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Coating paint for dyes removal: Performance and characteristic

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ABSTRACT

A coating paint (CP) was used as an alternative adsorbent for the removal of dyes from aqueous solution that can be coated on any surfaces. The CP was formulated from a natural adsorbent, binder and a carrier. In the experimental study, the CP coated on the interior surface of glass beakers before tested for adsorption performance. The characterization study of CP has been carried out using SEM and XRF. Among the tested adsorbents and binders, clay-based adsorbent and water-based binder resulted as the most suitable ingredients for CP formula since they performed within shorter time and gave higher percentage dye removal. The mechanism of treatment is based on charge interaction between both materials, CP and Methylene Blue (MB). The net negative charges of CP give capabilities to adsorb positively charges of MB dye. For batch adsorption study, the MB dye uptake by the CP was increased as the initial dye concentration and contact time increase. The percentage removal of MB was found to achieve 99% for 20–100 mg/L concentration and >60% for 200–500 mg/L upon equilibrium within 24 h. The current study revealed the potential of CP as a feasible and practical coating adsorbent for future wastewater treatment technology.
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1. Introduction

The discharge of dye effluents from various industries such as dye stuffs, textiles, paint and varnishes, inks, plastics, pulp and paper, food, rubber and cosmetic to the environment is a major cause of concern nowadays [1]. The environmental issues being a continuing problem for dyestuff manufacturer, dyers, water companies as well as environmental engineer since they are being force by regulatory department to increase the quality of water by reducing the level of colour in effluent and water courses. The dyes in effluents are of serious attention because of their adverse effects on human beings and the environment [2].

As dyes are designed to resist breakdown with time and exposure to sunlight, water, soap, and oxidizing agent, they cannot be easily removed by conventional wastewater treatment processes due to their complex structure and synthetic origins [3]. Besides, the treatment of dyes in industrial wastewater possesses several problems since dyes are generally difficult to biodegrade and photodegradate [4]. For the past twenty years, methods and systems for dye removal have been proposed and developed by many scientists and research engineers [5,6]. However, there are just some of the techniques significantly practical for applications and applied in industries. The use of these technologies for industrial process is still limited due to high budget allocation, low-efficiency and low capability to remove dyes [7].

Wastewater treatment for dyes removal varies from chemical, physical and biological method or appropriate combination of them before the treated water can be safely discharged. In general, each of the technique has its own advantages and limitation factors that need to be considered. Dye removal strategies must have a combination of different techniques due to the existence of benzene rings in the dye structure that can render individual treatment process in order to degrade the organic pollutants [8]. Coagulation, filtration and adsorption methods only transfer organic contaminant from one phase to another which indirectly caused the secondary pollutant to the environment and finally post-treatment of the waste is a prerequisite [8].

Although most of researchers admit that adsorption process is the most versatile and widely used method for water treatment, and claims that adsorption process is low cost, ease of operation and efficient in treatment, it still have its own drawbacks. The cost of overall treatment limits its application in the industries due to the requirement in installing new operating unit for the treatment system. Besides, high overall cost which includes adsorbent cost, adsorption column, adsorbent regeneration, maintenance and waste disposal are also other factors to be considered by industries. Eventually, it has leads to uneconomic investment for now and future prospect.

Nevertheless, this research study still applying adsorption concept and process in a way to cater the dye removal problems. The

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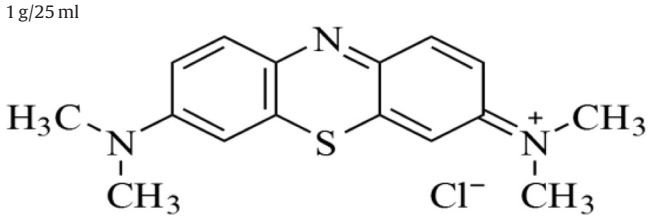
Fig. 1. The target of CP's application.

Table 1
Physical Properties and Molecular Structure of Methylene Blue.

Dye name	Methylene Blue
Color Index Number	52015
Chemical Formula	$C_{16}H_{18}N_3SCI$
IUPAC Number	3,7-bis (Dimethylamino)-phenothiazin-5-ium chloride
Molecular Weight	319.85 g/mol
λ_{max}	664 nm
Solubility in water	1 g/25 ml
Molecular Structure	

adsorbent has been modifying in terms of its form and flexibility to be applied in any surfaces for the removal of coloured wastewater. The adsorbent is in slurry form and targeting to be easily applied on any required surfaces and practical and useful product for the customers. Fig. 1 shows the targeted surfaces for CP application that focusing on coloured wastewater from textiles effluent.

1.1. Innovative application concept of adsorption

The target of CP's application is on drain or piping system from the in-situ textile company. The CP will be coated along the surface of drain that exists between the textile processing plant and textile treatment plant. Formerly after the effluent of colour wastewater being discharge, it will flow through the drain and adsorption process will occur concurrently.

1.2. Easily incorporated with existing plant facilities

The existing plant facilities included reservoir, tank, or sump that functioned as wastewater container will utilize simultaneously as support for CP. The CP which acts as flexible adsorbent will coat in the interior part of container and at the same time the adsorption process will occur inside the tank and finally will result in reduction in wastewater concentration.

1.3. Zero process energy and low maintenance requirements

The flexibility of CP as adsorbent layer 100% depend on existing facilities and does not require equipment or any other sophisticated technology. Even no process energy such as a pump or current is necessary. Low maintenance requirement is only for the painter to coat the CP into surfaces.

In a nutshell, this is an exploratory step in finding a new approach in adsorption process application which will open up options to industries meeting their requirement by providing fundamental results at a different angle of the adsorption concept [9]. This research work is an important building block in giving a new concept for adsorption application and aimed to be economical and easily acceptable by industries.

2. Materials and method

2.1. Adsorbate

The cationic dye, Methylene Blue (MB) is commercial grade supplied by Modern Lab Sdn. Bhd. Malaysia (MB: 97% purity). It was used as adsorbate or surrogate indicator to simulate industrial wastewater in order to evaluate the adsorption capacity of the adsorbent coating, used as received without further modification. The MB selection was guided by its strong adsorption onto solids also for its high solubility in water. One gram of MB dye was accurately weight for a stock solution of concentration 1000 mg/L and was diluted to the required concentrations

Table 2
The Condition Used for the Presence of Binder.

Sample	Bentonite	Binder	Solvent
Sample 1	/		
Sample 2		/	/
Sample 3 (CP)	/	/	/

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