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Mesoporous organic–inorganic hybrid aerogels through ultrasonic assisted sol–gel intercalation of silica–PEG in bentonite for effective removal of dyes, volatile organic pollutants and petroleum products from aqueous solution

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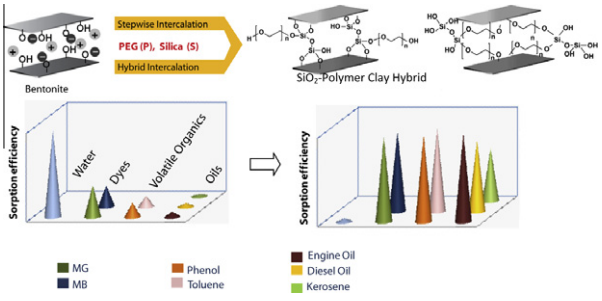
HIGHLIGHTS

- Hybrid organic–inorganic aerogels by ultrasonic assisted sol–gel intercalation.
- PEG grafted silica in the interlayer of bentonite clay.
- Hybrids showed mesoporous nature, high surface area and thermal stability.
- Hybrids demonstrated as good adsorbents for dyes and VOCs from aqueous solution.
- Hybrid aerogels exhibited good oil absorption efficiency with petroleum products.

GRAPHICAL ABSTRACT

Hybrid organic–inorganic aerogels with predominant mesoporous and marginal microporous nature, high surface area and thermal stability were obtained through a facile ultrasonic assisted sol–gel intercalation of SiO_2 and PEG in bentonite clay. The hybrids acted as highly efficient, multifunctional adsorbents for different environmental pollutants.



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ABSTRACT

Hybrid mesoporous materials with high surface area (1144 m^2/g) and enhanced thermal stability were achieved through ultrasonication assisted sol–gel-intercalation technique using bentonite clay and PEG grafted sol gel silica. Solvent extraction with mixed solvents showed efficient aerogel formation of the hybrids. The products were characterised by small angle X-ray diffraction, Fourier transform infrared spectroscopy, thermogravimetric analysis, scanning electron microscopy, transmission electron microscopy, zeta potential measurement and BET surface area analysis. The XRD analysis showed interlayer spacing of ~43.28 Å. The increasing spacing is interesting in a way that the available interior pore volume can be tailored for the enhanced adsorption of different pollutants. Clay-hybrid porous materials showed hydrophobic nature with high adsorption capacities for organic dyes (methylene blue and malachite green), volatile organic pollutants (phenol and toluene) and petrochemical derivatives (kerosene, engine oil and diesel). The contact time necessary to attain adsorption equilibrium and the optimum pH were found to be 2 h and 5.0–6.0, respectively. Kinetics of adsorption was rapid film diffusion with a pseudo-second-order rate constant. The best interpretation for the equilibrium data was given by the Langmuir isotherm indicative of homogenous surface and maximum adsorption capacity of clay-hybrid towards methylene blue, malachite green, phenol and toluene from aqueous solution was found to be 101.55, 98.42, 116.75 and 114.10 mg/g, respectively, and was found to be greater than commercial adsorbents like activated carbon, zeolite and activated alumina. Thermal regeneration studies were carried out by calcinating the exhausted adsorbents. Clay-hybrid aerogels were then demonstrated using different petroleum products to exhibit excellent oil absorption properties.

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