

**PREPARATION AND CHARACTERIZATION OF
NANOCELLULOSE THIN FILM FROM BROWN
SEAWEED (*SARGASSUM* Sp.) REINFORCED
X-CARBON NANOTUBE/POLYVYNIL
ALCOHOL COMPOSITES**



FLORINNA TAN

UMS
UNIVERSITI MALAYSIA SABAH

**FACULTY OF SCIENCE AND NATURAL
RESOURCES**

UNIVERSITI MALAYSIA SABAH

2017

**PREPARATION AND CHARACTERIZATION OF
NANOCELLULOSE THIN FILM FROM BROWN
SEAWEED (*SARGASSUM* Sp.) REINFORCED
X-CARBON NANOTUBE/POLYVYNIL
ALCOHOL COMPOSITES**

FLORINNA TAN



UMS
UNIVERSITI MALAYSIA SABAH

**THESIS SUBMITTED IN FULFILLMENT FOR
THE DEGREE OF MASTER OF SCIENCE**

**FACULTY OF SCIENCE AND NATURAL
RESOURCES**

UNIVERSITI MALAYSIA SABAH

2017

UNIVERSITI MALAYSIA SABAH

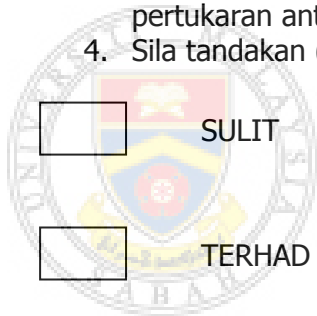
BORANG PENGESAHAN STATUS TESIS

JUDUL: **PREPARATION AND CHARACTERIZATION OF NANOCELLULOSE THIN FILM FROM BROWN SEAWEED (*SARGASSUM* Sp.) REINFORCED X-CARBON NANOTUBE/POLYVYNIL ALCOHOL COMPOSITES**

IJAZAH: **IJAZAH SARJANA SAINS (KIMIA INDUSTRI)**

Saya **FLORINNA TAN**, Sesi Pengajian **2013-2017**, mengaku membenarkan tesis Ijazah Sarjana Sains ini disimpan di Perpustakaan Univeristi Malaysia Sabah dengan syarat-syarat kegunaan seperti berikut:-

1. Tesis ini adalah hak milik Univeristi Malaysia Sabah.
2. Perpustakaan Univeristi Malaysia Sabah dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan tesis ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (/)



SULIT

(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA 1972)

TERHAD

(Mengandungi maklumat TERHAD yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

/

TIDAK TERHAD

Disahkan oleh,

FLORINNA TAN
MS1221011T

(Tandatangan Pustakawan)

Tarikh: 07 November 2017

(Dr. Jahimin A. Asik)
Penyelia

DECLARATION

I hereby declare that the material in this thesis is my own except for quotations, excerpts, equations, summaries and references, which have been duly acknowledged.

30 October 2017

.....
Florinna Tan
MS1221011T



UMS
UNIVERSITI MALAYSIA SABAH

CERTIFICATION

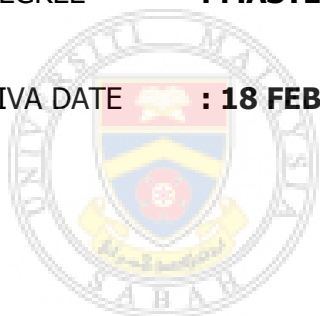
NAME : FLORINNA TAN

MATRIC NO. : MS1221011T

TITLE : PREPARATION AND CHARACTERIZATION
OF NANOCELLULOSE THIN FILM FROM BROWN
SEAWEED (*SARGASSUM* Sp.) REINFORCED
X-CARBON NANOTUBE/POLYVYNIL ALCOHOL
COMPOSITES

DEGREE : MASTER OF SCIENCE (INDUSTRIAL CHEMISTRY)

