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Plasma-treated Langmuir–Blodgett reduced graphene oxide thin film for applications in biophotovoltaics

Siti Aisyah Ibrahim[1] · Muhammad Musoddiq Jaafar[1] · Fong-Lee Ng[2,3] · Siew-Moi Phang[2,3] · G. Ghana Kumar[4] · Wan Haliza Abd Majid[1] · Vengadesh Periasamy[1]

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Abstract
The surface optimization and structural characteristics of Langmuir–Blodgett (LB) reduced graphene oxide thin (rGO) film treated by argon plasma treatment were studied. In this work, six times deposition of rGO was deposited on a clean glass substrate using the LB method. Plasma technique involving a variation of plasma power, i.e., 20, 60, 100 and 140 W was exposed to the LB-rGO thin films under argon ambience. The plasma treatment generally improves the wettability or hydrophilicity of the film surface compared to without treatment. Maximum wettability was observed at a plasma power of 20 W, while also increasing the adhesion of the rGO film with the glass substrate. The multilayer films fabricated were characterized by means of spectroscopic, structural and electrical studies. The treatment of rGO with argon plasma was found to have improved its biocompatibility, and thus its performance as an electrode for biophotovoltaic devices has been shown to be enhanced considerably.

1 Introduction

Due to expanding global population, worldwide energy demand has increased rapidly resulting in depletion of natural resources. It is estimated that the worldwide population will reach 9.7 billion in 2050 [1]. Hence, the race to find an alternative energy source has intensified with one option using synthetic photosynthesis as a renewable energy source [2]. In previous findings, various species of photosynthetic algae biofilms were studied using conventional indium tin oxide (ITO) electrodes for its electrical power output [2, 3]. However, the power output obtained was smaller as compared to the conventional sources requiring further improvements, especially in terms of electrode material and preparation. In this context, graphene-based electrodes utilized for applications such as in algae-biophotovoltaic (BPV) devices [2] have shown potentials for eventual development of highly efficient photosynthesis-based fuels cells.

One type of material generally considered as chemically derived graphene is reduced graphene oxide (rGO). Several names are given to rGO, such as chemically modified graphene, chemically converted graphene, functionalized graphene, or reduced graphene [4]. By the modification of chemical structure, the tuning of the bandgap has been investigated and developed for electronic applications with reasonable rGO conductivity. Multilayers of rGO as electrode can be deposited using several techniques such as electrophoretic deposition method and solution-based method [5, 6]. However, the most preferable technique to form rGO film is Langmuir–Blodgett (LB) method [7]. This method has the advantage to control the required amount of deposition onto the substrate accurately. In this case, the area of the rGO layer produced is homogenous and hence the resistivity values are controllable [7].

Several treatments were proposed in functionalizing the surface morphology of rGO; one such popular method is by using plasma treatment. The advantages of this method

✉ Siti Aisyah Ibrahim
ecahibrahim@gmail.com

✉ Vengadesh Periasamy
vengadeshp@um.edu.my

[1] Department of Physics, Low Dimensional Materials Research Centre (LDMRC), University of Malaya, 50603 Kuala Lumpur, Malaysia

[2] Institute of Ocean and Earth Sciences (IOES), University of Malaya, 50603 Kuala Lumpur, Malaysia

[3] Institute of Biological Science, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia

[4] Department of Physical Chemistry, School of Chemistry, Madurai Kamaraj University, Madurai, Tamil Nadu 625021, India