CERTIFICATION OF APPROVAL

STUDY OF MICROSTRUCTURE AND CHEMICAL PROPERTIES OF BARNACLES GROW AT EXTERNAL SURFACE OF PIPELINES.

by

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A project dissertation submitted to the
Mechanical Engineering Programme
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BACHELOR OF ENGINEERING (Hons)
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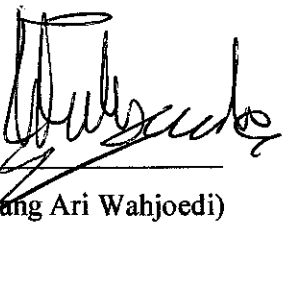
Approved by,



(AP Dr Bambang Ari Wahjoedi)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

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CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MAARUF B MOHAMAD

ACKNOWLEDGEMENT

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ABSTRACT

The study of microstructure and chemical properties of Barnacles grow at external surface of pipelines is a case study about the Barnacle that grows on the external pipeline that has brought to UTP by PETRONAS subsidiaries. The study will focus on the microstructure of the Barnacles hard shell and chemical compounds that could be found in the hard shell. The samples are characterized using characterization tools such as SEM, XRD, and FTIR. The observation from the SEM is the Barnacles hard shells contain a lot of pores, the XRD results show that the main component of the sample is Calcium Carbonate ($CaCO_3$), the FTIR show that the sample contains an organic compound such as Alcohol, Benzene, Vinyl and Primary Amine. It is recommended to further research to find the relationship between the chemical component and the coating of the pipeline where the Barnacles grown.

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LIST OF ABBREVIATION

1. UTP University Teknologi PETRONAS
2. PCSB PETRONAS Carigali Sdn Bhd
3. PMO Peninsular Malaysia Operations
4. FYP Final Year Project
5. OM Optical Microscope
6. SEM Scanning Electron Microscope
7. XRD X-Ray Diffraction
8. XRF X-Ray Fluorescence
9. FTIR Fourier Transform Infrared Spectrometry

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CHAPTER 1
INTRODUCTION

1.0 BACKGROUND

The background of the project or thesis is to study the microstructure of typical external pipeline growth barnacle. The barnacle is one of the thousand marine bivalves' species in the world. The intention or the initial idea of the study is to know and study the microstructure of the barnacle (the hard shell) for intellectual purposes. There might be something that could be done with the result of the finding.

The project is basically to study the characterization of the barnacles in term of their life cycle, ecology of their life, the place their normally found, their behavior and many more. But the focus will be more on the study of the microstructure of the typical external pipeline growth barnacles.

At Universiti Teknologi PETRONAS (UTP), there are some underwater pipelines that come from the Terengganu water where PETRONAS Carigali Sdn Bhd (PCSB) Peninsular Malaysia Operation (PMO) operated. These pipelines previously are used as oil and gas underwater pipelines and now it is replaced by the new pipeline. The pipelines are brought to Universiti Teknologi PETRONAS (UTP) to be studied by the expert, the researcher and the UTP lecturer. Meanwhile the author found that there are some kinds of marine lives that live around the pipelines. The author found that the external structure of the marine lives that live around the pipelines is unique and decide to have a further study on this subject.

1.1 PROBLEM STATEMENT

The problem statement is about the microstructure study of the external pipelines grown barnacles. The study is consisting of the microstructure pattern, the chemical and elemental composition of the hard shell. The living organism (Barnacle) is living

around the pipelines which were used to be underwater oil and gas pipelines. The structure of the hard shell of the external living organism is unique in term of layering and growth itself. The study and research is conducted to find more detail information about the elements that built up the hard shell of the living organism (Barnacle). The finding could help the author to carry on with another topic or interest in the future.

1.2 OBJECTIVES OF STUDY

The main objectives of this study are to make a study and research about the characteristic of this marine lives and the focus will be more on the microstructure of the hard shell itself. The study will cover the following purpose;

- To research the behavior of the barnacles using literature review method.
- To study the hard shell characteristic of the barnacles using characterization method such as OM, SEM, XRD, XRF and FTIR.

1.3 SCOPE OF STUDY

This project will cover by the current existed underwater pipelines at UTP and from the sample that already taken from the pipelines to do the observation and examination. The author will focus on the behavior of these marine lives for the first phase before process to the characteristic of the barnacles for the second phase.

Besides, the location to get real specimen is far from University Technologi PETRONAS (UTP) and this will limits author's availability to do sampling frequently. Besides, the transportation and cost is also one of the constraints. In order to achieve this objective, a few research, monitoring works, and laboratory works need to be carried out to obtain sufficient information with regard to the study case. Research will be done based on internet, journals, books, reports and interviews. Opinion from the expert in this marine bivalve will be taken into consideration in completing this study.

CHAPTER 2
LITERATURE REVIEW

Review for the study was taken profusely from journals, books, report and the internet. For this project, the spot to be highlighted will cover general information about barnacles. These notes are required to increase author basic knowledge on the topic. Here are some notes taken for the study.

