FABRICATION OF GRAPHENE OXIDE/ZINC OXIDE NANOCOMPOSITE THROUGH SPRAYING METHOD FOR SOLAR CELL APPLICATION

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ABSTRACT

This study aimed to fabricate counter electrode (CE) and photoanode for dye sensitized solar cells (DSSCs) application. The method used to synthesize graphene oxide (GO) was electrochemical exfoliation which assisted by custom-made triple-tails sodium 1, 4-bis (neopentyloxy)-3-(neopentyloxycarbonyl)-1, 4-dioxobutane-2-silphonate (TC14) and commercially available single-tail sodium dodecyl sulphate (SDS) surfactants. The GO was then reduced by reduction process in order to produce reduced GO (rGO). The samples of TC14-GO, TC14-rGO, SDS-rGO and hybrid of TC14-rGO with carbon nanotubes (CNTs) were used as CE. The CE thin films were fabricated by using spraying method on fluorine doped tin oxide (FTO) substrate. The platinum (Pt) was then coated on TC14-rGO and TC14-rGO/CNTs hybrid thin films. For the photoanode, the zinc oxide nanorods (ZnO NRs) and nanowires (NWRs) with the titanium dioxide (TiO_2) coating were fabricated via sol-gel immersion and squeegee method. The samples were characterized using electron microscopy, energy dispersive X-ray, high resolution transmission electron microscopy, X-ray diffraction, micro-Raman, ultraviolet visible spectroscopy and four-point probes measurement. Solar simulator, electrochemical impedance spectroscopy and cyclic voltammetry measurement were used to analyze DSSCs performances. The finding shows that the highest energy conversion efficiency for DSSCs application was found to be 0.0842% by using TC14-rGO/CNTs/Pt hybrid as CE and ZnO NWRs (24h)/TiO_2 bilayer as photoanode. The open circuit voltage, short circuit density and fill factor of the sample exhibited 0.608 V, 0.285 mA/cm^2 and 0.397, respectively. In conclusion, the rGO assisted by custom-made TC14 surfactant and its hybrid with CNTs and Pt was good material to be applied as CE for DSSCs application. In addition, ZnO NWRs (24h)/TiO_2 bilayer also demonstrated good candidates for photoanode due to large surface area thus improve the dye adsorption. Implication of this study is a novel, low cost and green approach for CE fabrication by using rGO assisted custom-made TC14 surfactant with CNTs.

FABRIKASI NANOKOMPOSIT GRAFIN OKSIDA/ZINK OKSIDA MELALUI KAEDAH SEMBURAN UNTUK APLIKASI SEL SURIA

ABSTRAK

Kajian ini bertujuan memfabrikasi elektrod kaunter (EK) dan fotoanod untuk aplikasi sel suria terpeka warna (SSTW). Kaedah yang digunakan untuk mensintesis grafin oksida (GO) adalah pengelupasan elektrokimia yang dibantu oleh surfaktan buatan rantaian bercabang tiga sodium 1, 4-bis (neopentiloksi) -3- (neopentiloksikarbonil) -1, 4-dioksobutana-2-sulfonat (TC14) dan komersial rantaian tunggal sodium dodesil sulfat (SDS). GO kemudiannya diturun menggunakan proses pengurangan untuk menghasilkan penurunan GO (pGO). Sampel TC14-GO, TC14-pGO, SDS-pGO dan hibrid TC14-pGO dengan nanotiub karbon (NTK) digunakan sebagai EK. Filem tipis EK difabrikasi melalui kaedah semburan ke atas substrat timah oksida didop fluorin. Platinum (Pt) kemudian disalut pada filem tipis TC14-pGO dan hibrid TC14-pGO/NTK. Untuk fotoanod, zink oksida-batangnano (ZnO-BN) dan wayarnano (ZnO-WN) dengan lapisan titanium dioksida (TiO_2) difabrikasi melalui perendaman sol-gel dan kaedah *squeegee*. Sampel-sampel tersebut dicirikan dengan menggunakan mikroskop elektron, penyerakan tenaga sinar-X, mikroskop elektron penghantaran resolusi tinggi, pembelauan sinar-X, spektroskopi mikro-Raman, cahaya nampak ultralembayung dan pengukuran prob empat titik arus-voltan. Pengukuran solar simulator, spektroskopi impedans elektrokimia dan voltammetri berkitar digunakan untuk menganalisis potensi SSTW. Hasil kajian menunjukkan bahawa kecekapan penukaran tenaga yang paling tinggi untuk aplikasi SSTW adalah 0.0842% dengan menggunakan hibrid TC14-pGO/NTK/Pt sebagai EK dan ZnO-WN (24jam)/TiO_2 dua lapis sebagai fotoanod. Voltan litar terbuka, kepadatan litar pintas dan faktor pengisi sampel menunjukkan angka masing-masing 0.608 V, 0.285 mA/cm^2 dan 0.397. Kesimpulannya, pGO dibantu oleh surfaktan buatan TC14 dan hibridnya dengan NTK dan Pt merupakan bahan yang sesuai digunakan sebagai EK untuk aplikasi SSTW. Tambahan pula, dua lapis ZnO-WN (24jam)/TiO_2 juga menunjukkan yang baik untuk fotoanod disebabkan luas permukaan yang besar seterusnya meningkatkan penyerapan pewarna. Implikasi kajian ini adalah ianya merupakan pendekatan baharu, kos rendah dan hijau untuk fabrikasi EK dengan menggunakan pGO dibantu surfaktan buatan TC14 dengan NTK.

