Large-Scale Synthesis of Carbon Nanotubes and Their Applications to the Counter Electrodes of Dye-Sensitized Solar Cells

李柏毅、葉競榮；陳雍宗；姚品全

E-mail: 9511366@mail.dyu.edu.tw

ABSTRACT

The ideal counter electrodes of Dye-Sensitized Solar Cells (DSSC) must meet the following requirement: (1) Good electrical conductivity to reduce the series resistance (RS), (2) Excellent chemical stability to protect from corrosive electrolytes and take part in undesired electrochemical reactions, (3) To reduce the over-potential of the redox couples (mediator, i.e. I-/I₃⁻ in typical DSSC) and (4) High surface area for mass transfer. Fullerenes family such as C₆₀ and carbon nanotubes (CNTs) have better electron affinity for fast transfer of photocurrent (electron shuttle). Carbon nanotubes have high porosity, large surface area with good electric conductivity and relatively easy synthesized in lab. Scale. Accordingly, in this study, we had fabricated multiwalled carbon nanotubes (MWNT) based counter electrode of DSSC in endeavor for cell performance improvement. MWNTs were synthesized by atmospheric thermal chemical vapor deposition over Co-Mo/MgO by using C₂H₂ as carbon source and H₂/NH₃ as reducing ambient at 700~900°C. The major products were multiwalled carbon nanotubes with diameter around 7~13 nm. The as-synthesized MWNTs with high carbon yield are easily purified and processed. The optimal pretreatment temperature is 800 °C. For higher nanotube density, reaction temperature of 800~900°C is desirable. As the growing temperature is increased, the diameter of MWNT is larger. One of the production yield is 0.733 g-CNT/hr whose growth rate is fastest at the very start of 10min. (0.057 g-CNT/min. g-cat). After purification of the as-grown MWNTs, finely dispersed CNTs were anchored on the ITO glasses as the counter electrode of DSSC. After fabrication of TiO₂ working electrode dyed with mercurochrome. The assembled DSSC was tested for I-V character under illumination. It revealed that CNT-based counter electrode own superior VOC and ISC under identical conditions. In comparison with the traditional Pt-counter electrode (VOC=0.49 V and ISC=1.86 mA), the CNT-counter electrode possessed higher cell performance with VOC=0.65 V and ISC=3.05 mA. After keeping the [KI]/[I₂] to 5/1, the influence of different electrolyte concentration were invesitagted. The results shows that there is optimal value of [KI]/[I₂]=0.3 M/0.06 M. Under the given electrolyte value, the DSSC have VOC=0.65 V and ISC=3.05 mA. Besides, it shows that under identical [KI]/[I₂] ratio, the VOC is always kept the same. By varying the [I₂] and keeping [KI]=0.3 M, the ISC will increase as the [I₂] is increased. The equivalent solar cells circuit analysis shows that the series resistance under best cell performance in this study is Ro=138 Ω, with ideal factor n=0.56 in comparison to that of Pt-counter electrode with Ro=190 Ω, n=0.4. As a conclusion, the CNTs is effective increase the electron transfer property of counter electrode of DSSC.

Keywords: MgO; Chemical vapor deposition; Dye-Sensitized; Counter electrodes; family; after
第二章 CNTs 試驗部

2.1 藥品與氣體

2.2 反應設備

2.3 觸媒製備

2.4 奈米碳管合成

2.5 純化

2.6 微結構分析

2.6.1 掃描式電子顯微鏡 (Scanning Electron Microscopy; SEM)

2.6.2 穿透式電子顯微鏡 (Transmission Electron Microscopy; TEM)

2.6.3 拉曼光譜儀 (Raman spectrnum; RS)

第三章 CNTs 成長結果與討論

3.1 前言

3.2 觸媒型態上的觀察

3.3 不同觸媒負載量的表面觀察

3.4 前處理時間、溫度的影響

3.4.1 前處理時間的影響

3.4.2 前處理溫度的影響

3.5 成長時間、溫度的影響

3.5.1 成長溫度的影響

3.5.2 成長時間對碳產率的影響

3.6 純化後的影響

第四章 DSSC 對電極之研究

4.1 研究背景

4.2 色素增感型太陽電池 (Dye-sensitized solar cells, DSSC) 簡介

4.3 色素增感型太陽電池對電極

4.4 光電化學太陽電池

4.5 色素增感型電化學電池的優點及其工作原理

4.6 有機太陽能電池之光電轉換特性

4.6.1 短路電流 (Isc, short circuit current)

4.6.2 開路電壓 (Voc, open circuit voltage)

4.6.3 填充因子 (FF, fill factor)

4.6.4 能量轉換效率 (η, power conversion efficiency)

4.7 DSSC 實驗部份

4.7.1 實驗藥品

4.8 實驗步驟

4.8.1 氧化銦錫玻璃 (ITO) 基板之清洗

4.8.2 工作電極的製作

4.8.3 對電極的製作

4.8.4 加入電解液及封裝

4.9 I-V 曲線之充電特性量測

4.10 太陽能電池之串聯電阻

4.11 結果與討論

5.1 結論

第六章 參考文獻

REFERENCES


