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

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THESIS SUBMITTED IN FULFILLMENT OF THE REQUIREMENT
FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

FACULTY OF SCIENCE AND MATHEMATICS
UNIVERSITI PENDIDIKAN SULTAN IDRIS

2016



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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 $70\text{ }^{\circ}\text{C min}^{-1}$, synthesis and vaporisation temperature of 800 and 570 $^{\circ}\text{C}$, 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 $70\text{ }^{\circ}\text{C min}^{-1}$, suhu sintesis dan pengewapan, masing-masing pada 800 dan 570 $^{\circ}\text{C}$, 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.



**TABLE OF CONTENTS**

	Page
DECLARATION	ii
ACKNOWLEDGEMENTS	iii
ABSTRACT	iv
ABSTRAK	v
TABLE OF CONTENTS	vi
LIST OF TABLES	xii
LIST OF FIGURES	xiv
LIST OF SYMBOLS AND ACRONYMS	xxiii

**CHAPTER 1 INTRODUCTION**

1.1 Introduction	1
1.2 Research Background	1
1.3 Research Problems	4
1.4 Research Objectives	10
1.5 Scope and Limitation of Studies	10





1.6 Thesis Organisation	12
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CHAPTER 2 LITERATURE REVIEW

2.1 Introduction	13
2.2 Growth Method of Carbon Nanotubes	14
2.2.1 Thermal Chemical Vapour Deposition Method	17
2.3 Carbon Source for the Production of Carbon Nanotubes	20
2.3.1 Chicken Fats and Their Chemical Composition	23
2.3.2 Fat, Oil, and Grease and Their Chemical Composition	25
2.4 Growth Mechanism of Carbon Nanotubes	30
2.5 Growth Termination of Carbon Nanotubes	34
2.6 Vertically Aligned Carbon Nanotubes Growth	36
2.7 Field Electron Emission Properties of Carbon Nanotubes	38
2.8 Field Electron Emission Enhancement by Carbon Nanotubes/Zinc Oxide Nanocomposite	43
2.9 Characterisation of Carbon Nanotubes	46
2.10 Summary	52





CHAPTER 3 MATERIALS AND METHODS

3.1	Introduction	53
3.2	Synthesis of Carbon Nanotubes	54
3.2.1	Thermal Chemical Vapour Deposition Method	54
3.2.2	Preparation of Substrates	56
3.2.3	Preparation of Carbon Precursor	56
3.2.4	Characterisations of Carbon Precursor	64
3.2.5	Preparation of Catalyst	74
3.2.6	Procedures to Synthesise Carbon Nanotubes by Thermal Chemical Vapour Deposition Method	75
3.3	Preparation of Zinc Oxide Nanostructure via Sol-Gel Immersion Method	77
3.3.1	Procedures to Synthesise Magnesium Zinc Oxide Seed Layer using Spin Coating Technique	77
3.3.2	Procedures to Synthesise Zinc Oxide Nano- structure	78
3.4	Synthesis Parameters	79
3.5	Characterisations of Samples	83





3.5.1	Field Emission Scanning Electron Microscopy and Energy Dispersive X-Ray Analysis	83
3.5.2	High Resolution Transmission Electron Microscopy	84
3.5.3	Micro-Raman Spectroscopy	85
3.5.4	Thermogravimetric Analysis	86
3.5.5	X-Ray Diffraction Analysis	87
3.5.6	Field Electron Emission Measurement	88
3.6	Brief Description of Experimental Work	89
3.7	Summary	91



CHAPTER 4 RESULTS & DISCUSSIONS

4.1	Introduction	92
4.2	Optimisation of Oil Extraction	93
4.2.1	The Effect of Processing Method	93
4.2.2	The Effect of Extracted Oil from Fat, Skin, and Fat-Skin Mixture	98
4.2.3	The Effect of Heating Method	104
4.3	The Optimisation of Synthesis Parameter	111
4.3.1	The Effect of Heating Rate	112





4.3.2	The Effect of Synthesis Temperature	119
4.3.3	The Effect of Vaporisation Temperature	128
4.3.4	The Effect of Catalyst Concentration	137
4.3.5	The Effect of Synthesis Time	146
4.3.6	The Effect of Precursor Volume	156
4.3.7	New Carbon Precursor: Gutter Oil	166
4.4	Growth Mechanism of Carbon Materials from Waste Chicken Fats and Gutter Oil.	173
4.4.1	Growth Mechanism of Carbon Nanotubes from Waste Chicken Fats and Gutter Oil	173
4.4.2	Growth Mechanism of Carbon Nanofibres with Sea Urchin-Like Structure from Waste Chicken Fats	176
4.5	Summary	181