2.0 BARNACLES

A Barnacle is a type of arthropod belonging to infraclass Cirripidia in the subphylum Crustacea, and is hence distantly related to crabs and lobster. Barnacles are exclusively marine, and tend to live in the shallow and tidal water typically in erosive settings. They are sessile suspension feeder and have two nektonic larval stages. Around 1220 barnacles species are currently know[6].

Barnacles are encrusters, attaching themselves permanently to a hard substrate. The most common, "acorn barnacles" (Sessilia) are sessile, growing their shell directly onto the substrate. Most barnacles are suspension feeders; they dwell continually in their shell- which is usually constructed of six plates and reach into the water column with modified legs. These feathery appendages beat rhythmically to draw plankton and detritus into the shell for consumption[6].

There members of the class have quite a different mode of life. For example, members of the genus *Sacculina* are parasitic, dwelling within crabs.

Although they have been found at water depths up to 600m, most barnacles inhabit shallow waters, with 75% of species living in water depths of less than 100m, and 25% inhabiting the intertidal zone. Within the intertidal zone, different species of

barnacle live in very tightly constrained locations, allowing the exact height of an assemblage above or below sea level to be precisely determined[6].

Since the intertidal zone periodically desiccates, barnacles are well adapted against water loss. Their calcite shells are impermeable, and they possess two plates which they can slide across their aperture when not feeding. These plates also protect against predation

Barnacles are displaced by limpets and mussels, who compete for space. They also have numerous predators.

They employ two strategies to overwhelm their competitors: "swamping" and fast growth. In the swamping strategy, vast numbers of barnacles settle in the same place at once, covering a large patch of substrate, allowing at least some to survive in the balance of probabilities. Fast growth allows the suspension feeders to access higher levels of the water column than their competitors, and to be large enough to resist displacement; species employing this response, such as the aptly named *Megabalanus*, can reach 7 cm in length; other species may grow larger still[6].

Competitors may include other barnacles, and there is (disputed) evidence that balanoid barnacles competitively displaced chthalamoid barnacles. Balanoids gained their advantage over the chthalamoids in the Oligocene, when they evolved a tubular skeleton. This provides better anchorage to the substrate, and allows them to grow faster, undercutting, crushing and smothering by the latter group.

Barnacles have 2 distinct larval stages before developing into a mature adult. Nauplius and cyprid stage.

Typical acorn barnacles develop six hard calcareous plates to surround and protect their bodies. For the rest of their lives they are cemented on the ground, using their feathery legs (cirri) to capture plankton[6].

CHAPTER 3
METHODOLOGY

When the project initiated, the author needs to identify all the relevant topics and choose the best topic based on interest and feasibility of the project. Final Year Project (FYP) lecturer is consulted in order to obtain some general overview of the project.

After getting a general overview of the project, research and literature review are to be done. A search will be made through the internet and from the libraries to collect all available information. Besides, information also will be obtained from the reports available in the journal and relevant institution that made an investigation and study on these marine lives. The research will be focus under these categories:

- The life cycle of the marine bivalve
- The shell characteristic of marine bivalve

Next, the criteria of the study will be justified based on the information gathered during the research. In this stage, all experiment and visits will be discussed and choose properly based on the considered requirement. Any constraint occurred during the study must be taken into consideration to avoid any incomplete scope of study. For better understanding, the lecturer must be consulted continuously from time to time.

After the specifying the area of study, the depth information will be obtained. For this study, experiments will be used as the method to obtain all the requirement information. The purposes of the experiment are as follows:

- To observe the molecular structure of the marine lives
- To observed the elements that built up the shell structure.

The type of experiments is proposed to be conducted for this study which is scanning electron microscopy (SEM). The purpose of doing the SEM is to determine the crystallography and the structure in the shells.

Lastly, all data and recommendations will be documented and submitted. At this point, the study is considered to be completed.

The general flow of the study is simplified in the Figure 1 on the next page. The flow of the specified topic is simplified on the Figure 2.

