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Adsorption of phosphate into waste oyster shell: thermodynamic parameters and reaction kinetics

Wan-Ting Chen, Chiao-Wen Lin, Po-Kang Shih*, Wen-Lian Chang

Department of Bioenvironmental Systems Engineering, National Taiwan University, No. 1, Sec. 4, Roosevelt Rd., Da'an Dist., Taipei 106, Taiwan
Tel. +886 2 3366 3459; +1 801 318 2852; Fax: +886 2 3366 3470; email: d99622004@ntu.edu.tw

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ABSTRACT

The present study explored the feasibility of exploiting an oyster shell as an adsorbent to remove the phosphate pollutants under different laboratory experimental conditions. The batch sorption was investigated for the solution temperature and the size of the oyster shell fragments. The results demonstrated that phosphate uptake capacity (q_e) increased with an increase in the solution temperature from 20 to 30°C and a decrease in the oyster shell diameter from 590 to 180 μm at an initial phosphate solution concentration of 10 mg/L. The thermodynamic parameters of the adsorption process were calculated. The positive value of ΔH° (40.61 kJ/mol) indicated that the adsorption of phosphate on oyster shell was endothermic; the positive value of ΔS showed good affinity of the phosphate toward the oyster shell; the positive value of ΔG (12.60 kJ/mol) suggested that the adsorption of phosphate into an oyster shell was a nonspontaneous reaction. Following the evaluation of the thermodynamic parameters, different kinetic models, including pseudo-second-order, Elovich, and intra-particle diffusion kinetics models, were studied to evaluate the adsorption process of the phosphate into an oyster shell. The pseudo-second-order kinetic model best fitted the phosphate adsorption into a waste oyster shell. This showed that the chemisorption mechanism plays a significant role in the adsorption process. The linear form of Elovich model revealed that the actually reacting solid surface, oyster shell, was energetically heterogeneous. The intra-particle diffusion model demonstrated that the diffusion mechanism was not the dominant rate-limiting step. The above results successfully established good potentiality for the application of waste oyster shell as a phosphate pollutant removal source.

Keywords: Adsorption; Phosphate; Kinetics; Thermodynamics

*Corresponding author.

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