CHAPTER 5 FIELD ELECTRON EMISSION STUDIES

5.1	Introduction	182
5.2	Field Electron Emission of Carbon Nanotubes Synthesised Using Waste Chicken Fats	183
5.3	Field Electron Emission Enhancement of Vertically Aligned Carbon Nanotubes by Fabrication of Vertically Aligned Carbon Nanotubes/Zinc Oxide Nanocomposites	191





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xi

5.3.1	Synthesis and Characterisation of Carbon Nanotubes/Zinc Oxide Nanocomposites	192
5.3.2	Field Electron Emission Properties of Vertically Aligned Carbon Nanotubes/Zinc Oxides Nanocomposite	214
5.4	Growth Mechanism of Zinc Oxide/Vertically Aligned Carbon Nanotubes Nanocomposites	228
5.5	Summary	232

CHAPTER 6 CONCLUSIONS AND FUTURE WORKS

6.1	Conclusions	234
6.2	Future Works	238



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REFERENCES

240

APPENDIX

261



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LIST OF TABLES

Tables No.		Pages
2.1	FFA composition of chicken fats	25
2.2	FFA present in FOG obtained from different collection points reported by various studies	29
3.1	Compounds identified and yield (% area) by GCMS of chicken oil	68
3.2	Compounds identified and yield (% area) by GC-MS of recovered FOG	69
3.3	CHNS analysis of chicken oil and gutter oil	72
3.4	Variations of parameters for the synthesis of CNTs	80
4.1	D, G and G' peaks FWHM and I_D/I_G ratio of the sample synthesised using the chicken oil from chop and blend method	96
4.2	The D, G and G' peaks, I_D/I_G ratio and the diameter of SWCNTs of the sample synthesised using oil extracted from skin, fat, and fat-skin mixture.	102
4.3	The analysis of amount of oil extracted from fat, skin, and fat-skin mixture	103
4.4	The comparison of extraction time and the amount of oil extracted using hot plate, gas stove, and oven	107
4.5	The D, G and G' peaks location and the I_D/I_G ratio of the sample synthesised using oil extracted using different heating method	110
4.6	The D, G and G' peaks location, FWHM and the I_D/I_G ratio of the sample synthesised with different precursor heating rate	118
4.7	The D, G and G' peaks and the I_D/I_G ratio of the sample synthesised with different synthesis temperature in the range of 700-900 °C	125
4.8	Summary of the TGA results for the CNTs synthesised with synthesis temperature of 750 and 800 °C	127
4.9	The I_D/I_G ratio of the CNTs samples synthesised at different vaporisation temperatures of 370-770 °C	135





4.10	The curve fitting results for second order Raman peak using the Lorentzian distribution function	136
4.11	Diameter, length and the growth rate of the CNTs synthesised using different catalyst concentration of 1.33-10.33 wt%	142
4.12	The D and G peaks position and the I_D/I_G ratio of the sample synthesised using catalyst concentration of 1.33-10.33 wt%	145
4.13	The weight % of element content at different part of VACNTs	152
4.14	Diameter, length and the growth rate of the nanotubes synthesised by synthesis time of 5-90 minutes	153
4.15	The D, G and G' peaks FWHM and the I_D/I_G ratio of the sample synthesised by synthesis time of 5-90 minutes	155
4.16	The average length, growth rate and diameter of the CNTs with respect to different precursor volume used	160
4.17	The position and FWHM of D, G and G' peaks as well as the I_D/I_G ratio of the sample synthesised using precursor volume in the range of 3 to 9 ml	162
4.18	Concentrations of metallic components in gutter oil analysed by ICP-OES	169
4.19	Summary of optimum parameters to synthesise VACNTs from waste chicken fat	181
5.1	XRD peaks position of pristine VACNTs, ZnO and VACNTs/ZnO nanocomposites.	210
5.2	Micro-Raman peak position and I_D/I_G ratio of pristine CNTs, ZnO, and CNTs/ZnO samples	214
5.3	FEE properties of pristine VACNTs, ZnO and VACNTs/ZnO nanocomposites	216
5.4	Fitted slope for F-N plots of FEE from pristine VACNTs, ZnO and ZnO/VACNTs nanocomposite samples	222





