SYNTHESIS OF ALIGNED CARBON NANOTUBES FROM WASTE CHICKEN FAT USING THERMAL CHEMICAL VAPOUR DEPOSITION METHOD FOR FIELD EMISSION DEVICES

NOR DALILA BINTI ABD RAHMAN

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ABSTRACT

This study aimed to synthesise carbon nanotubes (CNTs) from waste chicken fat as a carbon precursor and ferrocene as a catalyst. The method used in this study was thermal chemical vapour deposition. Several parametric studies were conducted to optimise the growth of CNTs from waste chicken fat. A new carbon precursor from gutter oil was also explored. The samples were characterised using electron microscopy, energy dispersive X-ray, X-ray diffraction, micro-Raman spectroscopy and thermogravimetric analysis. Field emission properties of the selected samples were analysed using field electron emission (FEE) measurements. The findings showed that the oil extracted from the mixture of fat-skin that were chopped into pieces and heated using oven was able to produce a dense vertically aligned CNTs (VACNTs) with small diameter (18.1-31.2 nm) and high crystallinity. Meanwhile, heating rate of 70 °C min^{-1}, synthesis and vaporisation temperature of 800 and 570 °C, respectively, catalyst concentration of 5.33 wt%, synthesis time of 60 minutes and precursor volume of 6 ml were considered as optimum parameters for the production of VACNTs from waste chicken fat, with carbon conversion of 51.94%. The composite of VACNTs with zinc oxide (ZnO) nanostructures were also fabricated using sol-gel immersion method in order to enhance their FEE performances. The growth of ZnO nanostructures on VACNTs improved FEE performances significantly as compared to other structures. In conclusion, VACNTs synthesised from waste chicken fat as well as their composite materials with ZnO nanostructures were good candidates to be used in field emission devices such as flat panel display. Implication of the study is that it offers a new innovation in green technology through the production of cheap and high quality VACNTs using the waste chicken fat.

SINTESIS NANOTIUB KARBON SEJAJAR DARIPADA SISA LEMAK AYAM MENGGUNAKAN KAEDAH PEMENDAPAN WAP KIMIA TERMA UNTUK PERANTI PEMANCARAN MEDAN

ABSTRAK

Kajian ini bertujuan mensintesis nanotiub karbon (NTK) daripada sisa lemak ayam sebagai karbon prekursor dan ferosena sebagai pemangkin. Kaedah yang digunakan dalam kajian ini adalah pemendapan wap kimia terma. Beberapa kajian parametrik dijalankan untuk mengoptimumkan penghasilan NTK daripada sisa lemak ayam. Karbon prekursor baharu daripada minyak longkang juga dikaji. Sampel dianalisis menggunakan mikroskop elektron, analisis tenaga sinar-X, pembelauan sinar-X, spektroskopi mikro-Raman, dan analisis termogravimetri. Pemancaran medan bagi sampel tertentu dianalisis menggunakan peralatan pemancaran elektron medan (PEM). Dapatan kajian menunjukkan bahawa minyak yang diekstrak daripada campuran lemak-kulit yang dipotong menjadi bahagian kecil dan dipanaskan menggunakan ketuhar telah berjaya menghasilkan NTK sejajar yang tumpat dengan diameter yang kecil (18.1-31.2 nm) dan kristaliniti yang tinggi. Sementara itu kadar pemanasan sebanyak 70 °C min^{-1}, suhu sintesis dan pengewapan, masing-masing pada 800 dan 570 °C, 5.33 peratus berat pemangkin, 60 minit masa sintesis, dan 6 ml isipadu prekursor telah dipertimbangkan sebagai parameter-parameter optimum bagi penghasilan NTK sejajar daripada sisa lemak ayam, dengan penukaran karbon sebanyak 51.94%. Komposit bahan karbon dengan struktur nano zink oksida (ZnO) juga difabrikasi menggunakan kaedah rendaman sol-gel untuk meningkatkan kemampuan PEM bahan. Pertumbuhan nanoZnO di atas struktur NTK meningkatkan kemampuan PEM secara signifikan berbanding struktur yang lain. Kesimpulannya, NTK sejajar yang disintesis daripada sisa lemak ayam serta bahan kompositnya dengan struktur nanoZnO adalah sesuai digunakan dalam peranti pemancaran medan seperti paparan panel rata. Implikasi kajian adalah ia menawarkan satu inovasi baru dalam teknologi hijau melalui penghasilan NTK sejajar yang berkualiti tinggi dan murah menggunakan sisa lemak ayam.

