EXFOLIATION OF FEW-LAYER GRAPHENE IN RED SPINACH SOLUTION: THE FABRICATION OF SMART “STICKY NOTE” SENSOR

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang Al-Sultan Abdullah or any other institutions.

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ABSTRAK

Grafin diiktiraf secara meluas sebagai bahan yang luar biasa yang berpotensi untuk digunakan dalam pelbagai jenis aplikasi. Salah satu kaedah paling berkesan untuk menghasilkan grafin bebas kecacatan dipanggil pengelupasan fasa cecair (LPE), yang boleh dibantu oleh sonikasi. Teknologi ini merupakan prosedur pemprosesan mudah yang juga berdaya maju dari segi ekonomi. Sebahagian besar pengelupasan grafin biasanya menggunakan kaedah LPE yang diproses menggunakan pelarut organik seperti dimethylformamide (DMF) dan N, N-methyl pyrrolidone (NMP). Bahan-bahan ini bersifat karsinogenik, dan pendedahan yang lebih lama kepada bahan ini boleh membahayakan pengguna dari segi kesihatan. Oleh itu, penemuan yang diperoleh dengan menggunakan ekstrak tumbuhan sebagai medium pengelupasan untuk grafit merupakan strategi yang sangat bagus untuk penciptaan grafin yang berkualiti tinggi dan kos rendah. Di samping itu, disebabkan kelebihan ketara sistem akueus berbanding sistem bukan akueus seperti kos yang lebih rendah dan potensi risiko kesihatan dan isu alam sekitar yang lebih sedikit, penggunaan sistem berasaskan air telah menarik banyak perhatian sejak beberapa tahun kebelakangan ini. Sehubungan dengan ini, penggunaan larutan ekstrak tumbuhan akan menjadi manfaat yang besar dalam proses membuat grafin daripada air. Tujuan kajian ini adalah untuk menilai keupayaan larutan ekstrak tumbuhan dalam membantu pengelupasan grafit. Hal ini akan dicapai dengan menggunakan larutan bayam merah untuk menghasilkan grafin bayam (G_S) melalui kaedah sonikasi. Kehadiran G_S dalam supernatan berikutnya telah disahkan dengan ketara daripada spektroskopi boleh dilihat Ultraviolet (UV-Vis), Mikroskopi elektron penghantaran (TEM), Mikroskopi daya atom (ATM) dan spektroskopi Raman. Kemunculan puncak yang mendominasi UV pada 272 nm untuk supernatan menunjukkan bahawa grafit berjaya dikelupas menggunakan larutan bayam merah. Di samping itu, didapati bahawa grafin yang disintesis mempunyai lebih sedikit kecacatan struktur (ID/IG: 0.5) berbanding dengan grafin oxida dan ia mempunyai nisbah karbon kepada oksigen (C/O) 6.8 yang tinggi, yang setanding dengan C/O untuk grafin berasaskan polisakarida. Kesan parameter pemprosesan G_S yang berbeza telah dianalisis, dan keputusan untuk kepekatan larutan bayam merah, kepekatan grafit, dan tempoh sonikasi diperoleh dengan ketepatan yang tinggi. Sebagai sebahagian daripada penyiasatan ke atas produktiviti grafin, kepekatan hasil sehingga 0.75 mg/ml (2.5 jam) telah diperolehi. Selepas itu, G_S yang telah dicipta telah digunakan sebagai dakwat untuk penderia nota melekit pintar, dan sifatnya telah disiasat. Kesimpulannya, penggunaan bayam merah sebagai larutan untuk pengelupasan grafin telah terbukti dan menjadi subjek kajian yang banyak. Kajian ini dijangka akan menyumbang kepada kemajuan pengeluaran grafin yang kos efektif dan membantu pembangunan pelbagai aplikasi yang sesuai.

ABSTRACT

Graphene is widely recognised as an incredible material that has the potential to be utilised in a wide variety of useful applications. One of the most effective methods for producing defect free graphene is called liquid phase exfoliation (LPE), which can be assisted by sonication. This technology was discovered to be an easy processing procedure that was also economically viable. However, the majority of exfoliation of graphene using the LPE method has been accomplished by utilising an organic solvent such as dimethylformamide (DMF) and N, N-methyl pyrrolidone (NMP), which is known to be carcinogenic, and a longer exposure to this substance may risk the user to the development of major health issues in the future. Because of the findings that came from earlier research, using plant extracts as an exfoliating medium for graphite seems to be an exceptionally promising strategy for the creation of graphene that is both of high quality and low in cost. In addition, due to the significant advantages of aqueous systems over non-aqueous systems such as lower costs and fewer potential health risks and environmental issues, the use of water-based systems has attracted much attention in recent years. In light of this, the use of plant extract solution would be an enormous benefit in the process of making graphene from water. The purpose of this study is to evaluate the capability of plant extract solution in assisting the exfoliation of graphite. This will be accomplished by employing a red spinach solution to produce spinach graphene (G_S) via the bath sonication method. The presence of G_S in the subsequent supernatant was significantly confirmed from Ultraviolet visible spectroscopy (UV-Vis), Transmission electron microscopy (TEM), Atomic force microscopy (ATM) and Raman spectroscopy. The appearance of a UV dominating peak at 272 nm for the supernatant indicates that graphite was successfully exfoliated using the red spinach solution. In addition to this, it was discovered that the synthesised graphene possessed fewer structural defects (ID/IG: 0.5) in comparison to graphene oxide and that it had a high carbon to oxygen ratio (C/O) 6.8, which was comparable to the C/O for graphene based on polysaccharides. To study the detailed about the production method, the effects of processing parameters for G_S were studied and the exponential factor for the red spinach solution concentration, graphite concentration, and sonication duration were obtained. As part of the investigation into the productivity of graphene, a yield concentration of up to 0.75 mg/ml (2.5 hours) was measured. After that, the graphene G_S that had been created was utilised as ink for a smart ‘sticky note” sensor, and its properties were investigated. In conclusion, the use of red spinach as a dispersant for exfoliation of graphene has been proven and the subject of a significant amount of research. It is expected that this study will contribute to the advancement of cost-effective graphene production and help the development of a variety of applications that are suited.

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