CHAPTER I

INTRODUCTION

I.1. Background

The rapid industrial development causes a rapid increase in waste generation, therefore it is necessary to improve the waste management system to achieve process efficiency. Industrial waste is one source of environmental pollution that contains various kinds of hazardous compounds. The textile industry is reported as one of the largest waste-producing industries, where malachite green (MG) is found contained in it. MG is known to be genotoxic, carcinogenic, thus it can be harmful to the the immune system and reproductive system [1,2]. Furthermore, the leather tanning, paper, food technology, and hair dye industry also known as the source of MG contamination in water body [3,4].

Adsorption is one of the most efficient techniques for reducing MG levels in wastewater. Therefore, an adsorbent with a high capacity is needed to remove the target dye from the liquid waste. Several adsorbents have been developed such as activated carbon [5], bentonite [6], lignin [7], zeolite [8], char [9], graphene [10], GO [11], and RGO [12]. Activated carbon is one of the most widely used adsorbents in industrial waste treatment. However, this material generally have a low adsorption capacity value of ~ 90 mg MG/g and low reusability performance [5,13]. Recently, graphene-based adsorbents have received great attention owing to its superior physical, mechanical and chemical features. Their very high surface area, large delocalized π-electron systems, enhanced active sites, and good chemical stability promote their applications as an adsorbent for wastewater handling purposes. Graphene and its derivatives have further been developed to improve their performance.

RGO is selected in this study since this compound has been reported possessed higher adsorption capacity than GO due to higher surface area [14] and lower number of oxygen functional groups. Higher surface area results more space available for the target dye molecules to occupy the adsorbent surface, whilst the decrease of oxygen functional groups on the surface of RGO enhance the hydrophobic properties and stronger π-π interaction between the adsorbent and adsorbate [15]. So that the adsorption ability of RGO is higher than GO and can be used as an adsorbent to remove dye from the solution [16].

In this study, GO was reduced using kaffir lime peel extract to become RGO. Citrus family contain lots of vitamins and antioxidant compounds. The citrus family is a source of natural antioxidants which contain large amounts of ascorbic acid, flavonoids, and phenolic compounds [17]. The higher component of phenolic compounds is directly related to increasing its reducing ability [18] and antioxidant activity [19]. Kaffir lime is one type of citrus fruits with high content of phenolic compounds compared to other fruits, even within citrus family [20–22]. The fruit peel has higher antioxidants than the fruit [23]. Therefore, kaffir lime peel has the potential for natural antioxidants due to its high content of phenolic and flavonoid compounds [21].

The polyphenol content in kaffir lime peel extract can be used as a reducing agent for GO. Most of the polyphenol components in kaffir lime peel extract are flavonoids consisting of flavanones, flavones, and flavonols [24]. Therefore, GO reduction requires the addition of kaffir lime peel extract in an optimal amount to obtain a higher adsorption capacity. Plant extract has advantages and disadvantages in reduced graphene oxide process. The advantages lie in the environmentally friendly materials, requiring low costs,

and being not dangerous because it does not use chemicals to reduce GO [25]. Meanwhile, its disadvantages lie in the inefficient reduction ability and global plant unavailability [12].

The RGO produced from the reduction of GO using kaffir lime was modified using metal-phenolic network (MPN) from combination of tannic acid and Fe, that is to enhance the adsorption capacity. The incorporation of MPN on RGO can provide additional adsorption sites, i.e. the hydroxyl groups of tannic acid. The MPN-coated RGO (MPN/RGO) in this study was prepared via two different methods, i.e. (I) reduction of GO into RGO by kaffir lime peel extract and followed by the MPN coating, (II) direct coating of MPN on GO and followed by reducing of GO to RGO by kaffir lime peel extract. The physicochemical characteristics of the MPN/RGO from method I and II were determined by Fourier Transform Infra-Red (FTIR) and Scanning Electron Microscope – Energy Dispersive X-Ray (SEM-EDX). The resulted MPN/RGO was used for the adsorption of MG, and the adsorption was modeled using isotherm and kinetic model equation; this is to determine the mechanism and the rate of adsorption.

I.2. Objectives

The aims of the present study are to:

1. study the preparation of MPN/RGO.
2. determine the adsorption capacity of MPN/RGO toward MG dye as the selected adsorbate.
3. investigate the kinetic, isotherm, and thermodynamic studies for MG adsorption using MPN/RGO.

I.3. Problem Limitations

1. Maceration technique using 41% ethanol solution was employed to obtain kaffir lime peel extract.
2. Polyphenols present in the extract of kaffir lime peel was used as the reducing agent during RGO preparation.
3. GO was prepared via modified Hummers method [26].