LIST OF FIGURES

Figures No.		Pages
2.1	Simplest set up of laser ablation method for synthesis of CNTs (Nessim, 2010).	14
2.2	Simplest set up of the arc discharge technique for synthesis of CNTs (Yan et al., 2014).	15
2.3	Schematic diagram of a CVD setup in its simplest form (Kumar, 2011).	17
2.4	(a) Grease trap installation (A1 Sewer & Drain Services, http://a1sewer-cleaning.com/is-grease-trap-installation-a-legal-requirement-for-your-business/ & Alpha Omega Plumbing & Septic, http://aoseptic.com/greasetrap-pumping.htm).	27
2.5	(a) Carbon diffuses through bulk of the metal catalyst as proposed by the Baker model (Baker, Barber, Harris, Feates, & Waite, 1972) and (b) carbon diffuses over the surface of the metal catalyst as proposed by Obelin et al. (Oberlin, Endo, & Koyama, 1976).	31
2.6	(a) Structure of a camphor molecule; reorientation of the camphor structure forming (b) a plane hexagon; and (c) a plane pentagon that are supposed to be the building blocks of the CNTs (Kumar & Ando, 2003).	32
2.7	The widely accepted growth model of (a) tip and (b) bottom growth (Baker, 1989). According to this model, if the interaction between catalyst and the substrate is weak, the catalyst would move up to the tips of the tubes as illustrated in (a). Meanwhile, strong catalyst-substrate interaction in (b) implies bottom growth model.	33
2.8	Cross-sectional SEM image of a VACNTs grown on silicon substrate (Einarsson, Murakami, Kadowaki, & Maruyama, 2008).	36
2.9	Standard field emission model from a metallic emitter (Bonard et al., 2002).	38





- 2.10 Various field emission geometries (a) rounded whisker (b) sharpened pyramid (c) hemi-spheroidal and (d) pyramidal (Utsumi, 1991). 41
- 2.11 SEM image of (a) the sample with a large-scale area; (b) ZnO nanorod ring pattern arrays with the ZnO seed layer; (c)-(d) SEM images of the ZnO-CNT heterostructure ring pattern arrays in different magnification (Liu, Fang, Zheng, Zhao, & Long, 2011). 45
- 2.12 Construction of (a) thermal electron gun and (b) field emission gun used in SEM (JEOL, http://www.jeol.co.jp/en/applications/pdf/sm/sem_atoz_all.pdf). 47
- 2.13 The organisation of TEM in comparison to that of the light microscope and SEM (Central Microscopy, University of Iowa, <http://cmrf.research.uiowa.edu/transmission-electronmicroscopy>) 49
- 2.14 Micro-Raman spectra for SWCNT, DWCNT, and MWCNT samples (Costa et al., 2008). 51
- 3.1 Schematic diagram of the TCVD system. 54
- 3.2 Typical TCVD furnace used for the synthesis of CNTs. 55
- 3.3 Chicken fats that had been cleaned (b) fats derived from the chicken skin and (c) the fats deposit surrounding organs. 57
- 3.4 Fats were blended until the texture of the fats become smooth and uniform. 59
- 3.5 Chicken fats were chopped into small pieces. 59
- 3.6 Heating process using hot plate (a) chicken fats were place in a beaker on a hot plate (b) after an hour of heating, the chicken oil separated from the cracklings. 60
- 3.7 Heating process using gas stove (a) chicken fats were placed in a frying pan (b) after 15 minutes of heating, chicken oil was extracted. 61
- 3.8 Heating process using oven. 62
- 3.9 Clear and golden-yellowish colour of filtered chicken oil obtained from heating using (a) hot plate (b) gas stove (c) oven. The leftover cracklings (d) from the extraction process. 63





