Removal of methylene blue from aqueous solutions onto *Bacillus subtilis*: determination of kinetic and equilibrium parameters

Aységül Ayla, Aynur Çavuş, Yasemin Bulut, Zübeyde Baysal*, Çetin Aytekin

Faculty of Science, Department of Chemistry, Dicle University, Diyarbakır, Turkey
Tel. +90 412 24 88 550/3193; Fax: +90 412 24 88 300; email: zbaysal@dicle.edu.tr

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**ABSTRACT**

In the present study, *Bacillus subtilis*, a Gram-positive bacteria, was used in dried biomass form as biosorbent for removal of methylene blue (MB) from aqueous solutions. Batch adsorption tests were performed at different contact times, temperatures, pH, adsorbent doses, and initial dye concentration. The adsorption isotherms are described by means of the Langmuir and Freundlich isotherms. It was found that the Langmuir equation fit better than the Freundlich equation. Maximum biosorption capacity was found to be 169.49, 178.57, and 181.82 mg g\(^{-1}\) at 298, 308, and 318 K, respectively. The adsorption kinetics of MB could be described by the pseudo-second-order reaction model. The activation energy of the biosorption (\(E_a\)) was determined as 11.30 kJ mol\(^{-1}\) at initial concentration of 50 mg L\(^{-1}\). Free energy of adsorption (\(\Delta G^*\)), enthalpy (\(\Delta H^*\)), and entropy (\(\Delta S^*\)) changes were calculated to predict the nature of adsorption. The estimated values for \(\Delta G^*\) were -21.22, -22.02, and -23.01 kJ mol\(^{-1}\) at 298, 308, and 318 K, respectively. The enthalpy changes and entropy of adsorption were 5.47 kJ mol\(^{-1}\) and 89.43 J mol\(^{-1}\) K\(^{-1}\), respectively. The experimental data obtained in the present study indicate that *B. subtilis* is a suitable and inexpensive adsorbent which can be used for dye removal in wastewater treatment processes.

*Keywords:* Biosorption; *Bacillus subtilis*; Methylene blue (MB); Thermodynamic parameters