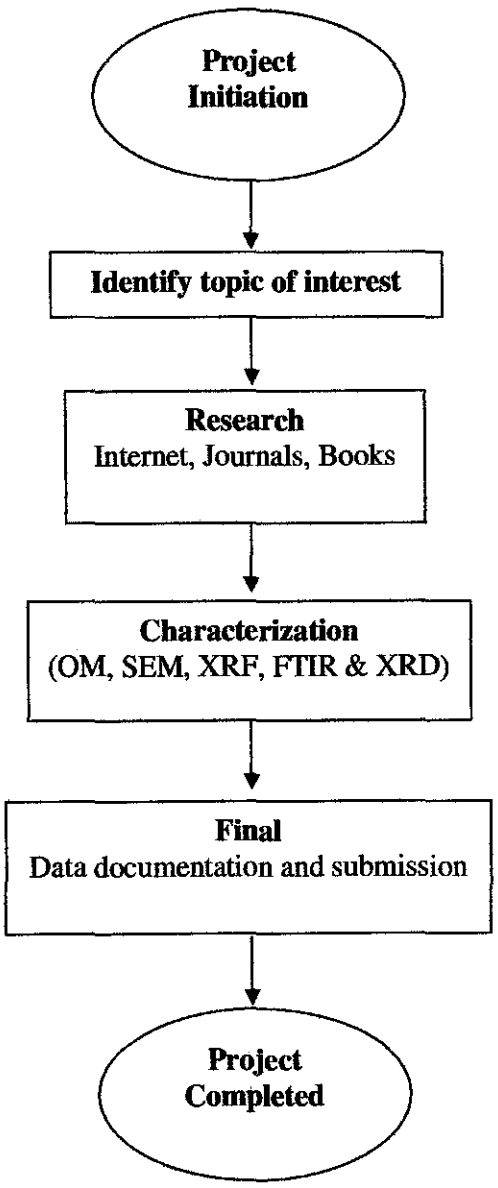

Figure 1: General Methodology of the study

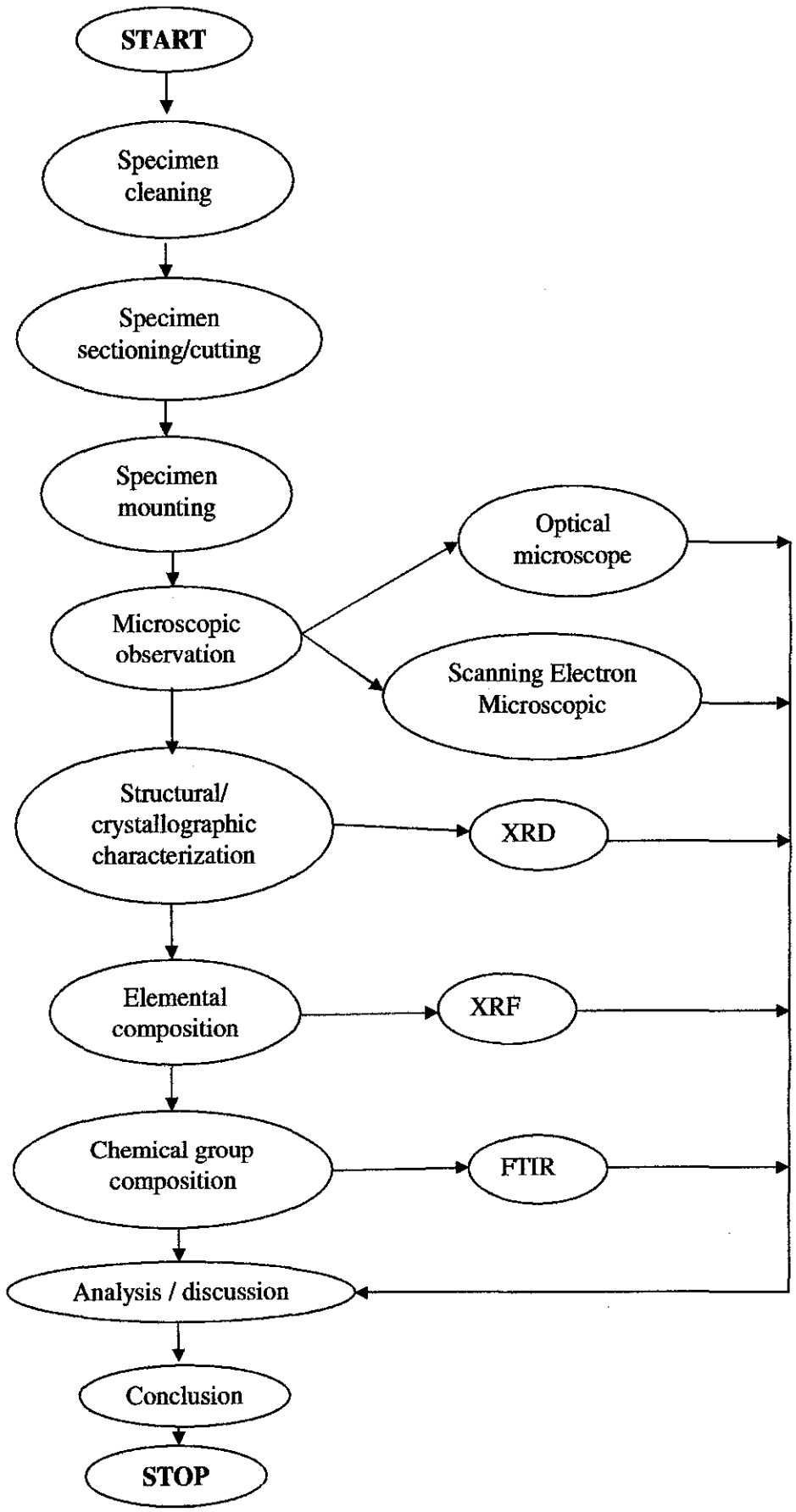

Figure 2: Methodology of the specific study

3.0 Optical microscope (OM)

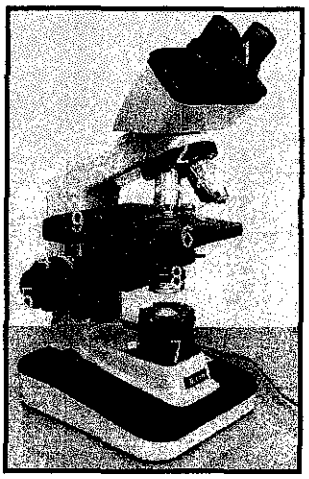

Figure 3: Optical Microscope

1. Ocular lens, or eyepiece
2. Objective turret
3. Objective lenses
4. Coarse adjustment knob
5. Fine adjustment knob
6. Object holder or stage
7. Mirror or light (illuminator)
8. Diaphragm and condenser[1]

Basic component of optical microscope:

- **The eyepiece** - a cylinder containing two or more lenses to bring the image to focus for the eye. The eyepiece is inserted into the top end of the body tube. Eyepieces are interchangeable and many different eyepieces can be inserted with different degrees of magnification. Typical magnification values for eyepieces include 5x, 10x and 2x. In some high performance microscopes, the optical configuration of the objective lens and eyepiece are matched to give the best possible optical performance. This occurs most commonly with a panchromatic objectives.

- **The objective lens** - a cylinder containing one or more lenses, typically made of glass, to collect light from the sample. At the lower end of the microscope tube one or more objective lenses are screwed into a circular nose piece which may be rotated to select the required objective lens. Typical magnification values of objective lenses are 4x, 5x, 10x, 20x, 40x, 50x and 100x. Some high performance objective lenses may require matched eyepieces to deliver the best optical performance.

- **The stage** - a platform below the objective which supports the specimen being viewed. In the center of the stage is a hole through which light passes to illuminate the specimen. The stage usually has arms to hold slides (rectangular glass plates with typical dimensions of 25 mm by 75 mm, on which the specimen is mounted).

- **The illumination source** - below the stage, light is provided and controlled in a variety of ways. At its simplest, daylight is directed via a mirror. Most microscopes, however, have their own controllable light source that is focused through an optical device called a condenser, with diaphragms and filters available to manage the quality and intensity of the light[1].

The whole of the optical assembly is attached to a rigid arm which in turn is attached to a robust U shaped foot to provide the necessary rigidity. The arm is usually able to pivot on its joint with the foot to allow the viewing angle to be adjusted. Mounted on the arm are controls for focusing, typically a large knurled wheel to adjust coarse focus, together with a smaller knurled wheel to control fine focus[1].

3.1 Scanning Electron Microscopic (SEM)