VIVA DATE : 18 FEBRUARY 2016



UMMS
UNIVERSITI MALAYSIA SABAH
CERTIFIED BY;

1. SUPERVISOR

Dr. Jahimin Asik @ Abd. Rashid Bin Asik

Signature

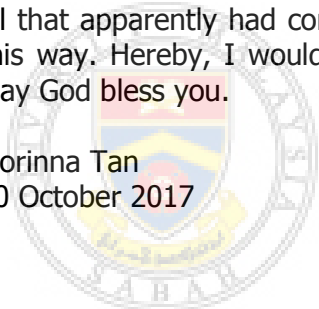
2. CO-SUPERVISOR

Rubia Binti Idris

ACKNOWLEDGEMENT

Foremost, I praise God, the almighty for granting me an opportunity and capability to complete my research and thesis successfully. Never to forget my esteemed family, my cordial thanks for spiritual support to me for all this years. I would like also to thanks to Malaysia government for the providing a scholarships via MyBrain15. MyBrain15 scholarships are really helpful. To University Malaysia Sabah, thanks for allowing me pursuing my research also provide a great facilities and infrastructure to accommodate my research. I would also like to take this opportunity to express my sincerity gratitude to both of my greatest supervisors; Dr. Jahimin Asik and Miss Rubia Bte Idris, for the excellence guidance, valuable advices, knowledge, and various experiences and also for detailed review and feedback during preparation of this thesis for the past year. I also wish to express my highest regard to all the staff members of Faculty Sciences and Natural Resources (FSSA) chemistry laboratory, who always give an assistance and support during my research; Puan Azimah, Mr. Taipin, Jerry and Recheidy. Not to forget, my beloved colleagues; Arvyvie, Bryan and Brian. We have been through all this by together for all this while, consensus and arguing to each other. Thanks for making this atmosphere for me in doing this research. Last but not less a special thanks to all that apparently had contributes their comments, assistance and guidance along this way. Hereby, I would like to express my sincere appreciation to all of them. May God bless you.

Florinna Tan
30 October 2017



ABSTRACT

Nowadays, celluloses not only can regenerate from nature but also by synthesizing with aid of the recent technology advancement. In this study, nanocellulose was extracted from brown seaweed *Sargassum* sp. via organosolvent and sulphuric acid treatments at specific ratio. It was found, the nanocellulose obtained are mostly crystalline with crystal index 77.1 %. In advance, varied amount of nanocellulose was added into polyvinyl alcohol (PVA) matrix with present of functionalized carbon nanotubes (*x*-CNT) to form a thin layer film via casting method. The thin films had an average thickness of 0.1 cm and then undergo characterization assessments. The results reveal that the optimized nanocellulose/PVA/*x*-CNT thin film possessed electrical properties around 2.68×10^{-07} S/m and tensile strength of 13.7 MPa with 62 % of elongation. Hence, nanocellulose/PVA/*x*-CNT thin film could be potentially utilized as a conductive material in electrical application in the future.



UMS
UNIVERSITI MALAYSIA SABAH

ABSTRAK

PENYEDIAAN DAN PENCIRIAN TERHADAP NANOSELULOSA FILEM NIPIS DARIPADA SARGASSUM SP. RUMPAI COKLAT GABUNGAN KARBON NANOTIUB YANG TELAH DIGUBAHSUAI

