CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Graphene is a one atom thick two-dimensional (2D) molecule entirely made of sp^2 hybridized carbon atoms. Graphene is the basic building blocks for other allotropes of sp^2 carbon such as graphite, carbon nanotubes and fullerenes (Nuvoli et al. 2011). In addition, a set of graphene sheet is graphite that stacked one another and held by weak Van der Waals forces, meanwhile fullerenes and carbon nanotube can be expressed as wrapped up and rolled graphene (Nuvoli et al. 2011).

Graphene possesses a various beneficial properties due to their good electrical and thermal conductivity along with strength, mechanical properties and elasticity. Several protocols have been adapted to prepare graphene including mechanical cleavage, chemical vapor deposition (CVD), epitaxial growth, total organic synthesis, and chemical method (Edwards & Coleman 2013), (Allen et al. 2010). Despite, every method that has been proposed have their respective advantages and disadvantages. Mechanical cleavage method is capable in producing less defects graphene sheets. Meanwhile CVD is used widely in industry due to its compatibility with the current complementary metal-oxide-semiconductor (CMOS) technologies. In epitaxial growth method, the obtained graphene sheets do not show presence of defects on the surface or edge of sheets. Total organic synthesis method is suitable to use for a mass production of graphene. On the other hand, cost of graphene production by using chemical method is low and more fit for industrial purpose. However, every methods mentioned before has its own drawbacks where they are either scalable or capable for mass production of graphene, involve in complex transfer process and high cost of production. Even though defects that exist on the surface of graphene sheets can be removed but it uses expensive and hazardous chemicals that may contribute to environmental issue.

Liquid phase exfoliation (LPE) method is one of the methods commonly used in exfoliating graphene. Usually N-methyl-2-pyrrolidone (NMP) and N,N-dimethylformamide (DMF) (Hernandez et al. 2008) is used as solvent to exfoliate graphene where the selection of the solvent used is based on the surface tension. Similar surface tension between solvents and graphite ensures in successful of graphene exfoliation. In industrial production of graphene, LPE method is preferably to use due to its scalability and low cost. This method involved dispersion of graphene in selected solvents and will undergo sonication process. The LPE method can be summarized into three categories based on variation of starting material used: liquid-phase exfoliation from graphite oxide, pristine graphite and expanded graphite (EG), and sonication-free liquid-phase exfoliation (Cui et al. 2011).

Thus, the aim of this research is to synthesis a graphene using activated carbon (AC) as starting material in solvent by LPE method. The reasons of this works backed by several factors including (i) nearly no report of utilizing AC as starting material for graphene exfoliation, (ii) low cost and renewable in Malaysia landscape and (iii) waste-to-wealth technology development. The strategy taken in this research is by optimizing several parameters including initial AC concentration, LPE temperature and bio dispersant concentration.

1.2 PROBLEM STATEMENT

Graphite composed of stacking graphene layers that are able to be separated by overcoming it Van der Waals forces. Several protocols have been employed in synthesizing graphene from various carbon sources. Typically, two categories of methods are used viz., bottom-up (growth from metal-carbon melts, epitaxial growth on silicon carbide (SiC), dry ice method, CVD method) and top-down (mechanical exfoliation, graphite intercalation, nanotube slicing, pyrolysis method, and electrochemical exfoliation) approach. Among those, LPE is considered as the easiest method in preparing graphene. However, this method is still hindered by the lower graphene yields.

In 2011, Mariani and co-workers suggested that sonication of graphite in assisted ionic liquid (1-hexyl-3-3methyl-imidazolium hexafluorophosphate, HMIH), produces a few layers graphene with ~5.33 mg mL^{-1} concentration (Ciesielski & Samorì 2014). Recently, the production of graphene derived AC was reported using *D*-tyrosine as the dispersant agent (Shams et al. 2015). However, the graphene conversion was rather low (0.8 wt%).

Due to the previous drawbacks, the research strategy was focused on the utilization of locally abundant activated carbon, i.e., palm kernel shell activated carbon as the carbon precursor. Since the ionic liquid dispersant is too expensive, the work is aiming to use relatively cheap amino acids dispersant. The ultimate goal of this works is to synthesis graphene form PKS AC at higher concentration and conversion percentage.

1.3 OBJECTIVES OF RESEARCH

The objectives of this research are:

(i) To optimize parameters (AC concentration, LPE temperature and bio-dispersant concentration) to increase exfoliation rate of graphene from AC by LPE method.

(ii) To study structural, morphology and physical properties of prepared graphene as function of exfoliation rate.