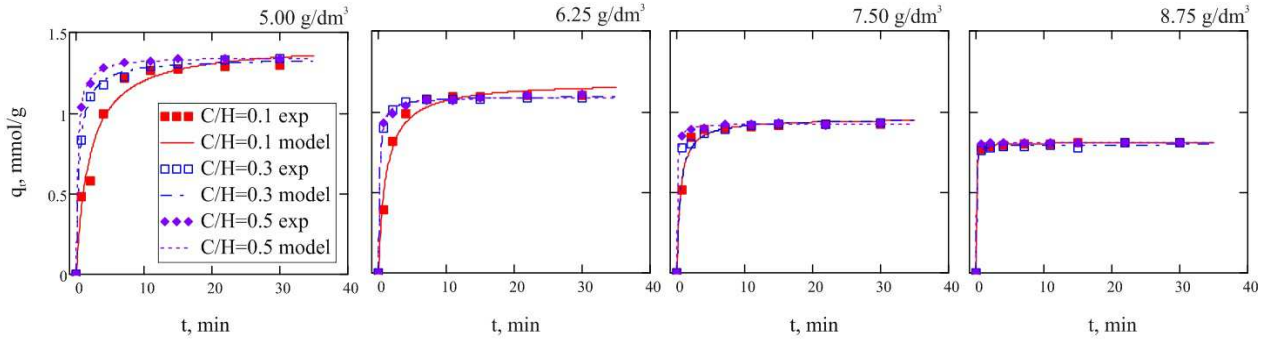

Figure 3. Experimental rate data and Blanchard model verification

4. Conclusions

Due to the change in hydrodynamic conditions in the reactor, an increase of impeller off-bottom clearance results in an increase of the critical impeller speed, power consumption and rate of copper exchange on zeolite NaX. An increase of mass concentration, affects not only the stated analyzed process variables but the amount of copper exchanged as well, which decreases with γ.

References

[1] N. Zwietering, Chem. Eng. Sci. 8 (1958) 244-253.
[2] G. Blanchard, M. Maunage, M. Martin, Water Res. 18 (1984) 1501-1507.

Keywords
"zeolite", "ion exchange kinetics", "batch reactor", "PBT impeller off-bottom clearance".