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Potential of growing graphene from solid waste products

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ABSTRACT – This feasibility study was conducted to identify the potential of growing graphene from solid waste products on 99% copper (Cu) substrate via Chemical Vapor Deposition (CVD) method. This study was focusing on growing graphene by using two types solid sources, which are fruit cover plastic waste and oil palm fiber. The coated surface was observed by using Scanning Electron Microscopy embedded with Energy Dispersive X-Ray Spectroscopy (SEM-EDS) and Raman Spectroscopy. From the peak findings, graphene is grown from both sources. However, from the Raman spectrum analysis, oil palm fiber produces higher carbon content compared to fruit cover plastic waste.

1. INTRODUCTION

Graphene is one of the most recent carbon nanomaterials that have attracted a widespread attention due to its excellent properties combination. Graphene is the sp2 allotrope which has monolayer film consisting of carbon atom that were arranged in two-dimensional hexagonal lattice [1]. According to Ye et al. [2], there were four forms of dimension such as; zero-dimensional, one-dimensional, two-dimensional and three-dimensional. It is said that nanotubes, graphite and graphene are carbon allotropes that present in their forms. So far, within the carbon allotropes family, graphene possessed the most excellence mechanical, electrical, optical, structural and thermal properties [1–8].

Due to these excellence properties, graphene has potential in huge application range such as fuel cell, solar cell. Electrodes, transistors, sensors, and as antifriction materials. Previously, before the discovery of graphene multi-potentials, there were many attempted in producing frictionless materials or at least super-low friction materials to reduce friction and wear in tribology field. This field were constantly demanded by automotive and machinery industries as they are highly dependable towards the ability to control the behaviour of friction and wear.

There are lots of study shows that graphene can be grown from variety carbon-containing sources including liquid, gaseous, and solid feedstock [9–14]. However, limited study proposed a solid waste as a carbon source. If the synthesized graphene can be readily used without any treatment or another superior process, the production cost can be lowered, and a good quality coating may be produced to face the demands and challenges in industries nowadays.

There were several methods that had been studied to grow graphene which are; CVD, exfoliation and cleavage, chemically derived, and other synthesis approached [6–7,12,14–17]. The CVD methods were widely used are able to synthesize high-quality graphene on catalytic surface such as copper and nickel [1].

2. METHODOLOGY

The solid sources of carbon selected for this study were the fruit cover plastic waste and oil palm fibre. Both sources are directly from its original state and did not undergo any treatment process. Figure 1 shows the solid source image. The source was weighed before placed into the left furnace meanwhile the 99% Cu substrate was on the right furnace. The schematic diagram of the graphene is shown in Figure 2, meanwhile the heating and cooling graph is shown in Figure 3.

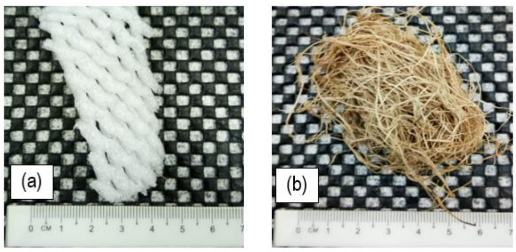

Figure 1 The solid source of (a) fruit cover plastic waste, and (b) oil palm fibre

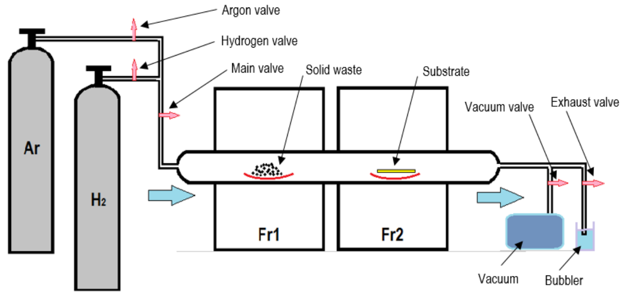

Figure 2 Schematic diagram for CVD process

The substrate was heated up to 1020°C and annealed for 30 minutes and 90 minutes for growth. Argon and hydrogen gaseous were feed during the whole process at 100sscm and 25sscm respectively.

The coated surface was then observed with SEM/EDS for surface morphology and chemical composition analysis. Later, analysis through Raman Spectroscopy was conducted to determine the carbon allotrope group.

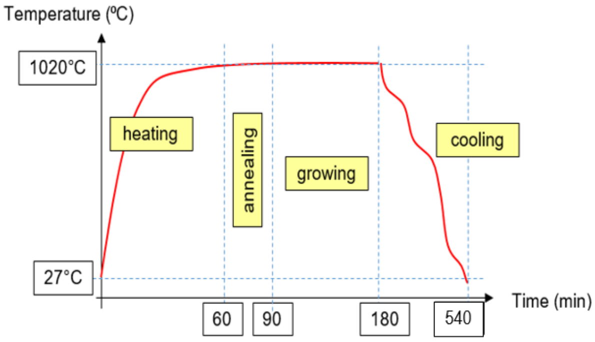

Figure 3 Heating, cooling, growing and cooling graph of the CVD process

3. RESULTS AND DISCUSSION

The pure and coated copper surface are shown in Figure 4. A distinct physical change is observed after the CVD process for both plastic fruit waste and the oil palm fibre. The pure copper is more reddish and coarser surface. However, the carbon grown surface from oil palm fibre source is shinier and brighter compared to the surface from the fruit cover plastic waste source. For SEM/EDS analysis, the micrograph image and the carbon composition content are shown in Figure 5 and Table 1.