Pada hari ini, selulosa bukan sahaja ditemui pada alam semulajadi tetapi boleh juga dibentuk semula dengan teknologi terkini. Dalam kajian ini, pelarut organo dan asid sulfurik digunakan sebagai rawatan untuk mendapatkan nanoselulosa pada nisbah tertentu daripada Sargassum sp. rumpai laut warna coklat. Hasil ekstrak nanoselulosa ditemui memiliki ciri-ciri crystal dengan index sebanyak 77.1 %. Terlebih dahulu, nanoselulosa yang didapati tadi digabungkan bersama karbon nanotiub yang telah digubah suai (x-CNT) ke dalam matrik polivinil alcohol (PVA) untuk membentuk satu filem nipis. Filem nipis tersebut dibentuk menggunakan teknik casting dan mempunyai purata ketebalan sebanyak 0.1 cm dan seterusnya akan dibuat penilaian perincian. Data yang telah dikumpul membuktikan filem nipis yang telah dioptimumkan daripada filem nipis nanoselulosa/PVA/x-CNT memiliki ciri-ciri pengalir elektrik dengan nilai 2.68×10^{07} S/m dan ciri-ciri tegangan dengan nilai 13.7 MPa pada pemanjangan filem yang hampir 62 % daripada kepanjangan asal filem tersebut. Oleh itu, filem nipis nanoselulosa/PVA/x-CNT boleh diguna pakai sebagai bahan semikonduktur dalam bidang elektrik pada masa akan datang.



UMS
UNIVERSITI MALAYSIA SABAH

TABLE OF CONTENTS

	Page
TITLE	i
DECLARATION	ii
CERTIFICATION	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
<i>ABSTRAK</i>	vi
TABLE OF CONTENTS	vii
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF ABBREVIATIONS/SYMBOLS	xiii
LIST OF APPENDIX	xvi
CHAPTER 1: INTRODUCTION	
1.1 Research Background	1
1.2 Problem Statements	3
1.3 Signification of Study	4
1.4 Objectives of Study	5
1.5 Scope of Study	6
CHAPTER 2: LITERATURE REVIEW	
2.1 Introduction to Polymer Nanocomposites	7
2.1.1 Synthesize of Polymer Nanocomposites	10
Melt Blending	10
In-situ Polymerization	11
Solvent Casting	13
2.2 Polymer Nanocomposite Components	14
2.2.1 Polymer Matrix Composites (PMCs)	14
2.2.2 Variation of Nanofiller or Reinforced Materials	17
2.3 Poly(vinyl alcohol) Polymer as a Matrix	19
2.3.1 PVA Nanocomposites	20

2.4	Cellulose	21
2.4.1	Cellulose Extraction Techniques	23
	Steam Explosion Technique	24
	Peroxyacetic Acid Technique	24
2.5	Brown Seaweed <i>Sargassum</i> sp. as a Sources for Cellulose	25
2.6	Nanocellulose	26
2.6.1	Preparation of Nanocellulose	27
2.6.2	Properties and Applications of Nanocellulose	28
2.7	Carbon Nanotubes	29
2.7.1	Properties and Applicationsof Carbon Nanotubes	30
2.7.2	Method and Properties of Functionalized CNT	32
2.8	Development of Nanocellulose Polymer Thin Film	32
2.9	Instrumental Properties	34
CHAPTER 3: METHODOLOGY		
3.1	Materials	36
3.2	Materials Preparation	38
3.3	Extraction of Cellulose from Brown Seaweed <i>Sargassum</i> sp.	38
3.3.1	Delignification of Brown Seaweed <i>Sargassum</i> sp.	38
3.3.2	Bleaching Process	38
3.3.3	Determination of Cellulose Content in Brown Seaweed <i>Sargassum</i> sp.	39
3.4	Preparation of Nanocellulose	40
3.5	Preparation of Nanocellulose/PVA/ <i>x</i> -CNT Solution	40
3.6	Characterization of Nanocellulose/PVA/ <i>x</i> -CNT Thin Film	42
3.6.1	Morphology Study of Nanocellulose/PVA/ <i>x</i> -CNT Thin Film	42
	Field Electron Scanning Electron Microscopy (FESEM)	42
	Transmission Electron Microscopy (TEM)	43
3.6.2	Thermal Study of Nanocellulose/PVA/ <i>x</i> -CNT Thin Film	43
3.6.3	Crystallinity of Nanocellulose/PVA/ <i>x</i> -CNT Thin Film	44
3.6.4	Mechanical Testing of Nanocellulose/PVA/ <i>x</i> -CNT Thin Film	45
3.6.5	Functional Group Study of Nanocellulose/PVA/ <i>x</i> -CNT Thin Film	45

