



Adsorption of methylene blue onto spinel magnesium aluminate nanoparticles: Adsorption isotherms, kinetic and thermodynamic studies



Bushra Ismail^{a,*}, Syed Tajammul Hussain^b, Sohaib Akram^b

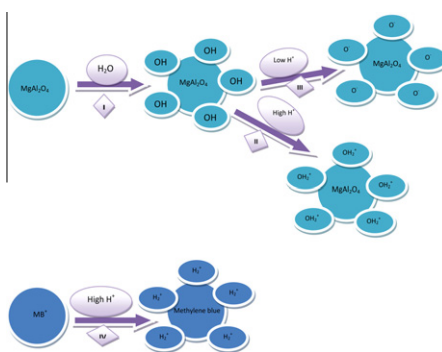
^a Department of Chemistry, COMSATS Institute of Information Technology, Abbottabad 22060, Pakistan

^b Nanoscience and Catalysis Division, National Centre for Physics, Quaid-e-Azam University Campus, Islamabad, Pakistan

HIGHLIGHTS

- ▶ Nanosized MgAl_2O_4 synthesized by coprecipitation method.
- ▶ Mesoporous material having large surface area was obtained.
- ▶ Adsorption favored at neutral pH.
- ▶ Chemisorption process is involved.
- ▶ Multilayer adsorption occurs with interactions between the adsorbed molecules.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:

Received 10 October 2012

Received in revised form 8 January 2013

Accepted 9 January 2013

Available online 17 January 2013

Keywords:

Mesoporous oxide
Water treatment
Adsorption
Isotherms
Kinetics

ABSTRACT

Magnesium aluminate spinel has been synthesized at nanoscale by coprecipitation method. The synthesized material was characterized for the phase composition, quantitative description, surface morphology, surface area, pore volume and pore diameter. X-ray diffraction analysis confirmed the formation of the cubic spinel phase with no peaks corresponding to the impurity phases. The Scherrer crystallite size calculated from line broadening is 20 nm. The pore surface area was found to be $343 \text{ m}^2/\text{g}$ by N_2 vapor adsorption experiments and material was characterized as mesoporous on the basis of pore diameter analysis. The scanning electron micrograph shows the agglomeration of particles while the nanosize is confirmed by the transmission electron micrograph. The porous nature of the material was then explored for carrying out the adsorption of methylene blue solutions onto the surface. Adsorption studies were carried out with 0.1 g of the material and the effect of pH and shaking times were studied and both were found to influence the adsorption. Adsorption data was also fitted to Temkin, Freundlich and the Langmuir adsorption models in order to study the mechanism of adsorption by interpreting the calculated parameters like, heat of adsorption (B_T), binding energy (K_T), degree of adsorption (K_F), heterogeneous factor (n), and energy of adsorption (K_L), binding forces (a_L), and the separation factor (R_L). The pseudo-second order rate constant (K_{p-2}), initial sorption rate (S_{rate}) and the half adsorption time ($t_{1/2}$) were also calculated and explained to clarify the mechanism of adsorption onto MgAl_2O_4 surface. Gibbs free energy was also calculated from the adsorption data at room temperature.

© 2013 Elsevier B.V. All rights reserved.

1. Introduction

Many industries such as textile, chemicals, refineries, leather, plastic, and paper, use different kinds of dye stuffs in various pro-

* Corresponding author. Tel.: +92 992 383 591; fax: +92 992 383 441.

E-mail address: bushraismail@ciit.net.pk (B. Ismail).