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Cost-effective microwave rapid synthesis of zeolite NaA for removal of methylene blue

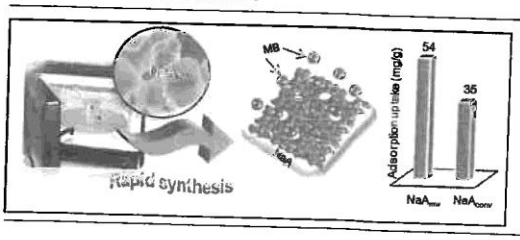
N. Sapawe [a], A.A. Jalil [a,*], S. Triwahyono [b], M.I.A. Shah [a], R. Jusoh [a], N.F.M. Salleh [a], B.H. Hameed [c], A.H. Karim [b]

[a] Institute of Hydrogen Economy, Faculty of Chemical Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia
[b] Ibnu Sina Institute for Fundamental Science Studies, Faculty of Science, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia
[c] School of Chemical Engineering, Engineering Campus, Universiti Sains Malaysia, 14300 Nibong Tebal, Penang, Malaysia

HIGHLIGHTS

- NaA_{mw} was completely formed within 15 min of ageing time.
- NaA_{mw} shows better performances compared to NaA_{conv}.
- Adsorption of MB onto NaA_{mw} takes place as monolayer adsorption.
- Adsorption of MB onto NaA_{mw} was controlled by both physi- and chemi-sorption.
- NaA_{mw} was still stable after five cycling runs.

GRAPHICAL ABSTRACT



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ABSTRACT

In this study, microwave rapid synthesized NaA (NaA_{mw}) was used to adsorb a methylene blue (MB) from an aqueous solution. The adsorption was optimized under four independent variables including: pH, adsorbent dosage, initial concentration, and ageing time based on central composite design (CCD) with response surface methodology (RSM). A period of 15 min was determined to be the optimum microwave ageing time for the synthesis of NaA_{mw}, which is about sixteen times shorter than using conventional heating technique. An amount of 1.0 g L^{-1} NaA_{mw} demonstrated the optimum dosage for adsorption of 120 mg L^{-1} MB, with predicted adsorption uptake of 53.5 mg g^{-1}, at pH 7 within 1 h of contact time at room temperature. This result approximated the laboratory result, which was 50.7 mg g $^{-1}$. The experimental data obtained with NaA_{mw} best fits the Langmuir isotherm model and exhibited a maximum adsorption capacity (q_{max}) of 64.8 mg g^{-1}, and the data followed the first-order kinetic equation. The intraparticle diffusion studies revealed that the adsorption rates were not controlled solely by the diffusion step. Thermodynamic studies showed that the adsorption is endothermic, non-spontaneous in nature, and favor at high temperature. These results confirm that the adsorption process of MB onto NaA_{mw} was controlled by both physisorption and chemisorption. The reusability study shows that the NaA_{mw} was still stable after five cycling runs. These results indicate that NaA_{mw} efficiently adsorbed MB, and could be utilized as a cost-effective alternative adsorbent for removing cationic dyes in the treatment of wastewater.

1. Introduction

The recent rapid increase in the use of the synthetic dyes, especially in the textile industry, is a major contributor to water pollution. Most of these dyes, including methylene blue, are toxic and must be removed from wastewater before discharge into water bodies, to ensure they remain safe for living organisms [1]. Adsorption on activated carbon is a popular method for removing dyes on the industrial scale [2,3]. However, activated carbon is still considered expensive and thus, much research is conducted into exploring the development of low-cost adsorbents, such as natural,

* Corresponding author. Tel.: +60 7 5535581; fax: +60 7 5536165.
E-mail address: aishah@cheme.utm.my (A.A. Jalil).

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PROF. DR. SUGENG TRIWAHYONO
Professor of Chemistry
Ibnu Sina Institute for Fundamental Science Studies
Universiti Teknologi Malaysia
81310 UTM Johor Bahru, Johor, Malaysia

CERTIFIED TRUE COPY

DR. AISHAH ABDUL JALIL
Associate Professor
Department of Chemical Engineering
Faculty of Chemical and Natural Resources Engineering
Universiti Teknologi Malaysia
81310, UTM Skudai, Johor