3.6.6	Conductivity Study Nanocellulose/PVA/ χ -CNT Thin Film	46
CHAPTER 4: RESULTS AND DISCUSSIONS		
4.1	Virtual Observation	48
4.2	Comparison Between Cellulose and Nanocellulose from Brown Seaweed <i>Sargassum</i> sp.	50
4.2.1	Infrared Transmittance Analysis of Raw Seaweed, Cellulose and Nanocellulose	51
4.2.2	Crystallinity Study of Raw Seaweed, Cellulose and Nanocellulose	54
4.2.3	Thermal Study of Raw Seaweed, Cellulose and Nanocellulose	57
4.2.4	Morphology Study of Cellulose and Nanocellulose	60
4.3	Combination of Nanocellulose and PVA as a Matrix with Various Ratio (Nanocellulose/PVA Thin Film)	62
4.3.1	FTIR Analysis of NC/PVA Thin Film	62
4.3.2	Mechanical Properties of NC/PVA Thin Film	63
4.3.3	Thermal Study of NC/PVA Thin Film	66
4.4	Evaluation of Nanocellulose/PVA Thin Film with Present of Modified CNT as Enhancement of Electrical Properties	69
4.4.1	Morphology Study of NC/PVA/ χ -CNT Thin Film	69
4.4.2	Thermal Study of NC/PVA/ χ -CNT Thin Film	72
4.4.3	Mechanical Testing of NC/PVA/ χ -CNT Thin Film	74
4.4.4	Conductivity Study of NC/PVA/ χ -CNT Thin Film	76
CHAPTER 5: CONCLUSIONS		
5.1	Summary of Research	78
5.2	Limitation and Future Work of Research	79
REFERENCES		80
APPENDIX		90

LIST OF TABLES

	Page
Table 2.1: Structure of Common Polymer Use a Matrix	16
Table 2.2: Examples of Nanofiller Incorporated in Polymer Composites for Property Enhancement	18
Table 2.3: Cellulose Weight Percent of Some Natural Fiber	22
Table 2.4: Taxonomy of Brown Seaweeds <i>Sargassum</i> sp.	26
Table 2.5: Characteristic of Nanocellulose From Different Sources	29
Table 3.1: Coding Name For Material's Content Percentage of Nanocellulose and x -CNT in PVA Thin Film	41
Table 4.1: Chemical Composition of Brown Seaweed <i>Sargassum</i> sp.	51
Table 4.2: Infrared Transmittance Peaks (cm^{-1}) of The Samples in Different Stages	53
Table 4.3: XRD Parameter From Cellulose Polymorphs	56
Table 4.4: Summary of TGA Analysis For Brown Seaweed, Cellulose and Nanocellulose	58
Table 4.5: Thermal Analysis of NC/PVA Thin Film	67
Table 4.6: Optimization of Nanocellulose Content Before Additional of x -CNT	68
Table 4.7: FESEM Image of NC/PVA/ x -CNT Thin Film with Three Different Magnifications	71
Table 4.8: Thermal Analysis of NC/PVA/ x -CNT Thin Film	73
Table 4.9: Conductivity Study of NC/PVA/ x -CNT Thin Film	77