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LIST OF ABBREVIATIONS

AlZnO	Aluminium Zinc Oxide
AOT4	Double-Tails Sodium Bis (3,5,5-Trimethyl-1-Hexyl) Sulfosuccinate
Au	Aurum
CdTe	Cadmium Telluride
CIS	Copper Indium (Gallium) Selenide
CE	Counter Electrode
cm	Centimetre
CNTs	Carbon Nanotubes
C-V	Cyclic Voltammetry
CVD	Chemical Vapour Deposition
C_2H_7NO	Mono-Ethanolamine
$C_3H_8O_2$	2-Metoxyethanol
D	Defect and Disorder Peak
DC	Direct Current
DLG	Double Layer Graphene
DI-water	De-Ionized Water
DMPII	1,2-Dymethyl-3-Propylimidazolium Iodide
DSSCs	Dye Sensitized Solar Cells
DWCNTs	Double-Walled Carbon Nanotubes
EDX	Energy Dispersive X-Ray

EIS	Electrochemical Impedance Spectroscopy
eV	Electron Volt
F	Faraday
FESEM	Field Emission Scanning Electron Microscopy
FLG	Few Layer Graphene
FF	Fill Factor
FRA	Frequency Response Analyzer
FTO	Fluorine Doped Tin Oxide
FWHM	Full Width at Half Maximum
G	Crystalline Graphite Peak
GO	Graphene Oxide
HiPCO	High-pressure Carbon Monoxide
HRTEM	High Resolution Transmission Electron Microscopy
HMT	Hexametylenetramine
Hz	Hertz
I	Current
ITO	Indium Tin Oxide
I_D/I_G	Ratio of D and G peak
I_{sc}	Short Circuit Current
I-V	Current-Voltage
I^-/I^{3-}	Dimethyl-Propyl-Benzimidiazole Iodide/Tri-Iodide
J_{sc}	Short Circuit Current Density
J-V	Current-Voltage
M	Molar

MgO	Magnesium Oxide
MgZnO	Magnesium Zinc Oxide
MLG	Many Layer Graphene
ml	Mililitres
Mins	Minutes
MWCNTs	Multi-Walled Carbon Nanotubes
Nb_2O_5	Niobium Pentaoxide
nm	Nanometer
NRs	Nanorods
NWRs	Nanowires
N3	Cis-Bis(Isothi Cis Ocyanato) Bis(2,2′-Bipyridyl-4,4′ Dicarboxylato) Ruthenium(II)
N719	Di Tetrabutylammonium Cis-Bis (Isothiocyanato) Bis (2,2' Bipyridyl-4,4'-Dicarboxylato) Ruthenium (II)
O	Oxygen
°C	Degree Celsius
PE-CVD	Plasma-Enhanced Chemical Vapour Deposition
PH	Potential of Hydrogen
PLD	Pulsed Laser Deposition
PSS	Single-Tail Poly (Sodium 4-Styrenesulfonate)
Pt	Platinum
PVD	Physical Vapour Deposition
rGO	Reduced Graphene Oxide
rpm	Radians Per Minute
s	Second