Before author can take their first SEM image of, say, a mosquito, they have to prepare the specimen. Because SEMs, unlike optical microscopes, operate in a vacuum and rely on electric fields to work, sample preparation can be a complicated process. The author start by cleaning it of any dust or debris. Once clean, it's ready to be mounted in the SEM if the specimen is fairly conductive. Otherwise, it's coated in a conductive material like gold or platinum through a process called sputter coating before it's ready for viewing. Sputter coating allows a sample to be grounded, preventing it from being damaged by the electron beam[2].

Since specimens placed in the microscopes also are subject to a vacuum, they sometimes undergo additional preparation to ensure that they hold up under such extreme conditions. Biological samples, for instance, are typically dehydrated before being placed in an SEM. Otherwise, the low atmospheric pressure of a vacuum would cause the water in biological samples to evaporate quickly, destroying the sample in the process. Other specimens are frozen before they are examined, and still others are chemically treated so that they survive the magnification process[2].

Researchers, like photographers, have a variety of controls over the images they produce. The magnification, focus, contrast and brightness of an image are all at the fingertips of the operator of an SEM. While some models have dedicated hardware for these settings, the more recent integration of computerized controls has both lowered the cost of SEMs and simplified their operation[2].

Finally, make sure to observe some safety precautions when operating the instrument. In the process of scanning specimens, SEMs generate small levels of radiation in the form of X-rays as electrons beneath the surface of a specimen are dislodged and replaced by other electrons. While X-rays are inherently dangerous to humans, you shouldn't be too worried about operating an SEM. Most of the instruments have a highly isolated specimen chamber, designed to keep out electrical and magnetic interference, so any X-rays generated in the magnification process shouldn't pose a threat to the operator. Still, researchers should make sure to observe any safety precautions concerning the operation of the SEMs at their institution[2].

3.2 X-RAY FLUORENCENSE (XRF)

X-ray fluorescence (XRF) is the emission of characteristic "secondary" (or fluorescent) X-rays from a material that has been excited by bombarding with high-energy X-rays or gamma rays. The phenomenon is widely used for elemental analysis and chemical analysis, particularly in the investigation of metals, glass, ceramics and building materials, and for research in geochemistry, forensic science and archaeology[3].

3.3 X-RAY DIFFRACTION (XRD)

X-ray diffraction finds the geometry or shape of a molecule using X-rays. X-ray diffraction techniques are based on the elastic scattering of X-rays from structures that have long range order. The most comprehensive description of scattering from crystals is given by the dynamical theory of diffraction[4].

