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Adsorption of natural organic matter analogues by multi-walled carbon nanotubes: Comparison with powdered activated carbon

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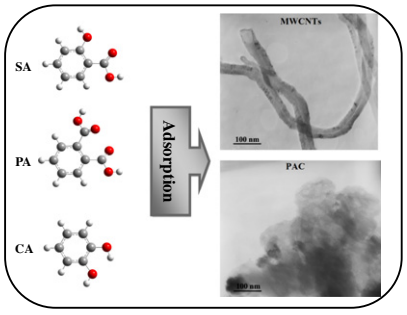
HIGHLIGHTS

- Adsorption of three NOM analogues on MWCNTs and PAC was investigated.
- MWCNTs possessed lower adsorption capacities towards the three compounds than PAC.
- Four adsorption mechanisms acted simultaneously but had different contribution.
- Thermodynamic parameters (ΔG^0, ΔH^0 and ΔS^0) depended on the adsorbate loadings.
- This study is essential for further assessing the risks of carbon nanomaterials.

GRAPHICAL ABSTRACT



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ABSTRACT

With increasing production and application of carbon nanotubes (CNTs), the interaction between CNTs and natural organic matter (NOM) in water has been attracting more and more concerns. In this study, adsorption of three NOM analogues including salicylic acid (SA), phthalic acid (PA) and catechol (CA) on multi-walled carbon nanotubes (MWCNTs) as well as commercial powdered activated carbon (PAC) were investigated. All adsorption isotherms were fitted well by Freundlich isotherm model ($R^2_{adj} > 0.99$), which was supported by the site energy distribution analysis. PAC possessed 2–10 times higher adsorption capacities towards the three compounds than MWCNTs, indicating the presence of pore-filling effect. Hydrophobic interaction, electrostatic interaction, hydrogen bond and π–π interaction acted simultaneously but had different contributions in the adsorption of the three NOM analogues on PAC and MWCNTs. Thermodynamic analysis revealed that SA and PA adsorption on the two adsorbents were exothermic while CA endothermic. Variation of the thermodynamic parameters including ΔG^0, ΔH^0 and ΔS^0 depended on the adsorbate loadings. These findings are expected to promote the understanding of the interaction between NOM and CNTs for further evaluating the environmental risks of nanomaterials.

1. Introduction

Carbon nanotubes (CNTs) have attracted great attention due to their wide potential applications such as adsorbents, composite materials and pollution prevention reagents [1,2] since their discovery twenty years ago [3]. It was estimated that nearly 350 tons of CNTs were synthesized during 2007–2008 [4], and their global market is projected to reach $ 1 billion in 2014 with annual growth rate of 58.9% [5]. Increasing production and extensive use of CNTs have raised their exposed possibility to natural waters via discharging from manufacturing plants or wearing out from compos-

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