- 3.10 (a) FOG collected from grease trap, (b) dark and murky colour of gutter oil after heating and filtration, (c) the debris left after filtration. 64
- 3.11 TGA and DTA curves of (a) chicken oil (b) gutter oil and (c) comparison of TGA curves for the chicken and gutter oil. 66
- 3.12 FTIR spectra of chicken and FOG oil. 73
- 3.13 The preparation step of floating catalyst approach where the ferrocene was directly mixed with chicken oil and stirred using a hot plate magnetic stirrer. The colour of the oil turned into darker colour as the catalyst concentration increased from 1.33 to 10.33 wt%. 75
- 3.14 Illustration of configurations of (a) CNTs-ZnO and (b) ZnO-CNTs nanocomposites. 83
- 3.15 FESEM instrument (Hitachi SU8020) was used to characterise the morphology and the surface structure of the samples. 84
- 3.16 HRTEM instrument (JEOL JEM 2100F) was used to characterise the morphology and the surface structure of the samples at an atomic level. 85
- 3.17 Micro-Raman spectroscopy (Renishaw InVia microRaman System) was used to investigate the crystallinity of the samples. 86
- 3.18 TGA analyser (Pyris 1 TGA, Perkin Elmer) was used to investigate the purity of the samples. 87
- 3.19 In-house fabricated FEE equipment at NIT was used to study the ability of the samples synthesised to emit the electron. 88
- 3.20 Flow chart of overall experimental work. 90
- 4.1 The FESEM image of the (a)-(b) VACNTs synthesised using the chop method oil and (c)-(d) CNTs synthesised using the blend method oil. 94
- 4.2 Micro-Raman spectra of the CNTs synthesised using the oil from different method. 96
- 4.3 RBM modes of SWCNTs for the sample synthesised using the oil from different methods. 97





4.4	The FESEM images of the CNTs synthesised using oil extracted from (a)-(b) skin, (c)-(d) fat, (e)-(f) fat-skin mixture.	99
4.5	Micro-Raman spectra for the CNTs samples synthesised using fat, skin, and fat-skin mixture.	100
4.6	RBM modes of SWCNTs for the sample synthesised using fat, skin, and fat-skin mixture.	101
4.7	The FESEM images of VACNTs synthesised using the oil extracted using (a)-(b) hot plate, (c)-(d) gas stove, and (e)-(f) oven.	105
4.8	The TGA and DTGA analysis of the raw fat-skin mixture.	108
4.9	The FESEM images of carbon microspheres synthesised using raw fat-skin mixture.	109
4.10	The micro-Raman spectra for the samples synthesised using different heating method.	110
4.11	FESEM images of VACNTs synthesised with the heating rate of (a)-(b) 2, (c)-(d) 20, and (e)-(f) 70 °C min ⁻¹ .	112
4.12	FESEM images of CNFs synthesised with the heating rate of 150 °C min ⁻¹ (Suriani, et. al., 2015b).	114
4.13	HR-TEM images of (a) VACNTs synthesised at 70 °C min ⁻¹ and (b)-(c) CNFs synthesised at 150 °C min ⁻¹ (Suriani et. al., 2015b).	115
4.14	Micro-Raman spectra with for VACNTs and CNFs synthesised from waste chicken fat with different precursor heating rate of 2-150 °C min ⁻¹ .	116
4.15	(a)-(b) No CNT produced at synthesis temperature of 600 and 650 °C; (c) CNTs synthesised at synthesis temperature of 700 °C.	120
4.16	FESEM images of the VACNTs synthesised at synthesis temperature of (a)-(b) 750 and (c)-(d) 800 °C.	121
4.17	FESEM images of the CNTs synthesised at (a) 850 and (b) 900 °C.	122
4.18	Micro-Raman spectra of the sample synthesised using different synthesis temperature ranging from 700-900 °C.	124
4.19	TGA curves for CNT synthesised with synthesis temperature of 750 and 800 °C.	126





4.20	FESEM images of (a) flake-like carbonaceous carbon structures; (b) the CNTs and carbon nanospheres synthesised at low vaporisation temperature range of 370 and 420 °C, respectively.	129
4.21	FESEM images of the sample synthesised with vaporisation temperature of (a)-(b) 470; (c)-(d) 520; and (e)-(f) 570 °C.	130
4.22	FESEM images of quasi-aligned CNTs synthesised at precursor vaporisation temperatures of (a)-(b) 670; and (c)-(d) 770 °C.	132
4.23	Micro-Raman spectra of the samples synthesised at different vaporisation temperatures of 370-770 °C.	134
4.24	FESEM images of the sample synthesised at ferrocene concentration of (a)-(b) 1.33; (c)-(d) 3.33; (e)-(f) 4.33; and (g)-(h) 5.33 wt%.	138
4.25	FESEM images of the sample synthesised at ferrocene concentration of (a)-(b) 6.33; (c)-(d) 7.33; (e)-(f) 10.33 wt%.	141
4.26	EDX maps of carbon and Fe catalyst of (a) 1.33; (b) 5.33; and (c) 10.33 wt%.	143
4.27	Micro-Raman spectra of the sample synthesised using different catalyst concentration of 1.33-10.33 wt%.	144
4.28	FESEM images of the sample synthesised at various synthesis time of (a)-(b) 5, (c)-(d) 30, (e)-(f) 40, (g)-(h) 50, (i)-(j) 60, (k)-(l) 70, (m)-(n) 80 and (o)-(p) 90 minutes at different magnification. The inset images show the structure of the secondary array.	147
4.29	The FESEM images with EDX analysis done on (a) the boundary line; (b) a random point on boundary line; and (c) lower part of the boundary line.	151
4.30	Micro-Raman spectra of the samples synthesised at various synthesis time of 5-90 minutes.	154
4.31	The FESEM images of quasi-aligned CNTs synthesised using precursor volume of (a)-(b) 3 ml and (c)-(d) 4 ml at different magnification.	157
4.32	The FESEM images of quasi-aligned CNTs synthesised using precursor volume of (a)-(b) 5 and (c)-(d) 6 ml at different magnification.	158





