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Adsorption and desorption mechanisms and kinetic study of synthesized iron doped zeolite for phosphate in aqueous phase

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For the removal of phosphorus from wastewater to prevent eutrophication, zeolites are considered as the most robust, reliable and budgetary adsorbent. In this study, Fe-zeolite-A was synthesized using sol-gel hydrothermal method. SEM, EDS, XRD, XPS and FT-IR characterization of the samples were conducted to confirm the proper synthesis of Fe-zeolite-A and to decipher the mechanism behind adsorption and desorption. XPS data suggests that the Fe ion got incorporated into the zeolite-A framework in the sites of Si, Al and Na. The synthesized iron zeolite adsorbed and desorbed phosphate much faster than zeolite-A. The peak shift of Fe-2p and O-1s in the XPS, as well as the band shift and change in intensity in the FT-IR spectra of the zeolite backbone corresponding to –OH bending and stretching confirmed the involvement of ligand exchange mechanism. In the working pH, H_2PO^{4-} acted as a ligand and formed 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 change in peak and intensity of Al-2p in XPS proved the involvement of Al in adsorption through precipitation and desorption by releasing the free aluminum in the form of AlPO4-. As zeolites are more selective to H+ ion, it exchanged its Na+ ion in the phosphoric acid medium due to reaction with acid and formed soluble NaH_2PO_4. It was confirmed by EDS data, XPS peak intensity and constant increase in pH of the solution towards neutralization due to decrease in H+ ion. In the desorption phase, the H+ ion in the zeolite got exchanged with Na+ due to addition of adequate NaOH to maintain alkalinity. 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 5.216 mg/g Fe·min and 0.54 mg/g Al·min.