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# Influence of the alkyl chain length of cyanine dyes on their adsorption by $Na^+$-montmorillonite from aqueous solutions

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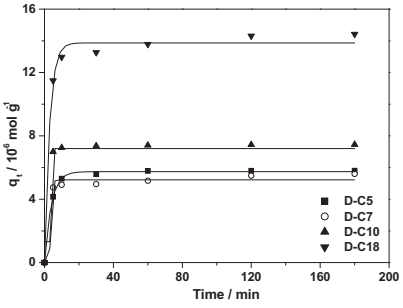
## HIGHLIGHTS

- The adsorption of cyanine dyes from aqueous solution onto $Na^+$-montmorillonite was investigated.
- The kinetics and adsorption isotherms were studied.
- The equilibrium amount of the dye adsorbed depends largely on the alkyl chain length.
- The adsorption of the dye is affected by the conditions controlling the clay/dye interaction.
- The adsorption process is physical, endothermic, and non-spontaneous.

## GRAPHICAL ABSTRACT

The change in the adsorbed amounts of four cyanine dyes as a function of time and alkyl chain length onto $Na^+$-MMT.

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## ABSTRACT

Adsorption of cyanine dyes from aqueous solution onto the surface of $Na^+$-montmorillonite ($Na^+$-MMT) was investigated spectrophotometrically. A set of four linear alkyl chain cyanine dyes (D-$C_5$, D-$C_7$, D-$C_{10}$, and D-$C_{18}$), were used in this work to evaluate the effect of carbon chain length on the efficiency of dye adsorption. The loading of the dye onto $Na^+$-MMT surface was increased with increasing the length of alkyl chain. The effect of the contact time, initial concentration of the dye, pH of solution and temperature on the adsorption process were studied. Adsorption isotherms were established and found to correlate well with the Freundlich, Langmuir, and Dubinin–Radushkevich adsorption models. Values of the constants $K_f$ and $1/n$ determined from the Freundlich isotherm decreased with the increase in the tail length of the dye (D-$C_5$ → D-$C_{18}$). The same trend was observed for the Langmuir adsorption constant, $K_L$. The $E$ values calculated from Dubinin–Radushkevich isotherm increased with increasing the alkyl chain length of the cyanine dyes but still less than 16 kJ $mol^{-1}$, suggesting physical adsorption process. Further, the thermodynamic parameters (the enthalpy, $\Delta H$, Gibb's free energy, $\Delta G$, and entropy, $\Delta S$) characteristics of $Na^+$-MMT/dye interaction were evaluated. The adsorption of cyanine dyes onto $Na^+$-MMT was not spontaneous and endothermic. The magnitudes of $\Delta H$ and $\Delta S$ have dropped on going from D-$C_5$ to D-$C_{18}$. In contrast, as the size of the alkyl tail on the dye increased, Gibb's free energy $\Delta G$ was decreased. As far as the adsorption kinetics is concerned, the present adsorption regime followed pseudo-second-order kinetic model rather than pseudo-first-order model. The intraparticle diffusion model resulted in the existence of both the bulk and intraparticle diffusions of the dye molecules into the interior pore surface of $Na^+$-MMT particles.



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