- Single-crystal X-ray diffraction is a technique used to solve the complete structure of crystalline materials, ranging from simple inorganic solids to complex macromolecules, such as proteins.
- Powder diffraction (XRD) is a technique used to characterize the crystallographic structure, crystallite size (grain size), and preferred orientation in polycrystalline or powdered solid samples. Powder diffraction is commonly used to identify unknown substances, by comparing diffraction data against a database maintained by the International Centre for Diffraction Data. It may also be used to characterize heterogeneous solid mixtures to determine relative abundance of crystalline compounds and, when coupled with lattice refinement techniques, such as Rietveld refinement, can provide structural information on unknown materials. Powder diffraction is also a common method for determining strains in crystalline materials. An effect of the finite crystallite sizes is seen as a broadening of the peaks in an X-ray diffraction as is explained by the Scherrer Equation.

- Thin film diffraction and grazing incidence X-ray diffraction may be used to characterize the crystallographic structure and preferred orientation of substrate-anchored thin films.
- High-resolution X-ray diffraction is used to characterize thickness, crystallographic structure, and strain in thin epitaxial films. It employs parallel-beam optics.
- X-ray pole figure analysis enables one to analyze and determine the distribution of crystalline orientations within a crystalline thin-film sample.
- X-ray rocking curve analysis is used to quantify grain size and mosaic spread in crystalline materials[4].

3.4 Fourier Transform Infrared (FTIR) Spectrometry

The functions of FTIR are as below:

- Determines the type of paint (chemicals, pigments, etc.) by analyzing the way in which its various components absorb infrared light.
- Solvent tests expose the paint sample to various chemicals to look for reactions such as swelling, softening, curling and color changes[5].

Infrared spectroscopy is widely used in both research and industry as a simple and reliable technique for measurement, quality control and dynamic measurement. It is of especial use in forensic analysis in both criminal and civil cases, enabling identification of polymer degradation for example. It is perhaps the most widely used method of applied spectroscopy[7].

The instruments are now small, and can be transported, even for use in field trials. With increasing technology in computer filtering and manipulation of the results, samples in solution can now be measured accurately (water produces a broad absorbance across the range of interest, and thus renders the spectra unreadable without this computer treatment). Some instruments will also automatically tell you what substance is being measured from a store of thousands of reference spectra held in storage[7].

By measuring at a specific frequency over time, changes in the character or quantity of a particular bond can be measured. This is especially useful in measuring the degree of polymerization in polymer manufacture. Modern research instruments can take infrared measurements across the whole range of interest as frequently as 32 times a second. This can be done whilst simultaneous measurements are made using other techniques. This makes the observations of chemical reactions and processes quicker and more accurate[7].

Techniques have been developed to assess the quality of tea-leaves using infrared spectroscopy. This will mean that highly trained experts (also called 'noses') can be used more sparingly, at a significant cost saving[7].

Infrared spectroscopy has been highly successful for applications in both organic and inorganic chemistry. Infrared spectroscopy has also been successfully utilized in the field of semiconductor microelectronics: for example, infrared spectroscopy can be applied to semiconductors like silicon, gallium arsenide, gallium nitride, zinc selenide, amorphous silicon, silicon nitride, etc[7].

Fourier Transform Infrared Spectroscopy (FTIR) provides specific information about chemical bonding and molecular structures, making it useful for analyzing organic materials and certain inorganic materials. Chemical bonds vibrate at characteristic frequencies, and when exposed to infrared radiation, they absorb the radiation at frequencies that match their vibration modes. Measuring the radiation absorption as a function of frequency produces a spectrum that can be used to identify functional groups and compounds[8].

The Gantt Chart for the project can be found on APPENDIX

CHAPTER 4

RESULT

4.0 PREPARATION OF THE SAMPLE

4.0.1 XRD, XRF and FTIR

The sample for XRD, XRF and FTIR must be in powder form, so the solid sample is grinded using the grinder.

Figure 4: solid sample

Figure 5: front view

Figure 6: Top view

Figure 7 : Grinder Is Operating

Figure 8: Powder form

Figure 9: powder

4.0.2 OM and SEM

The sample for Optical Microscope (OM) and Scanning Electron Microscopy (SEM) is in solid form. Thus, the sample must be cut into smaller pieces and mount properly. Because the sample is a carbonate and can't sustance high temperature and high pressure. The cold mounting is used instead of hot mounting.

