Structural properties of graphene from green carbon source via Thermal Chemical Vapour Deposition (CVD)

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ABSTRACT – The most common carbon source is graphite oxide in synthesis the graphene layers. This study proposed palm oil as the best new source as a carbon feedstock which is more cheaper, green and bio-renewable resources. The palm oil was placed in the first furnace (precursor furnace) and the 2 cm x 2 cm Nickel seeded substrate was placed in the second furnace (deposition furnace). The furnaces were heated to 450ºC and range from 1000ºC to 1100ºC for first and second furnaces consecutively. Argon gas acted as carrier gas to carry the carbon atom towards the Nickel substrate. After several minutes synthesis time, both furnaces were switched off for cooling process. The as-synthesized graphene was characterized in confirming its properties using Atomic Force Microscopy and Raman Spectrometer. Raman spectra show that D peak appears at ~1345 cm^{-1} and G peak appears at ~1595 cm^{-1}. From the results, it shows that palm oil is the one of the most promising renewable natural carbon sources available to synthesize the graphene.

1. INTRODUCTION

Graphene was discovered by Andre Geim and Kostya Novoselov a decade ago in 2004 at the University of Manchester. Graphene is the hardest material compare to the diamond and about 300 times harder than steel. It is also good thermal conductivity compare to other carbon structures such as carbon nanotubes, graphite and diamond at room temperature. The most common carbon source is graphite oxide that used to synthesis graphene layers. Researchers are trying to synthesis graphene using new natural carbon source.

Palm oil shows its properties as a promising new natural carbon source in synthesis of graphene. Lots of long carbon chain contains in fatty acids such as palmitic acid, the main fatty acid in palm oil, has 18 carbons in a chain. Therefore, in this study we used the palm oil as a natural carbon feedstock. The double furnace CVD method was used to synthesize graphene and Argon as a carrier gas. The graphene has deposited on the Nickel seeded substrate. After that, the graphene was characterized by Raman Spectrometer and Atomic Force Microscopy to study the structural properties and surface topography.

2. METHODOLOGY

The commercial palm oil was obtained to use as natural carbon source. Several volume of palm oil was placed in the alumina boat. The carbon source was placed in the middle of precursor furnace and the 2 cm x 2 cm Nickel seeded substrate was placed in the middle of deposition furnace. Argon was flown for 10 minutes to wash out any contaminant gaseous inside the tube and to give inert ambient for the synthesis purpose. The deposition furnace was heated up to in range 1000ºC and 1100ºC. When the deposition temperature was stable, the precursor furnace was heated up to 450ºC. Both furnaces were switch off immediately after several minutes of synthesis time. Furnaces were rapidly cooled to room temperature. Table 1 shows the parameter that was studied in this experiment. The deposited graphene was characterized by Raman Spectrometer and Atomic Force Microscopy.

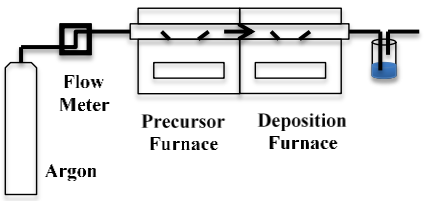

Figure 1 Schematic diagram of the Chemical Vapour Deposition (CVD) method.

3. RESULTS AND DISCUSSION

The synthesized graphene from CVD method as shown in figure 1 was characterized using Raman Spectrometer. Figure 2 shows a set of representatives Raman spectra of the graphene at different synthesis time and deposition temperature. We observed that the synthesis of high quality graphene can be obtained at a

temperature of 1100°C. On the other hand, the obtained graphene had a large number edge disorder and defects as the presence of D band. Poor graphitization process takes place during the synthesis of graphene and confirms the defect materialized.

Table 1 Deposition temperature and synthesis time parameter to synthesize graphene.

No.	Deposition Temperature	Synthesis Time
1		3 minutes
2	1000°C	5 minutes
3		7 minutes
4		3 minutes
5	1100°C	5 minutes
6		7 minutes

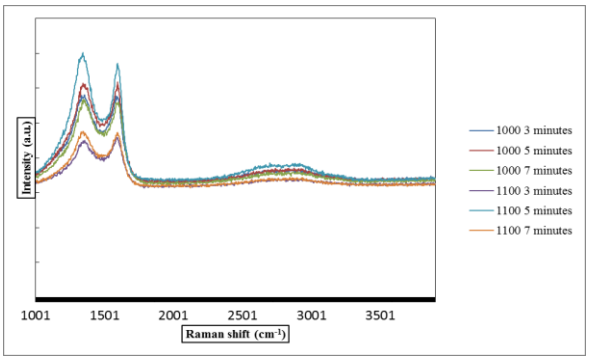

Figure 2 Raman spectra of the synthesized graphene at different deposition temperature and synthesis time.

The synthesis time is one of the most important parameters to synthesize the high quality graphene. The effect of synthesis time was investigated during the growth of graphene. The synthesis time was varied from 3 minutes to 7 minutes with the deposition temperature was fixed at 1000°C and 1100°C consecutively. We found that the synthesis of graphene need longer time to complete graphene coverage.

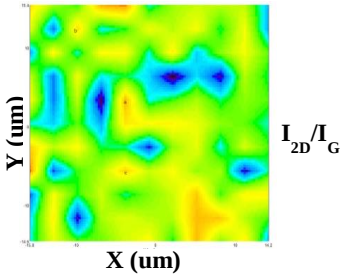

Figure 3 Raman map of the synthesized graphene at 1100 °C deposition temperature and 7 minutes synthesis time.

Raman map shows that the graphene is not perfectly uniform in figure 3. The non-uniformity of graphene is due to the contact of the van der Waals force between graphene and nickel seeded substrate differs from region to region. Therefore, the AFM image has proved that the surface topography of graphene is not uniform and has average roughness of 44.541 nm in 10 μm^2 area region.

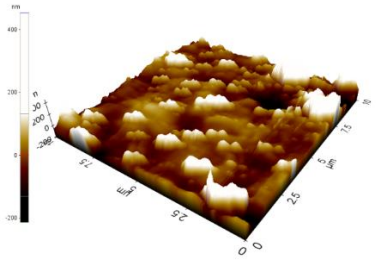

Figure 4 AFM image of the synthesized graphene at 1100°C deposition temperature and 7 minutes synthesis time.

4. CONCLUSIONS

We demonstrate that the palm oil is a promising natural carbon source to synthesize graphene. Raman spectroscopy is one of the powerful tools that used to determine the crystallinity and defects of graphene layers. The control over the quality of graphene by adjusting the deposition temperature and synthesis time provides useful information on the growth mechanism of CVD of graphene.

5. ACKNOWLEDGEMENT

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