Adsorption-Desorption Mechanism and Kinetic Study of Synthesized Iron Doped Zeolite for Phosphate in Aqueous Phase

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Abstract

Zeolite-A and Fe-zeolite were synthesized using the sol-gel hydrothermal method. The removal of phosphate from an aqueous solution was performed by adding 2 g PO43-/L of Z-A and Fe-zeolite-A separately and compared. XRD, SEM, EDS, FTIR and XPS characterization techniques were used to decipher the adsorption-desorption mechanism. The synthesized Fe-zeolite-A adsorbed and desorbed phosphate much faster than any other reported study so far. The peak shift in the XPS (Fe-2p & O-s), as well as the band shift and change in intensity in the FT-IR spectra (–OH) of the zeolite backbone, confirmed the involvement of ligand exchange mechanism. In the working pH, H2PO4^{-} acted as a ligand and formed a surface complex with Fe through OH bond, whereas at alkaline pH it was desorbed into the solution in the form of HPO42^{-}. The EDS data, Si–O–Al band shift and intensity change in FT-IR, along with the change in peak and intensity of Al-2p in XPS proved the involvement of Al in adsorption and desorption process. As zeolites are more selective to H+ ion, it exchanged its Na+ ion in the phosphoric acid medium due to reaction with acid. It was also confirmed by EDS data, XPS peak intensity and constant increase in pH of the solution towards neutralization due to the decrease in H+ ion. The adsorption data of phosphate onto Fe-zeolite-A fitted well with Langmuir's isotherm model and pseudo-second-order kinetic model, which means that the amount of PO43^{-} adsorbed depends on the surface area of adsorbent regardless of the concentration. The amount of PO43^{-} adsorbed by the metal ions is 156.47 mg PO43^{-}/g Fe and 16.19 mg PO43^{-}/g Al and the adsorption rate was found to be 5.216mg/g Fe·min and 0.54mg/g Al·min.

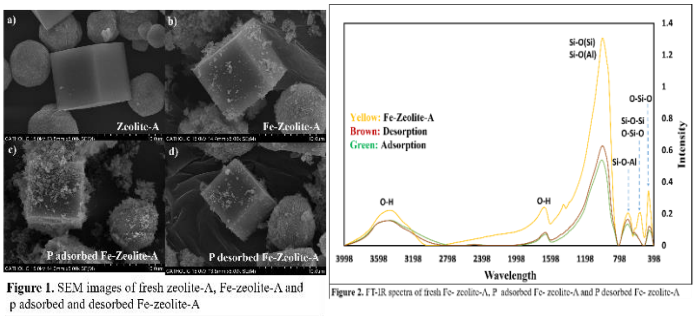


Figure 1. SEM images of fresh zeolite-A, Fe-zeolite-A and p adsorbed and desorbed Fe-zeolite-A

Figure 2. FT-IR spectra of fresh Fe- zeolite-A, P adsorbed Fe- zeolite-A and P desorbed Fe- zeolite-A

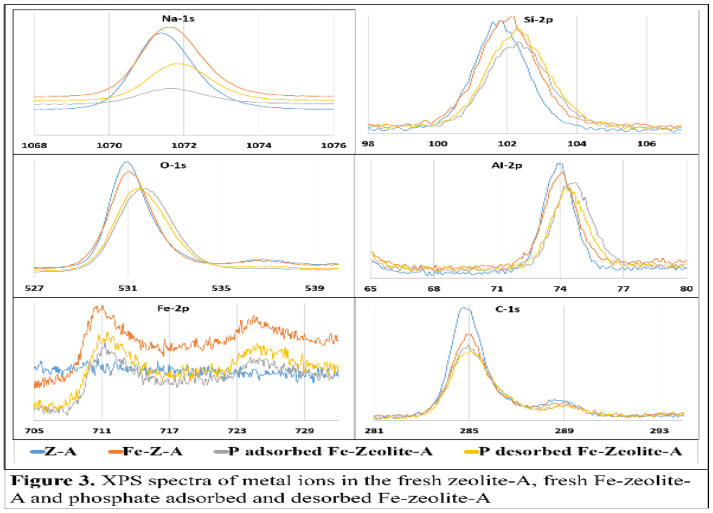


Figure 3. XPS spectra of metal ions in the fresh zeolite-A, fresh Fe-zeolite-A and phosphate adsorbed and desorbed Fe-zeolite-A

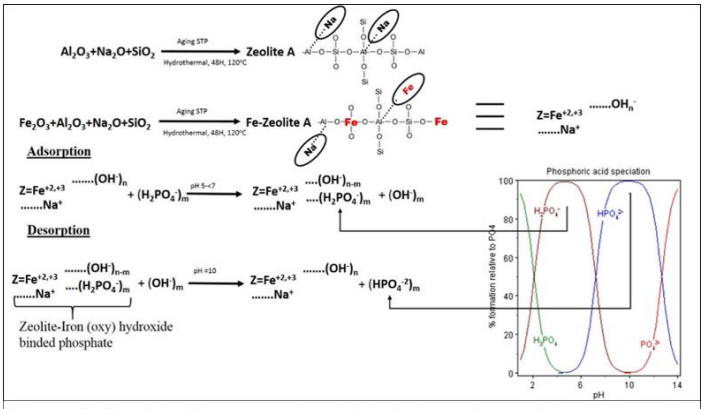


Figure 4. Explains the mechanism behind adsorption and desorption of phosphate from the surface of iron incorporated Fe-zeolite-A zeolite

Recent Publications

1. Hendrik EVVB, & Bert M (2015) Phosphorus promotion and poisoning in zeolite-based materials: synthesis, and catalysis. Chem. Soc. Rev. 44:7406–7428.
2. Vira S, Jaroslaw G, Anna H (2016) Mechanism of Phosphates Sorption by Zeolites Depending on Degree of their Substitution for Potassium Ions. Chemistry & Chemical Technology 10:2: 235-240.
3. Yinhai H, Hai L, Yingbo D, Liang W (2017) Preferable adsorption of phosphate using lanthanum-incorporated porous zeolite: Characteristics and mechanism. Applied Surface Science 426: 995–1004.



Biography

Professor Kwang Soo Kim, is the corresponding author of this article. Professor Kim pursued his PhD from Inha University, South Korea. Currently, he is a Professor at University of Science and Technology Korea, South Korea and a Senior Research Fellow at Korea Institute of Civil Engineering and Building Technology. He is the PhD supervisor of Md Saifuddin, the presenter of this research work. Professor Kim has published many research articles on mitigation of wastewater and polluted air in many renowned international journals. He has more than dozen international patents which has been commercialized.

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