LIST OF FIGURES

	Page
Figure 2.1 : A comparison between nanometer and hair.	8
Figure 2.2 : Classification of composite according to reinforcement.	9
Figure 2.3 : Schematic representation of a typical pharmaceutical twin-screw extruder.	11
Figure 2.4 : Schematic synthesization of polyaniline/cadmium sulphide nanocomposite.	12
Figure 2.5 : Structure of thermoplastics, elastomers and thermosets.	15
Figure 2.6 : Formation of PVA molecules from PVAc.	19
Figure 2.7 : Molecular structure of cellulose.	21
Figure 2.8 : A fullerene molecule (0D), a carbon nanotube (1D) and graphite (3D). (from left to right)	31
Figure 3.1 : (a) Raw brown seaweed Sargassum sp. in wet and (b) dried condition.	36
Figure 3.2 : Flow chart for preparation of NC/PVA/x-CNT thin film.	37
Figure 3.3 : (a) Delignification process to removing the lignin inside the seaweed and (b) bleaching process of seaweed for further whitening and remove the remain lignin.	39
Figure 3.4 : Hydrolysis process to obtain nanocellulose.	40
Figure 3.5 : Handmade casting plate using recycles glass.	42
Figure 3.6 : Transmission Electron Microscopy machine.	43
Figure 3.7 : Thermo Gravimetric Analysis machine.	44
Figure 3.8 : (a) X-ray Diffraction machine and (b) Universal Tensile Machine.	46
Figure 3.9 : Fourier Transform Infrared Spectroscopy machine.	47
Figure 3.10: Electric impedance analysis machine.	47

Figure 4.1 :	Illustration outcome of cellulose and nanocellulose preparation (a) delignified cellulose, (b) bleached celluloses, (c) hydrolyzed cellulose (nanocellulose).	49
Figure 4.2 :	NC/PVA thin film with different percent of nanocellulose in PVA; (a) C1 (b) C2 (c) C3 (d) C4 (e) C5 (f) C6.	49
Figure 4.3 :	NC/PVA/x-CNT thin film with different percent of CNT content; (a) D1 (b) D2 (c) D3 (d) D4.	49
Figure 4.4 :	Image of (a) raw seaweed, (b) cellulose and (c) nanocellulose.	51
Figure 4.5 :	FTIR spectra of (a) raw seaweed, (b) cellulose and (c) nanocellulose.	54
Figure 4.6 :	XRD pattern of (a) raw seaweed, (b) cellulose and (c) nanocellulose.	56
Figure 4.7 :	TGA-DTG thermogram of (a) raw seaweed, (b) cellulose and (c) nanocellulose.	59
Figure 4.8 :	FESEM images of (a) raw seaweed, (b) cellulose, (c) and (d) nanocellulose.	61
Figure 4.9 :	TEM image of (a) cellulose and (b) NC.	61
Figure 4.10:	FTIR spectra of NC/PVA thin film for six different ratios; (a) C1, (b) C2, (c) C3, (d) C4, (e) C5 and (f) C6.	63
Figure 4.11:	Tensile strength of NC/PVA thin film.	65
Figure 4.12:	Elongation at break of NC/PVA thin film.	65
Figure 4.13:	Stress strain curves of NC/PVA thin film.	66
Figure 4.14:	Comparison (a) TGA and (b) DTG thermograms between the ratios of NC to PVA.	68
Figure 4.15:	Comparison (a) TGA and (b) DTG thermograms of Nanocellulose Thin Film/x-CNT.	73
Figure 4.16:	Tensile strenght of NC/PVA/x-CNT thin film.	75
Figure 4.17:	Elongation at break of NC/PVA/x-CNT thin film.	75
Figure 4.18:	Stress strain curves of NC/PVA/x-CNT thin film.	76

LIST OF ABBREVIATIONS/SYMBOLS

ACC	- Aqueous Counter Collision
Bis-GMA	- 2,2-Bis-[4-(Methacryloxypropoxy)-Phenyl]-Propane
BNC	- Bacterial Nanocellulose
CdS	- Polyaniline/Cadmium Sulfide
CdSe	- Cadmium Selenide
CdTe	- Cadmium Telluride
CH₃COOH	- Acetic Acid
CNCs	- Cellulose Nanocrystals
CNTs	- Carbon Nanotubes
Cu	- Cupper
DMF	- Dimethylformamide
DTG	- Derivative Thermal
E	- Elongation At Break
EIA	- Electronic Impedance Analysis
FESEM	- Field Emission Scanning Electron Microscopy
FOLEDs	- Organic Light Emitting Diodes
FTIR	- Functional Group By Using Fourier Transform Infrared Spectroscopy
H₂O₂	- Peroxide Acid
H₂S	- Hydrogen Sulphide
H₂SO₄	- Sulphuric Acid
HCl	- Hydrochloric Acid
I	- Thickness
M	- Moisture Content
Me₂Cd	- Dimethyl Cadmium