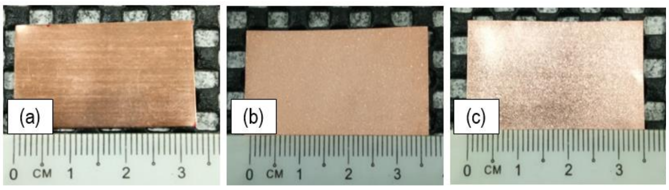

Figure 4 The surface image of (a) a pure copper, (b) carbon grown from fruit cover plastic waste source, and (c) oil palm fibre source

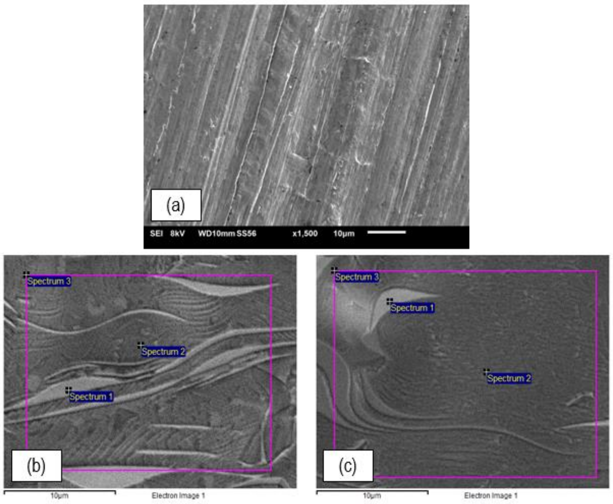

Figure 5 The SEM image of (a) a pure copper, (b) carbon grown from fruit cover plastic waste source, and (c) oil palm fibre source

Table 1: EDS analysis on element content

Sample	Weight %		
	Carbon	**Oxygen**	**Copper**
Pure Copper	2.49	0.79	96.72
Carbon growth from fruit cover plastic waste	44.65	0.72	54.63
Carbon growth from oil palm fibre	61.03	0.87	38.1

The SEM image shows that there is a presence of rippled on both surfaces that yet confirmed by the EDS analysis as a carbon element. The machining effect on the pure Cu surface also disappeared as it was covered by the carbon layer. The EDS analysis also suggests that despite the carbon content is higher, the oxygen content remains the same.

From the Raman spectra as in Figure 6, despite both solid sources can growth a carbon, the carbon produced has a little bit different as the location of the D, G, and 2D band peak are slightly slanted. In addition, the height of those mentioned peak is also different.

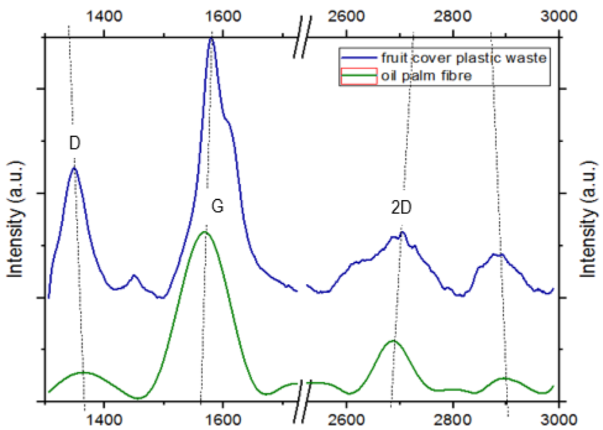

Figure 6 Raman spectra for carbon growth on Cu substrate from fruit cover plastic waste and oil palm fibre sources

According to study by Sharma et al. [17] and Ji et al. [18], the graphene that they obtained was supposed to shows G band peak at around 1580 cm^{-1} and 2D band at around 2730 cm^{-1} with no distinct D band peak. Their findings also showed that the 2D band peak were higher than the G band peak. However, according to Salifairus et al. [19], they claimed that they succeed in growing graphene with presence of D band peak and no 2D band peak presence in their Raman Spectroscopy analysis.

4. CONCLUSION

In this study, the attempt in growing graphene from solid waste products can be considered successful. The Raman spectroscopy analysis suggests that the carbon grown was at the same allotropes despites the fruit cover plastic waste produces higher G band peak. Meanwhile, the EDS analysis suggests that oil palm fibre produced higher carbon content compare to the fruit cover plastic waste. Hence, it can be concluded that graphene is possible to be grown from both fruit cover plastic waste and oil palm fibre sources.

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