Optical Study of Graphene Quantum Dots from Sawahlunto Coal Graphite

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Abstract: Graphene quantum dots (GQDs), quantum sized graphene materials, have been proposed to be candidate in optical and energy storage devices applications due its transparant properties and high surface area. In this work, Sawahlunto coal graphite was converted into GQDs and analysed the optical properties. The coals were dispersed in strong acid and irradiated with ultrasound before oxidized and hydrothermalized into GQDs. UV-vis spectroscopy and photoluminescence spectrophotometer were used to determined the conjugate structure and emission type respectively. The UV-vis spectra showed that the product had conjugated structure in 230 nm. Photoluminescence results confirmed that the GQDs had cyan emission.

1 INTRODUCTION

Graphene quantum dots (GQDs), one of carbon nanomaterials always takes an advanced part in development of modern science and technology. This quantum size exhibits excelent progress in optoelectronic and energy storage device (Li et al. 2015). This is due to its transparant property and high surface area (Yan and Liu, 2014).

GQDs can be obtained from graphene, graphene oxide (GO), carbon nanotubes (CNTs), carbon fibers and graphite as precursor. GO is be converted to be GQDS by Hummers method and followed by redox treatment repeatedly. This method is simple and efective mass production, but requires high cost (Bak, Kim and Lee, 2016). Hence, several literatures have reported an advance investigation of GQDs with low cost and high yield such as using high temperature autoclave (Sun et al. 2013) and microwave treatment (Shin et al., 2014).

Coal, a high carbon compound material, is able to produce graphene to subtitute graphite (Powell and Beall, 2015). Coal from Sawahlunto, West Sumatera is a kind of a high volatile bituminous with 40,79% - 49,67 % of carbon. It is potentially converted into GQDs. It had been reported that coal from Sawahlunto can be converted into graphene by exfoliation graphitization graphite at 900 ºC (Purwandari et al. 2020).

In this study, GQDs were synthesized from the coal using modified hummers asisted by hydrothermal method. To the best of our knowledge, there is no optical study yet about this coal graphene quantum dots for optical applications. The GQDs optical properties were studied by using UV-Vis spectroscopy and photoluminescence.

2 METHODS

2.1 Materials

Sawahlunto Sijunjung coal graphite powder (BB900) is obtained from CFM-RC Laboratory. CPRO WELD commercial graphite powder (KG), *Merck* sulfuric acid 98% (H_2SO_4), pottasium permangate ($KMnO_4$) and EMSURE sodium hydroxide (EMSURE) were purchased from Sigma Aldrich.

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2.2 Synthesis of Graphene Quantum Dots (GQDS)

BB900 (200 mg) was dispersed in a 100 ml H_2SO_4 for a few minutes before irradiated by ultrasonic for 2-5 hours. $KMnO_4$ (1 g) was slowly added to the mixture under ice batch to keep temperature under 25 ^oC and keep until being brownish suspension. The suspension was heated in hydrothermal autoclave vessel at 180 ^oC for 18-24 hour and cooled under room temperature. The resultant hydrothermal was injected slowly to deionized water and added NaOH until pH become 7 under ice batch condition. The injected suspension was then filtered using 200 nm porous membrane. The same procedure was also used to produced GQDs from commercial graphite powder (GK).

2.3 Characterization

2.3.1 UV-Visible

UV-Vis spectrophotometer (UV 2400 PC Series, Shimadzu) was used to determined conjugate bond of GQDs. UV-Vis was carried out in range 200-800 nm.

2.3.2 Photoluminescence

Photoluminescence (AURORA 4000) were used to determine emission of this GQDs product. Photoluminescence was carried out in range 200-800 nm with UV-light excitation in 375 nm.

3 RESULTS AND DISCUSSION

Graphene quantum dots (GQDs) in this work were obtained from Sawahlunto coal graphite (BB900) by using modified hummers method and assisted by hydrothermal. Before oxidized with strong oxidator $KMnO_4$, BB900 was dispersed in strong acid H_2SO_4 and irradiated using ultrasound to weaken the Van Der Walls bond (Shin et al., 2014). The oxidized product was hydrothelmalized to cut graphene oxide lattice into tiny dots at high temperature (Bak, Kim and Lee, 2016). Finally, the tiny dots was characterized by UV-Vis spectroscopy and photoluminescene spectroscopy.