- 4.33 The FESEM images of CNTs synthesised using precursor volume of (a)-(b) 7; (c)-(d) 8; and (e)-(f) 9 ml at different magnification. 159
- 4.34 Micro-Raman spectra of the CNTs synthesised using precursor volume in the range of 3 to 9 ml. 161
- 4.35 TGA and DTGA curves of CNTs synthesised using 6 ml chicken oil. 163
- 4.36 FESEM images of the CNTs synthesised using gutter oil. 166
- 4.37 Lower magnification TEM image of CNTs, (b) kinked, Y-junction and bamboo-shape CNTs, and HR-TEM images of (c)-(d) hollow-centred and (e) bamboo-shape CNT. 167
- 4.38 EDX analysis of gutter oil shows the existence of metallic components (Na and Ca). 169
- 4.39 Micro-Raman spectrum showing the D, G and G' lines of the CNTs from gutter oil. 170
- 4.40 The TGA and DTGA curves of CNTs synthesised from gutter oil. 171
- 4.41 Primary growth process of CNTs synthesised from waste chicken fat and gutter oil involving (a) decomposition and dissolution; (b) diffusion and supersaturation; and (c) precipitation; (d) further growth of CNTs assisted by the hexagonal carbon radicals presence in gutter oil. 175
- 4.42 The possible mechanism for the formation of sea urchin-like CNFs. Path 1- A (i): Nucleation of Fe or Fe-C particles. A (ii): Encapsulation of Fe_3C by carbon that condensed out. B: Spherically shaped nucleus formed by the aggregation of the Fe_3C structure promoted by high heating rate applied. Path 2- C (i): Fe particles from ferrocene decomposition deposited on Si substrate. C (ii): Fe particles agglomerated due to high heating rate applied. C (iii): Decomposition and dissolution reactions of the hydrocarbon molecules from the decomposed ferrocene and the precursor forming large, spherically-shape Fe_3C nucleus. D: Outward diffusion of carbon to form the CNFs from the nucleus (Suriani et. al., 2015b). 176
- 4.43 XPS photoelectron spectra of C1s for sample synthesised within (a) 20; (b) 40; and (c) 60 minutes (Suriani et al., 2015b). 178
- 4.44 XPS photoelectron spectra of Fe2p for 20-60 minute samples. 179





- 5.1 FESEM image of VACNTs synthesised at different synthesis time; (a)-(b) 30 and (c)-(d) 60 minutes. 184
- 5.2 HR-TEM images of the sample synthesised at (a) 30 and (b) 60 minutes. Red arrows indicate the defects in the CNTs. 185
- 5.3 Micro-Raman spectra of the VACNTs synthesised at 30 and 60 minutes. 186
- 5.4 Typical *J-E* curve for the VACNTs from waste chicken fats synthesised by 30 and 60 minutes. 187
- 5.5 F-N plot of the VACNTs from waste chicken fats showing two linear segments. 188
- 5.6 Band structure of the cathode, illustrating the double-barrier model under different bias conditions. (a) In equilibrium condition i.e., without external bias; (b) at a low electric field, in which direct tunnelling occurred at Barrier 1, while F-N tunnelling occurred at Barrier 2; and (c) at a high electric field, in which F-N tunnelling occurred through both Barriers 1 and 2. 189
- 5.7 (a) FESEM images of (a) the MgZnO seed layer deposited by the spin coating technique; (b) top and (c) side view of the ZnO nanostructure synthesised using the sol-gel immersion method. 193
- 5.8 EDX analysis of ZnO nanorods synthesised using sol-gel method with MgZnO as seeded catalyst. 194
- 5.9 FESEM images of (a) ZnO-VACNTs nanocomposite, with a high magnification image of the synthesised VACNTs shown as the inset image. Only the VACNTs were visible in the image. (b) The expected configuration of the ZnO-VACNTs nanocomposite. (c) High magnification FESEM image showing that only flake-like structures and CNTs remain on the substrate, instead of ZnO nanorods, after the CNTs were synthesised on top of the ZnO layer. 196
- 5.10 (i) At the synthesis temperature of 600 °C, ZnO nanorods started to sublime; (ii) ZnO nanorods deformed as the synthesis temperature increased; (iii) at 800 °C, the ZnO nanorods completely deformed into a flake-like structure; (iv) the ZnO lattice structure of flake-like ZnO with Zn vacancies as a result of sublimation; (v) the Fe atoms from ferrocene decomposition doped Zn vacancies. 197