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LIST OF SYMBOLS AND ACRONYMS

CNFs	-	Carbon Nanofibres
CNTs	-	Carbon Nanotubes
CVD	-	Chemical Vapor Deposition
DTGA	-	Differential Thermal Analysis
EDX	-	Energy Dispersive X-ray
FEE	-	Field Electron Emission
FESEM	-	Field Emission Scanning Electron Microscopy
FTIR	-	Fourier Transform Infrared Spectroscopy
FOG	-	Fat, Oil, and Grease
GC-MS	-	Gas Chromatography-Mass Spectroscopy
HMT	-	Hexamethylenetetramine
HRTEM	-	High Resolution Transmission Electron Microscopy
ICP-OES	-	Inductively Coupled Plasma-Optical Emission Spectroscopy
MgZnO	-	Magnesium Zinc Oxide
MWCNTs	-	Multi-walled Carbon Nanotubes
RBM	-	Radial Breathing Mode
SWCNTs	-	Single-walled Carbon Nanotubes
TCVD	-	Thermal Chemical Vapor Deposition
TEM	-	Transmission Electron Microscopy
TGA	-	Thermogravimetric Analysis
VACNTs	-	Vertically Aligned Carbon Nanotubes
VOC	-	Volatile Organic Compound
XRD	-	X-ray Diffraction

Zn-HMT	-	Zinc-Hexamethylenetetramine
ZnO	-	Zinc Oxide
β	-	Field Enhancement Factor
ω	-	Radial Breathing Mode Peak
ϕ	-	Work Function
Å	-	Angstrom
β	-	Field Enhancement Factor
°C	-	Degree Celcius
a-C	-	Amorphous Carbon
D	-	Defect-Activated Peak
E_F	-	Fermi Energy
E_{loc}	-	Local Electric Field
Fe	-	Iron
F-N	-	Fowler-Nordheim
G	-	Crystalline Graphite Peak
g	-	Gram
I_D/I_G	-	Ratio of D and G peaks
I-V	-	Current-Voltage
J-E	-	Current Density-Electric Field
*L*a	-	In Plane Graphitic Crystallite Size
M	-	Molar
ml	-	Milliliter
µm	-	Micrometer
nm	-	Nanometer
wt%	-	Weight Percentage

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter discussed about research background, problems, objectives, as well as the scope and limitation of the studies. The research problems that encourage this study were discussed extensively. At the end of this chapter, the thesis organisation was presented.

1.2 Research Background

Nanotechnology is an emerging and exciting area of scientific development. As one of the most active research fields in modern materials science, it offers ways to create smaller, lighter and faster devices using fewer raw materials and less energy consumption. The term nanotechnology was first suggested by Norio Taniguchi in 1974 (Taniguchi, 1974 as cited in Drummen, 2010) to describe the technology that strives for precision at the level of about one nanometer (10^{-9} m). One of the fundamental component and keystone to nanotechnology is nanomaterials that referred to materials with the grain size of less than 100 nm. The properties of nanomaterials are significantly different from those of atoms and bulk materials. This is mainly due to the surface effects and the quantum size effects (Roduner, 2006). These effects not only modify the materials properties, but also enhance the properties resulting in superb and versatile materials (Volokitin et al., 1996)

The first creation breakthrough of the new nanomaterials was reported in 1985 by Kroto et al. with the discovery of the new carbon type in nature – the fullerenes (C60) (Kroto, Heath, O'Brien, Curl, & Smalley, 1985). This led to the discovery of carbon nanotubes (CNTs) in 1991 by Iijima (Iijima, 1991). CNTs are ideal nanoscale material that viewed as cylindrical structure formed from graphene sheet which is rolled up into seamless hollow tube and closed by fullerenoid end-caps. In general, CNTs can be classified as either single-walled CNTs (SWCNTs), double-walled CNTs or multi-walled CNTs (MWCNTs) depending on the number of rolled graphene shells. Figure 1.1 shows carbon structures of C60, SWCNT, and MWCNT.