3.1 UV-Vis Spectrocopy Analysis

The conjugate aromatic structure was investigated by using UV-Vis spectroscopy. **Figure 1** showed that the tiny dots of Sawahlunto coal graphite (GQDs-BB900) and comercial graphite (GK). Both tiny dots peaks show that there were no signifikan friction at the wavelength. GQDs-BB900 and GQDs-GK had first UV absorptions peaks at 230 nm and 235 nm respectively. This first absorbance indicated π–π* C-H sp^2 aromatic transitions (Shin et al., 2014). The second absorbance was also detected at 284 nm and 299 nm for GQDs-BB900 and GQDs-GK. This absorbance confirmed C=O n- π* domains (Song et al. 2014). The transitions of π–π* aromatic were generally appeared from 200 to 270 nm and C=O n- π* transitions were above 260 nm (Chen et al. 2018). Although there was no significant frictions in wavelength, the spectra showed significant spacing in intensity of first absorbances. This friction confirm that the tiny dots from BB900 had more conjugated aromatic structure than GK.

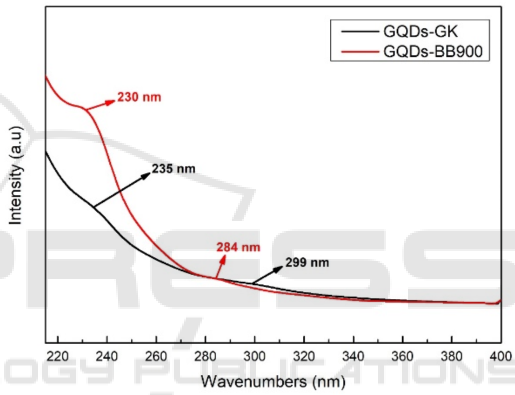

Figure 1 UV-vis spectra of graphene quantum dots from Sawahlunto coal graphite (GQDs-BB900) and commercial graphite (GQDs-GK)

3.2 Photoluminesnence Analysis

Optical properties of this study were determined by using photoluminescence (PL) spectrophotometer. The PL was used to detect the emission of tiny dots of GQDs as seen in **Figure 2**. From the Figure, UV light with excitation at 375 nm was irrariated againts GQDs-BB900, a strong peak appeared between 412 and 658 nm with maximum intensity at 493 nm. This maximum intensity indicated that the tiny dots of Sawahlunto coal graphite emitted cyan emission. The same excitated UV light was also used against GQDs-GK, a stronger peak appeared between 412 and 670 nm with maximum intensity at 467 nm. The maximum intensity indicated that the tiny dots of commercial graphite emitted blue emission. The wavelength of blue emission and cyan emission were 450-485 nm and 485-500 nm respectively (Bruno and Svoronos, 2005).

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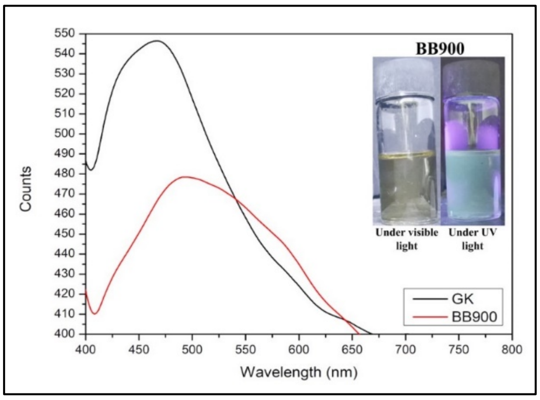

Figure 2 Emission intensity of graphene quantum dots from sawahlunto coal graphite (GQDs-BB900) and commercial graphite (GK)

4 CONCLUSION

Graphene quantum dots (GQDs) which was synthesized from Sawahlunto coal graphite (BB900) by using Hummers method with hydrothermal asissted had been done. It has conjugated aromatic structure and cyan emission which have potential for optical applications.

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