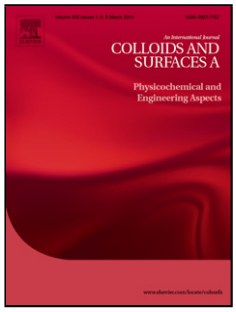

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Organo-vermiculites modified by low-dosage Gemini surfactants with different spacers for adsorption toward *p*-nitrophenol

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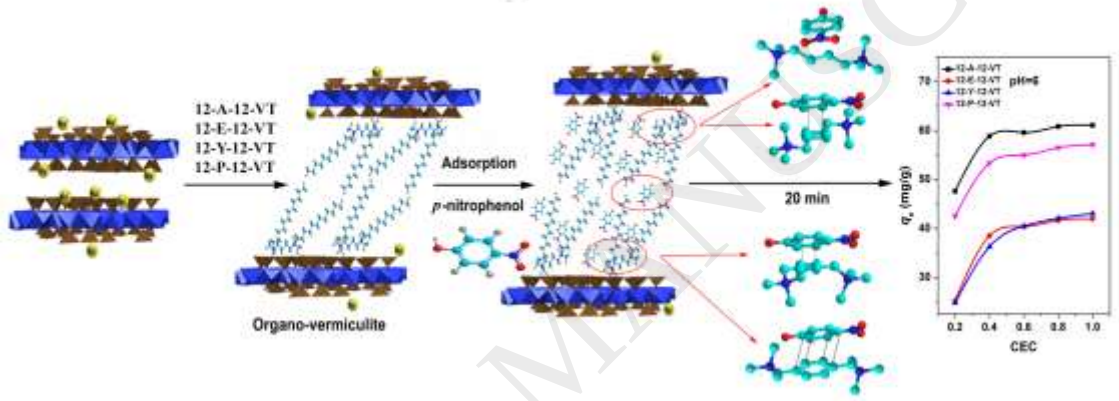
Graphical abstract



Abstract

Butyl group and unsaturated groups (2-butenyl, 2-butynyl and dimethylphenyl) have been introduced as spacers of Gemini surfactants for modifying vermiculite (VT) to exploit easily industrialized adsorbents and to explore systematically the effects of spacers on the adsorption of *p*-nitrophenol (PNP). Four organo-vermiculites (OVTs including 12-A-12-VT (alkyl), 12-P-12-VT (dimethylphenyl), 12-E-12-VT (2-butenyl), 12-Y-12-VT (2-butynyl)) have been prepared successfully and characterized by FT-IR, XRD, TG, SEM, BET, elemental analysis and Zeta potential. The results show that the four have low saturated adding amount of surfactant (0.4 CEC), and 12-A-12 with flexible alkyl group shows markedly higher loading amount (18.8 wt%) on VT than the three surfactants with rigid unsaturated spacer (16.7 wt%, 15.7 wt% and 15.4 wt%). The batch experiment results of OVTs to PNP demonstrate that the four are ranked by adsorption capacity as follow: 12-A-12-VT >12-P-12-VT > 12-E-12-VT ≈ 12-Y-12-VT, their maximum adsorption all occur at pH = 6 within 20 min and 12-A-12-VT possess stronger removal capacity (q_{max}=106.5 mg/g) than other clay-based adsorbents. Furthermore, Kinetic studies are found pseudo-second-order (R^2 > 0.999) and equilibrium data are fitted well by Freundlich isotherm model (R^2 > 0.98). The calculated thermodynamic parameters exhibit that the adsorption processes