Figure 10 : Big sample is cutting into small pieces

Figure 11: Abbrasive cutter

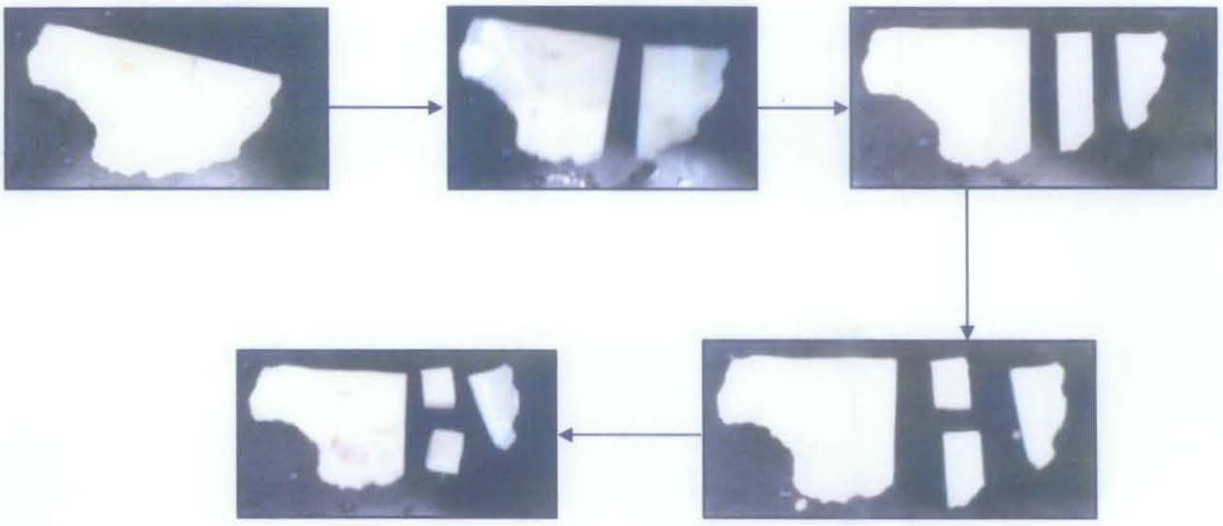

Figure 12: Process flow in cutting the sample

After the sample is cut in small pieces using abrasive cutter (Figure 13), the selected pieces is mounted using the cold mounting techniques.

Figure 13: Mounted Sample.

Before the sample could be examine under the Optical Microscope (OM) or Scanning Electron Microscopy (SEM), the sample must be polished to make sure the sample surface is exposed to the atmosphere, otherwise the sample is stuck in the middle of the cold mounting and cannot be examined under OM and SEM.

(a) (b) (c)

Figure 14: polished process using different roughness of paper, (a) polishing process, (b) grind paper grade P280, (c) grind paper grade P60

The polishing process involved the rotating machine with the roughness paper is attached to it. The roughness paper is differentiating by the number at the back of the paper. The small number indicates the rough surface paper. The processes start with the small number and continuing with a bigger numbers in stages. The purpose is to make sure the surface of sample is clean and clear before examine using OM and SEM.

Figure 15: The mounted sample after polishing process

4.1 RESULTS FOR EACH CHARACTERIZATION METHOD

4.1.1 Fourier Transform Infrared Radiography (FTIR)

There was 2 samples tested which called SAMPLE A and SAMPLE B. The difference between those 2 samples just the location where the sample was collected.

There was several preparation need to be done before the testing using FTIR machine could be run. The first thing is to add some chemical compound so called Hamburg Chemical (GmBh).

The purpose of the chemical is to give the background image to the graph, otherwise the graph will have no peak.

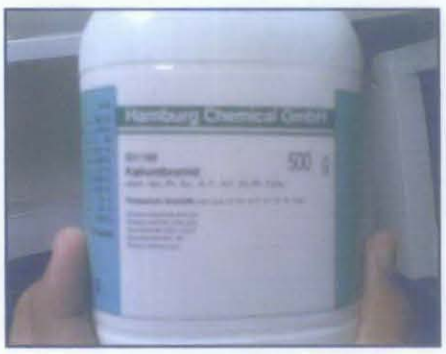

Figure 16 : Hamburg Chemical

Figure 17 : Hamburg Chemical is mix with sample

After the chemical is added with the sample, the mixture is grind slowly to make the compound of the mixture tinier. Then the mixture is press using presser at 9000 psi to make the mixture become a round and flat.

Figure 18: The mold

Figure 19: The Presser

(a) **(b)**

Figure 20: The mixture after becoming a round and thin shape, (a) The mixture is put into the shape, (b) the mixture before put into the machine

(a) (b)

Figure 21: The machine, (a) front view, (b) serial number

Figure 22: The FTIR machine

After the preparation and running the testing using FTIR machine, the result will be shown in term of graph and peaks.