MEK	- Methyl Ethyl Ketone
MWCNTs	- Multiwall Carbon Nanotubes
NC	- Nanocellulose
PAA	- Peracetic Acid/Peroxyacetic Acid
PAN	- Polyacrylonitrile
PE	- Polyethylene
PET	- Polyethylene Terephthalate
PMM	- Poly(Methyl Methacrylate)
PNs	- Polymer Nanocomposites
POSS	- Polyhedral Oligomeric Silsesquioxane
PVA	- Polyvinyl Alcohol
PVAc	- Polyvinyl Acetate
PVC	- Polyvinyl Chloride
R	- Residue Weight
Rb	- Bulk Resistant
SC/AA	- Sodium Chloride And Acetic Acid
SWCNTs	- Single Wall Carbon Nanotubes
TEM	- Transmission Electron Microscopy
TGA	- Thermo Gravimetric Analysis
THF	- Tetrahydrofuran
T_{max}	- Major Degradation Peak Temperature
T_{on}	- Onset Temperature
UTM	- Tensile Properties By Using Universal Mechanical Testing Machine
UV	- Ultraviolet
x-CNT	- Modified Carbon Nanotube
ZnSe	- Zinc Selenide

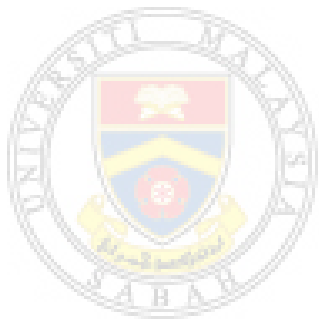
<i>cm</i>	- Cetimeter
<i>GPa</i>	- Giga Pascal
<i>Hz</i>	- Hertz
<i>kV</i>	- Kilo Voltage
<i>min</i>	- Minute
<i>mm</i>	- Milimeter
<i>nm</i>	- Nanometer
<i>rpm</i>	- Revolutions per minute
<i>wt</i>	- Weight



UMS
UNIVERSITI MALAYSIA SABAH

LIST OF APPENDIX

	Page
Appendix A TGA-DTG of NC/PVA thin film for six different ratios (a) C1, (b) C2, (c) C3, (d) C4, (e) C5 and (f) C6	90
Appendix B TGA-DTG of NC/PVA/x-CNT thin film for six different ratios (a) D1, (b) D2, (c) D3 and (d) D4	91
Appendix C Poster PEREKA 2014	92



UMS
UNIVERSITI MALAYSIA SABAH

CHAPTER 1

INTRODUCTION

1.1 Research Background

Polymer composite had been introduced into the world since early 1960s. Polymer nanocomposites are produced by incorporating materials on the nanometer scale (<100 nm) into a polymer matrix. These nanomaterials can be referred as nanofibril, nanocrystal or nanoparticles which having ability to improve stiffness, strength, toughness, thermal stability, barrier properties and flame retardant compared to the pure polymer matrix (Kamel, 2007: 547). The incorporation between polymer matrix and nanomaterial whether will improve the properties of matrix or creating a new ability of the composite either one or both.

There were precise types of material for every polymer matrix. While the properties of composites can directly affected by the filler volume fraction, the aspect ratio, alignment in the composite, and other geometric considerations (Mittal, 2010: 1). For an example, multiwall carbon nanotubes can disperse easily in polyacrylonitrile (PAN) matrix. In order to compose PAN matrix, Pirlot *et al.* (2002: 2) had stated that PAN can only be dissolved in dimethylformamide, but it will coagulate faster when contact with water.

