

Enhance the adsorption behavior of methylene blue from wastewater by using ZnCl₂ modified neem (*Azadirachta indica*) leaves powder

Syed Khalid Mustafa^a, Hatem A. Al-Aoh^{a,*}, Suhair A. Bani-Atta^a, Lubna R. Alrawashdeh^b, Meshari M.H. Aljohani^a, Meshari A. Alsharif^a, A.A.A. Darwish^{c,d}, H.S. Al-Shehri^e, Mohammad Ayaz Ahmad^f, Jozza N. Al-Tweher^a, M.A. Alfaidi^g

^aDepartment of Chemistry, Faculty of Science, University of Tabuk, Tabuk 71491, Saudi Arabia, Tel. +6-537692007; emails: issa_hatem2@yahoo.com/halawah@ut.edu.sa (H.A. Al-Aoh), Tel. +6-531210675; email: syed.pes@gmail.com (S.K. Mustafa), Tel. +6-535817359; emails: s_bantatta@yahoo.com/s_bantatta@ut.edu.sa (S.A. Bani-Atta), Tel. +6-553063991; email: mualjohani@ut.edu.sa (M.M.H. Aljohani), Tel. +6-505312500; email: me_alsharif@ut.edu.sa (M.A. Alsharif), Tel. +6-505372056; email: jtowaihar@ut.edu.sa (J.N. Al-Tweher)

^bDepartment of Chemistry, The Hashemite University, P.O. Box: 150459, Zarqa 13115, Jordan, Tel. +00962-791834872; email: lubna.reyad@yahoo.com (L.R. Alrawashdeh)

^cDepartment of Physics and Nanotechnology Research Unit, Faculty of Science, University of Tabuk, Tabuk 71491, Saudi Arabia, Tel. +6-535846573; email: aadarwish@gmail.com (A.A.A. Darwish)

^dDepartment of Physics, Faculty of Education at Al-Mahweet, Sana'a University, Al-Mahweet, Yemen

^eKing Khaled Military Academy, SANG, Jeddah, Saudi Arabia, Tel. +6-506376383; email: h.s.alshehri@outlook.com (H.S. Al-Shehri)

^fDepartment of Physics, Faculty of Science, University of Tabuk, Tabuk, Saudi Arabia, Tel. +6-597747600; email: mayaz.alig@gmail.com (M.A. Ahmad)

^gDepartment of Biological Science, Duba University College, University of Tabuk, Duba, Saudi Arabia, Tel. +6-534373132; email: Malfaidi@ut.edu.sa (M.A. Alfaidi)

Received 10 June 2020; Accepted 23 August 2020

ABSTRACT

Many unwanted by-products containing several hazardous dyes are found in wastewater produced from the manufacturing units, such as printing, leather, paper, textiles, cosmetics, etc. Especial attention is given to overcome this problem, using different treatment methods and adsorbents. From the tree leaves of the neem (*Azadirachta indica*), an adsorbent was developed, characterized, and used for Methylene Blue (MB) elimination from wastewater. The area of the adsorbent surface, pore volume, and average pore width were found to be 58.6 m²/g, 0.106 cm³/g, and 13.8 Å, respectively. The adsorption behavior of MB using the modified powder of neem leaves was investigated under different experimental conditions. The adsorption capacities for MB by chemical modified adsorbent were found to be 370, 434, and 476 mg/g at 298, 313, and 328 K, respectively. The kinetic and isotherm calculated data obeyed the models of second-order kinetic and Langmuir, correspondingly. Constants of thermodynamics like ΔS° , ΔH° , and ΔG° were estimated. The positive values of ΔH° recommend that this adsorption is an endothermic process. The values of ΔG° are negative at the temperatures under investigation (298–328 K), indicating that this adsorption is a spontaneous process.

Keywords: Methylene Blue; Neem (*Azadirachta indica*) leaves; Thermodynamic parameters; Isotherm parameters; Kinetic parameter

* Corresponding author.