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RESEARCH ARTICLE

Flakes Size-Dependent Optical and Electrochemical Properties of MoS_2

Eslam Atef Abdelaziz Aboelazm[1,†], Gomaa Abdelgawad Mohammed Ali[1,2,†], Hamed Algarni[3,4] and Kwok Feng Chong[1,*]

[1]Faculty of Industrial Sciences & Technology, Universiti Malaysia Pahang, Gambang, 26300 Kuantan, Malaysia; [2]Chemistry Department, Faculty of Science, Al–Azhar University, Assiut, 71524, Egypt; [3]Research Centre for Advanced Materials Science (RCAMS), King Khalid University, Abha 61413, P. O. Box 9004, Saudi Arabia; [4]Department of Physics, Faculty of Sciences, King Khalid University, P. O. Box 9004, Abha, Saudi Arabia

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Abstract: ***Background***: Molybdenum disulfide (MoS_2) is a transition metal dichalcogenides and has some interesting and promising properties. MoS_2 has direct and indirect band gaps depending on its crystalline structure. In addition, its sheets morphology makes it a good candidate for supercapacitor applications.

Objective: The aim of this work is to study the effect of MoS_2 flakes size on its optical and electrochemical properties.

Method: MoS_2 with different flakes sizes were prepared by exfoliation method. The exfoliation was performed by sonication of MoS_2 powder in N,N-Dimethylformamide followed by different centrifugation speeds. UV-Vis spectra illustrated the optical energy gap was inversely proportional to the MoS_2 flakes size.

Results: Absorption coefficient values indicated that the exfoliation reduced the number of layers. Symmetric supercapacitor was made from two MoS_2 electrodes and tested in 6 M KOH electrolyte. The specific capacitance was found to be dramatically increased with decreasing flakes size (9.5 and 4.5 mF/cm^2 for 0.26 and 0.98 μm flakes size, respectively).

Conclusion: These findings recommend that MoS_2 can be the excellent electrode material for supercapacitor.

Keywords: Molybdenum disulfide, nanoflakes, optical band gap, supercapacitors, cyclic voltammetry.

1. INTRODUCTION

Molybdenum disulfide (MoS_2) nowadays has great attention in research fields due to its exciting properties. MoS_2 is a transition metal dichalcogenides (TMDs) [1] in which its properties are highly dependent on the crystalline structure and sizes to determine the metallic (1T) or semiconductor (2H) phase [2]. Moreover, MoS_2 shows a direct band gap in monolayer 2H-MoS_2 and indirect band gap in bulk 2H-MoS_2 [3]. The tunable band gap in MoS_2 allows it to be used in electronic and optical applications [4-6]. Apart from the electronic application, it is used as a lubricant due to its low friction coefficient and high lubricity and stability at high temperature [7]. Other unique properties of MoS_2 are high luminescence quantum efficiency [8], high exhibiting photoluminescence [9] and potential substitution of the zero band gap materials [10]. The layered structure in MoS_2 which is held by weak van der Waals forces at the interlayer allows ions diffusion without significant any volume expansion. Because of this, MoS_2 was studied as a cathode material for batteries [11], supercapacitors, solar cells and conductors [12-15]. For the electrochemical applications, MoS_2 in single phase or composites in different morphologies are extensively studied. The 2D layer of MoS_2 showed a specific capacitance of 0.5 mF/cm^2 at 10 mV/s while the bulk exfoliated MoS_2 sheets showed specific capacitance of 2 mF/cm^2 at 10 mV/s [16]. The findings proved the bulk exfoliated MoS_2 sheets possess higher charge storage properties and render it to be the potential electrode material for supercapacitors. Various approaches were developed to exfoliate bulk MoS_2 crystal. Similar as the first report on graphene exfoliaiton, mechanical exfoliation was used to produce MoS_2 nanosheet [17-19]. In addition, the MoS_2 nanosheet also can be produced by the liquid phase exfoliation process by sonicating bulk MoS_2 in the organic solvent [16, 20]. The process of exfoliation produces MoS_2 nanosheets in various sizes, which behave differently especially in the context of electrochemistry as most of the

*Address correspondence to this author at the Faculty of Industrial Sciences & Technology, Universiti Malaysia Pahang, Gambang, 26300 Kuantan, Malaysia; Tel: +609 5492403; Fax: +609 5492766;
E-mail: ckfeng@ump.edu.my

† E.A.A. Aboelazm and G.A.M. Ali contributed equally to this work as first authors.

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