REMOVAL OF METHYLENE BLUE USING SPENT BLEACHING EARTH
DOPED WITH ZINC OXIDE UNDER VISIBLE LIGHT

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A proposal submitted in the fulfilment
of the requirement for the award of degree of
Bachelor of Engineering (Chemical)

Faculty of Chemical Engineering
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9th JANUARY 2013
Batch experiments are carried out to remove cationic dye, methylene blue (MB), using spent bleaching earth (SBE) as an adsorbent and zinc oxide as the photocatalyst. Spent bleaching earth is a waste that inevitably generated from edible oil processing. Meanwhile, zinc oxide is a semiconductor acts as sensitizers for light-induced redox-processes. Operating parameters studied were pH, initial dye concentration, adsorbent dosage, contact time and catalyst loadings. The dye solution is firstly added with SBE and followed by zinc oxide by stirring of solution for 30 min under visible light. Methylene blue concentration was determined using spectrophotometer. The optimum initial dye concentration is at 25mg/L and optimum contact time of 30min. The adsorbed amount of MB dye on spent bleaching earth increased with increasing pH, spent bleaching earth dosage, contact time and catalyst loadings. The removal of the methylene blue increased with increasing in pH which leads to the increasing number of negatively charged sites that are available. The availability of adequate surface area of adsorbent also affects the percentage removal of MB with time. It was further found that the sorption isotherms follow the Freundlich model with good determination coefficient. From this study, it can be concluded spent bleaching earth and zinc oxide present good removal efficiency of methylene blue. Besides, zinc oxide can enhance the removal of MB.
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Banat, I.M., Nigam, P., Sing, D., Marchant, R., (1996). Microbial decolorization of
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and activated date pits as potential adsorbents for dye containing waters.
*Process Biochemistry* 39: 193-20

Banat, F., Al-Asheh, S., Al-Ahmad, R., Bni-Khalid, F. (2007). Bench-scale and
packed bed sorption of methylene blue using treated olive pomace and
charcoal. *Bioresource Technology* 98: 3017–3025

studies for the adsorption of Acid dye onto modified hectorite. *Journal of
Hazardous Materials* 136(3): 989-992

in wastewater using ZnO as semiconductor catalyst. *Journal of Hazardous
Materials* 112(3): 269-278.

Chandra, T.C., Mirna M.M., Sudaryanto, Y., Ismadji, S., (2007). Adsorption of basic
dye onto activated carbon prepared from durian shell: studies of adsorption
equilibrium and kinetics, *Chemical Engineering Journal* 127: 121-129

on Montmorillonite. *Advanced Materials Research* 454: 305-309.

Chiu, W.S., Khiewa, P.S., Clokea, M., Isa, D., Tana, T.K., Radiman, S., Abd-
Photocatalytic study of two-dimensional ZnO nanopellets in the
decomposition of methylene blue. *Chemical Engineering Journal* 158: 345-352

Cooper, P., (1993). Removing colour from dyehouse waste waters: a critical review
of technology available. *Journal Social Dyers Colorists* 109: 97-100