5.11	EDX analysis of the ZnO-VACNTs nanocomposite.	198
5.12	(a) TEM and (b) HR-TEM images of the ZnO-VACNTs nanocomposites.	199
5.13	(a) VACNTs synthesised by optimum parameter (b) top view of the MgZnO deposited on the VACNTs via the spin coating technique.	201
5.14	(a) Side and (b) top view of ZnO nanorods grown on the VACNTs; (c) the ZnO growth pattern indicated that aligned morphology of the VACNTs is not disrupted by the growth of ZnO nanorods; and (d) high magnification of flower-like ZnO nanorods.	202
5.15	EDX spectrum of the VACNTs-ZnO nanocomposite.	203
5.16	HR-TEM image of VACNTs-ZnO nanocomposite sample, showing the defect in the CNTs structure.	205
5.17	XRD analysis of the VACNTs-ZnO and ZnO-VACNTs nanocomposites in comparison with pristine VACNTs and ZnO.	207
5.18	(a) Micro-Raman spectra of the VACNTs, ZnO, ZnO-VACNTs, and VACNTs-ZnO and an enlarged spectrum showing ZnO peaks of the (b) ZnO-VACNTs and (c) VACNTs-ZnO samples.	210
5.19	Typical <i>J-E</i> curves for the VACNTs, ZnO and VACNTs/ZnO nanocomposites. Inset figure shows the magnified curves at low field region.	214
5.20	Band diagrams of (a) pristine VACNTs and (b) ZnO-VACNTs samples illustrating the addition of Fe:ZnO-C alloy layer that reduce the substrate-VACNTs barrier.	217
5.21	Schematic plot of the equipotential lines of the electrostatic voltage for VACNTs and ZnO nanorods, demonstrating the screening effect as a result of dense VACNTs.	218
5.22	Schematic band diagram of the VACNTs-ZnO nanocomposite (a) before and (b) after annealing, illustrating the reduction of the Schottky barrier height and the ZnO band gap, and the formation of the CNTs-ZnO alloy at the VACNTs-ZnO interface.	219
5.23	The F-N plots of pristine VACNTs, ZnO and VACNTs/ZnO nanocomposites samples.	221





- 5.24 Enlarged J - E curve of all samples shows dramatic increment in the emission current of ZnO-VACNTs sample. 223
- 5.25 Current stability measurement of pristine VACNTs sample. 224
- 5.26 Current stability measurement of pristine ZnO sample. 225
- 5.27 Current stability measurement of ZnO-VACNTs sample. 226
- 5.28 Current stability measurement of VACNTs-ZnO sample. 227
- 5.29 Schematic diagram showing the possible growth mechanism for ZnO-VACNTs nanocomposite. (a) Sublimation of ZnO nanorods started at 600 °C; (b) deformation of ZnO nanorods as synthesis temperature further increased; (c) complete deformation of ZnO nanorods into flake-like structure at 800 °C; (d) deposition of Fe particles from ferrocene decomposition on Fe:ZnO flake-like structure; (e) hydrocarbon particles catalytically decomposed on Fe particles and (f) VACNTs array grown on Fe:ZnO-C layer. 229
- 5.30 Possible growth mechanism of VACNTs-ZnO nanocomposite; (a) The synthesised VACNTs with an uneven surface; (b) MgZnO layer with rough and uneven surface deposited on the VACNTs surface by spin coating; (c) the immersion of the substrate in the ZnO solution resulting in the interaction between Zn-HMT complex and MgZnO; (d) ZnO nanorods grown in the direction of c -axis. Flower-like ZnO were formed as a result of agglomerated MgZnO which forms colloidal particles. 231





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



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.