Besides that, the filler in the polymer composite can be organic or inorganic materials. Cellulose is an example of organic material which is renewable sources. Cellulose can be derived to be nanomaterials that had played a major role in research and development of biocomposite technology by determining the properties and characteristic of the cellulose at the nano scale. Furthermore, cellulose is composed of repeating units of β -1,4 glucose by glycosidic linkage while nanocellulose have a nano scale dimension. As a result, the production and utility of nano scale cellulose fibres in polymer show a high strength and stiffness combined with low weight, biodegradability and renewability.

nanocellulose have a nano scale dimension. As a result, the production and utility of nano scale cellulose fibres in polymer show a high strength and stiffness combined with low weight, biodegradability and renewability.

The interesting characteristics and performance of cellulose-fibre-reinforced polymer composite such as low density, non abrasive, combustible, nontoxic, low cost, and biodegradable properties make it received much attention in a research field to prepare a various type of composites (Kalia *et al.*, 2009). Based on previous research, Legnani *et al.* (2008) has reported their work on nanocomposite substrates based on bacterial cellulose which is produced by Gram-negative, acetic acid bacteria *Gluconacetobacter xylinus* and Boehmite-siloxane systems were used as substrates for fabrication of flexible Organic Light Emitting Diodes (FOLEDs). They have claimed that the FOLEDs have a great improvement on the optical transmittance in the visible range. This showed that the cellulose also can incorporate with other material to generate conductivity.

On the other hand, this study is emphasizing on the incorporation of functionalized carbon nanotubes and nanocellulose. Carbon nanotubes (CNT) are tubular structures that are typically in nanometre diameter and many micrometres in length. This unique structure endowed CNT with various superior properties, for example, low density, very high stability, an outstanding tensile strength and resilience, good current carrying capacity and heat transmission ability, and extraordinary electronic behaviour (Collins and Avouris, 2000; Chu *et al.*, 2010: 1118). This idea of incorporation of CNT into nanocellulose is to make a new biodegradable product film that can conduct electricity. There are various techniques on how to synthesize the nanocomposite polymer such as drawing, template synthesis, phase separation, electro spinning and self-assembly. In this study, casting method will be used to make thin film composite. Where, a combination of polyvinyl alcohol matrix and nanocellulose reinforced with functionalized CNT were used. Subsequently, introduce conductivity property into polymer matrix.

1.2 Problem Statements

The demands of new end product in daily life are extremely challenging where the sources can be limited up to some point. Most of the industries are based on petroleum based polymer. As we know that, the petroleum oil can be derived into several stage of end user. Today, our daily products are mainly based from polymer material, such as, brusher, clothing, chair, car and other. Day after day, the product is improving, which will make more new product come out. At the same time, the sources will also be affected. But somehow, the sources of polymer based are not only from non-renewable feed stocks but also from renewable feed stock. The majority of polymers based are from non-renewable feed stock such as polyvinyl chloride, it has been widely used in many industries for various purposes like plastics and bottles. However, the petroleum feed stock is getting low so a new replacement from renewable feed stock is important to be practised.

Furthermore, non-renewable feed stock is often high cost compares to renewable feed stock as there are costs for processing a product. Since the economy is depending on petroleum oil and gas stock, there is no confirmation of fixed price for the raw materials. As a result, the availability of non-renewable feed stock will not last longer. As we know that, our petroleum oil prices are increasing from time to time. Emphasizing on renewable feed stock can be another solution to the matter above in order to produce a renewable new product.

Besides that, there is plenty of renewable feed stock sources such as plant and algal which can used to produce bio fuel or cellulose derivatives. But then, there only a few researches been conducted on brown seaweed field that specifying on cellulose composition. Since brown seaweed, especially *Sargassum* species was abundantly distributed on our beach coast area; with its rapid population that may cause a lot of problem. It is known that the *Sargassum* sp. is a non consumable product, which can be the choice to be highlighted to diversify its uses. The recent studies are also only revolving and focusing on the function of brown seaweed as a filtration unit; the research to utilize *Sargassum* sp. in this unprecedented field will venture into a new class of study to improve its usability.

