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Aqueous phosphate removal behavior of chemically synthesized vaterite nanoparticles: Isotherms and kinetic study

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Eutrophication is one of the most adverse impacts of nutrient contamination of water bodies. Recent studies have shown that the primary limiting factor for eutrophication is phosphorus. We developed a vaterite polymorph of porous calcium carbonate nanoparticle to remove phosphate ions in water. These nanoparticles were synthesized using calcium acetate and sodium bicarbonate in a water-ethylene glycol media at a temperature of 100°C in a reaction time of 24 hours and characterized by the X-Ray Diffraction and the Fourier transform infrared spectroscopy which show the presence of vaterite. Particle size was 25.5 nm, and the Scanning Electron Microscopy coupled with Energy Dispersive X-Ray Analysis show the spherical vaterite nanoparticles and the presence of calcium, carbon and oxygen. The phosphate removal efficiency was tested with different concentrations of phosphate solutions (2 ppm – 80 ppm), pH levels (5 – 12), adsorbent dosages (0.05 g – 0.25g), and contact times (0 – 120 min). Ion chromatography was used to analyze phosphate in water samples. The maximum adsorption percentage of 100% was obtained with 50 mL of 2 mgL^{-1} phosphate solution and 0.15 g of the synthesized nanoparticle. Adsorption data were well fitted with the Langmuir adsorption isotherm model and the pseudo-second-order kinetic model with R^2 of 0.99 and 0.98 (Rate constant - 0.083 $gg^{-1}min^{-1}$), respectively. Phosphate adsorption is not influenced in the presence of F^-, NO_3^- and SO_4^{-2} as phosphate shows 100% removal in the presence of them. The study presents a viable option for removing excess phosphate and controlling eutrophication.

Keywords: adsorption, phosphate, nanoparticle and removal efficiency

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