CHAPTER 3
Synthesis of Graphene from Rice Husk via Pyrolysis Process

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3.1 INTRODUCTION

Graphene was basically discovered by the extraction from graphite using a method known as micromechanical cleavage. Graphene consists of two types of layers, which are the Single-layer graphene and Bi-layer graphene. Graphene has a structure of hybridized sp2 bonding and therefore, has three sigma bonds and π orbitals in the structure perpendicular to the plane (Malola et al., 2010). The hexagonal structure is bonded with strong sigma bonds while the π bonds are in the outer layer between different graphene layers. Discovery of graphene is interesting as it can be synthesized on a large scale using various methods. Synthesis of graphene requires extraction process depending on the size, purity, and efflorescence.

In the late 19 century, multi-layer graphite was synthesized using decomposition method in the presence of single crystal surface. After that, more methods and approaches were discovered by number of researchers to synthesize an actual graphene and it was only successful in 2004 (Eizenberg & Blakely, 1979). Initially graphene was found in the form of small flakes through the method known as mechanical exfoliation of graphite. Following the discovery, there were many other

methods established for graphene synthesis such as chemical exfoliation, chemical synthesis, and also thermal chemical vapour deposition (CVD) method (Li et al., 2009). Hence, graphene can be synthesized using various methods and it is divided into Top-down and Bottom-up. This method in synthesizing graphene differs by their size thickness of graphene sheets and also their advantages and disadvantages.

3.2 PYROLYSIS PROCESS IN BIOCHAR PRODUCTION

Pyrolysis is basically heating of an organic material such as biomass in the absence of oxygen. The material is heated at high temperature and it involves chemical and physical separation into various molecules. In fact, pyrolysis is usually carried out with thermal treatment in an endothermic process which produces products with high energy content. Moreover, pyrolysis usually produces three products: one liquid, bio-oil; one solid, bio-char; and one gaseous (syngas) (Soltes & Elder, 2018). The yield of products depends on temperature, particle size, heating rate and also the composition of feedstock. Therefore, the higher the temperature, the higher the quality of non-condensable gases (syngas, synthetic gas) produced, and the lower temperature, the higher the quality of solid product (charcoal, bio-coal). Meanwhile, smaller particle size will result in high quantity of pyrolysis product. Furthermore, higher heating rate will decrease the char yield and at the same time increase the gas and liquid yield.

Meanwhile, pyrolysis can be classified into slow pyrolysis, fast pyrolysis, and flash pyrolysis (Raveendran et al., 1996). Slow pyrolysis basically is used to enhance the production of char at low heating rate and low temperature, while fast pyrolysis higher

temperature is used without the presence of oxygen and it is popular in producing liquid fuel. However, flash pyrolysis is a better and become attractive in the production of different phase of fuel from biomass.

3.3 GRAPHENE SYNTHESIS FROM BIOMASS

Biomass is an eco-friendly alternative source and a recognized renewable energy in demand around the world. Biomass is complex in nature and it contains several amounts of ash, nitrogen, and sulphur (Demirbaş, 2002). In fact, biomass can be converted into various thermal, biological, and physical processes. Biomass can be used for many purposes such as providing heat to industries, supplying electricity and so on. In addition, biomass is formed by dead plant or animal manure consisting of compounds such as carbon, hydrogen nitrogen, oxygen, and inorganic species. Moreover, biomass can also be produced by the photosynthesis process. Biomass release heat through solar energy during combustion process (Kumar et al., 2012). Furthermore, biomass is known to be the only alternative energy that can be converted to solid, liquid, and gaseous fuels. In fact, biomass can be classified into few major components such as cellulose, hemicelluloses and lignin, which differ by their decomposition behaviour. One of the biomasses that can be used to synthesize graphene is rice husk.

Rice husk is basically an organic waste and it is usually produced in large quantities. Rice husk is a waste material that is available in many countries producing rice. In fact, world rice production is around 700 million tons and rice husk contain about 30%-50% organic carbon. Moreover, by weight, rice husk consists of 20%, approximate 50%, cellulose, 25% to 30% lignin, 15% to 20% silica, and 10% to 15% moisture (Ramage