1.3 Significance of Study

Cellulose from renewable feed stock could be a replacement for petroleum feed stock. There are plenty of researchers on the application of cellulose in our daily life product. Some of the research is still ongoing and some of it had already produced variety of products. Most of the researcher focused on cellulose from high level plant sources such big tree. There is limited study on acquiring cellulose from low level plants; while these vegetations are also proved to have cellulose content despite of its small amount, for example seaweed. Seaweed may contain low cellulose composition compared to high plant but they are in abundant population, and grow rapidly. Hence the amount of the cellulose to be extracted is adjustable.

In general, *Sargassum* sp. is one of brown seaweed family that has the ability of growing fast which make it abundantly available. Since the *Sargassum* sp. are non primary food sources for human being, making it a primary reason to be selected in this study. Furthermore, *Sargassum* sp. is abundantly found in Sabah area especially at Semporna district. Cellulose from *Sargassum* sp. can be used as a replacement material in many applications. In addition, using seaweed as raw material will contribute in significant cost savings of product.

Furthermore, the research on cellulose from *Sargassum* sp. can contribute to enhance knowledge on cellulose composition from brown seaweed family. A suitable method can be created in order to get cellulose from *Sargassum* sp., in which other method of extracting will be tested in this study. Moreover, cellulose can also be used in electric field with the help from reinforcement with metal. Thus, this study can be conducted to determine the ability of nanocellulose to act as a filler to gain mechanical properties and with the present of the x-CNT to possess the ability to conduct electricity in the film. So, alternative biodegradable film that is electric conductive can be presented in our electronic field which can be more preferable later on. Based on the literature, the research on the distribution of cellulose in electronic field was actually been initiated, but the source of the cellulose are from different green vegetation. Therefore the study of utilizing cellulose from brown seaweed *Sargassum* sp. was conducted with reinforcement of

x-CNT to further enhance the nanocomposite polymer film with several physical and chemical attributes.

1.4 Objectives of Study

This study embarks on the following objectives:

- i. To extract nanocellulose from brown seaweed *Sargassum* sp.
- ii. To prepare and optimize fine thin film from the combination of nanocellulose and polyvinyl alcohol (PVA) matrix.
- iii. To demonstrate the suitable ratio of combination of nanocellulose/PVA and functionalized CNT (x -CNT), will give a composite with good mechanical strength and conductive.



UMS
UNIVERSITI MALAYSIA SABAH

1.5 Scope of Study

The scope consists of three steps of preparation of thin film composite. Namely, the preparation of nanocellulose, optimizing the best thin film of nanocellulose/polyvinyl alcohol and synthesizing of nanocellulose film reinforced with x-CNT. The sample of this study is the brown seaweed *Sargassum* sp. which supplied from Semporna, Sabah. In the previous research on cellulose, it was stated that the best way to get cellulose is via organosolvent method. Therefore, in this study, the method was focused on using organosolvent which is the combination of two chemicals; acetic acid and hydrogen peroxide; also known as peroxyacetic acid. Peroxyacetic acid is a well-known delignification and bleaching agent. Cellulose will undergo acid hydrolysis as a final step to get nanocellulose.

The x-CNT will be added into nanocellulose/PVA polymer via casting method. Finally, the nanocellulose/PVA/x-CNT film will be characterized in term of morphology using Field Emission Scanning Electron Microscopy (FESEM) and Transmission Electron Microscopy (TEM); thermal properties by using Thermo gravimetric analysis (TGA); crystallinity size via X-Ray diffraction (XRD); tensile properties by using Universal Mechanical Testing Machine (UTM); functional group by using Fourier Transform Infrared Spectroscopy (FTIR); conductivity test via electronic impedance analysis (EIA). The information will be used to redesign and optimized the nanocellulose composite film.