The result of the FTIR is as below;

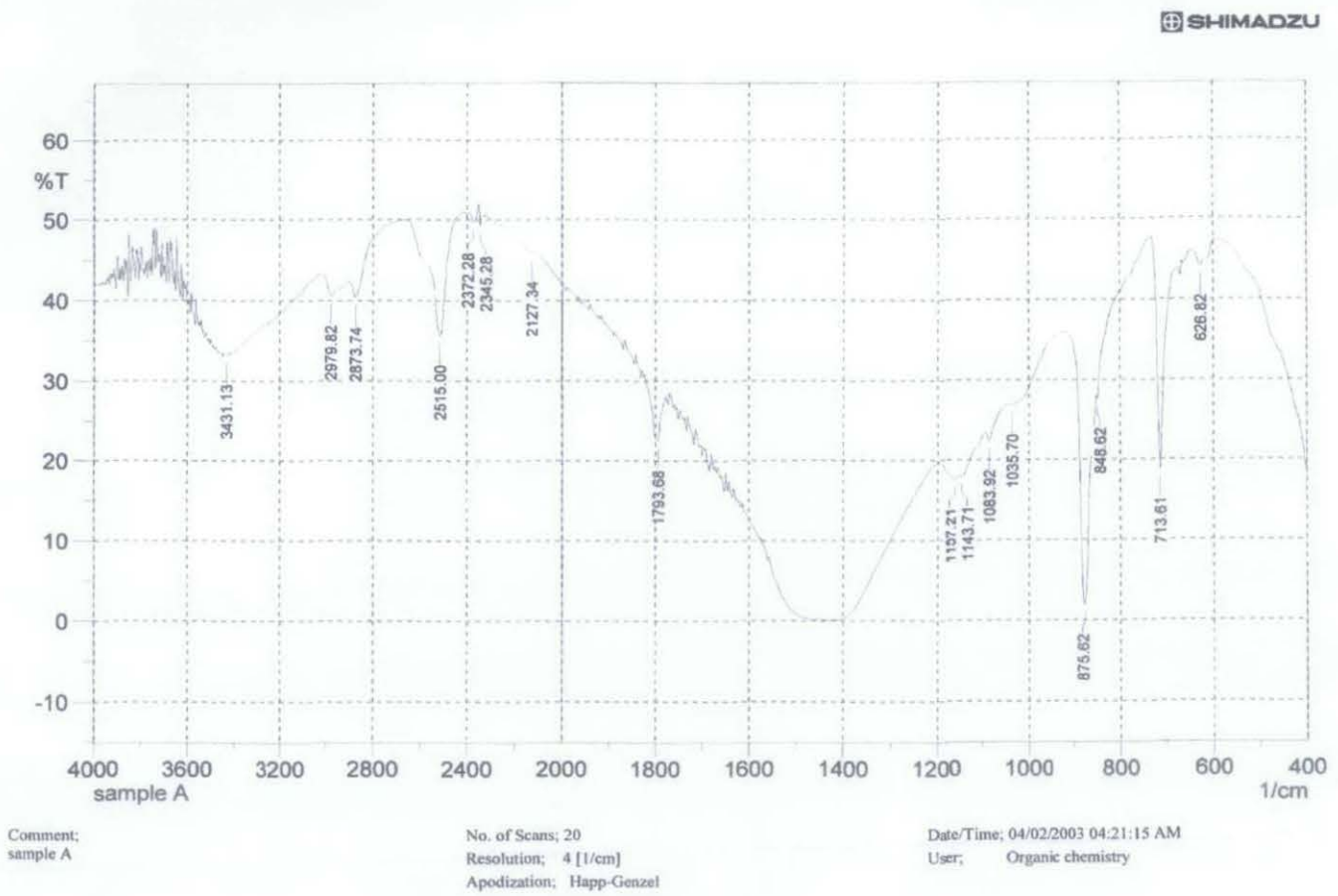

Figure 23: Sample A result

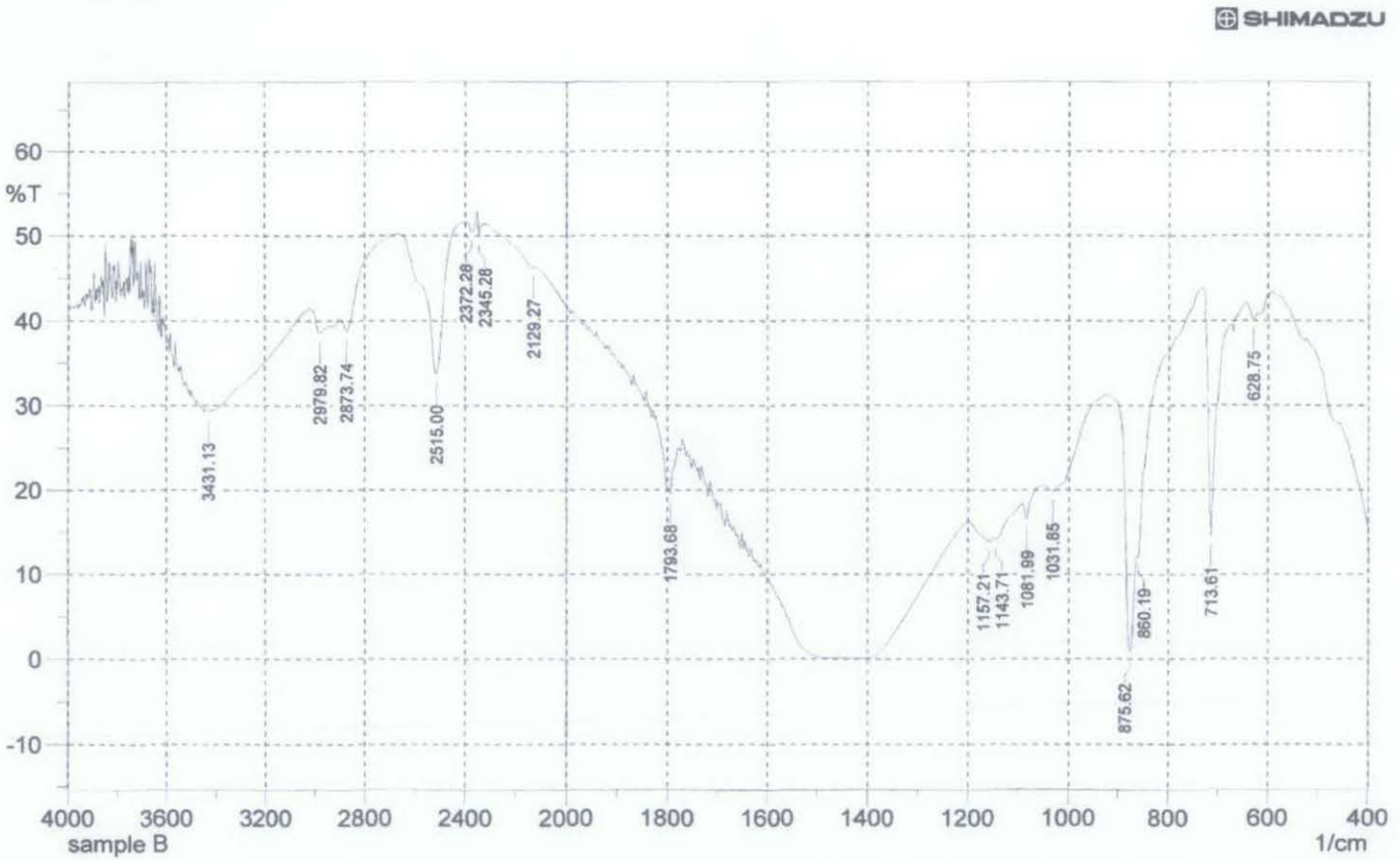

Figure 24: Sample B result

Analysis for FTIR

For Sample A

Table 1: FTIR analysis for sample A

Peaks(cm^{-1})	Type of Bond	Appearance
626.82	Chloroalkanes (540-760 cm^{-1}) (C-X)	Weak to medium
713.61	Chloroalkanes (540-760 cm^{-1}) (C-X)	Weak to medium
848.62	Para-disub benzene (800-860 cm^{-1}) (C-H)	Strong
875.62	Meta-disub benzene (860-900 cm^{-1}) (C-H)	Strong
1035.7	Aliphatic Amines (1020-1220 cm^{-1}) (C-N)	
1083.92	Secondary Alcohols (1100 cm^{-1}) (C-O)	Strong
1143.71	Secondary Alcohols (1100 cm^{-1}) (C-O)	Strong
1157.21	Tertiary Alcohols (1150-1200 cm^{-1}) (C-O)	Medium
1793.68	anhydrides (1760-1820 cm^{-1}) (R=O)	
2127.34	Isocyanides (2165-2110 cm^{-1}) (R-N-C)	
2345.28	ammoniums ions (2400-3200 cm^{-1}) (N-H)	Multiple Broad peak
2372.28	ammoniums ions (2400-3200 cm^{-1}) (N-H)	Multiple Broad peak
2515	ammoniums ions (2400-3200 cm^{-1}) (N-H)	Multiple Broad peak
2873.74	ammoniums ions (2400-3200 cm^{-1}) (N-H)	Multiple Broad peak
3431.13	Primary Amines (3400 -3500 cm^{-1}) (N-H)	Strong
2979.82	vinyl (2975 cm^{-1}) (C-H)(C=CH)	Strong

Since sample A and sample B gives the similar graph shape, thus give the same reading on the IR spectroscopy correlation table. The author could conclude that the sample B is as same as sample A in term of chemical content.

Table 2: Chemical Elements in Segment A and Segment B

Peaks (cm^{-1})	Sample A	Sample B
626.82	X	X
713.61	X	X
848.62	X	X
875.62	X	X
1035.7	X	X
1083.92	X	X
1143.71	X	X
1157.21	X	X
1793.68	X	X
2127.34	X	X
2345.28	X	X
2372.28	X	X
2515	X	X
2873.74	X	X
3431.13	X	X
2979.82	X	X

4.1.2 X-Ray Diffraction (XRD)

The characterization method was successfully done by the author on 28 August 2009 with the assistant from the lab technologies on duty.

There was 2 samples tested which called SAMPLE A and SAMPLE B. The difference between those 2 samples just the location where the sample was collected.

Since the XRD machine is dangerous machine because it's using the gama ray in the operation, only the custodian is permitted to use the machine. The author just pass the sample A and sample B in powder form to be tested and approximately after 2 weeks, the result is ready to be collected at the custodian office.

The result as below;

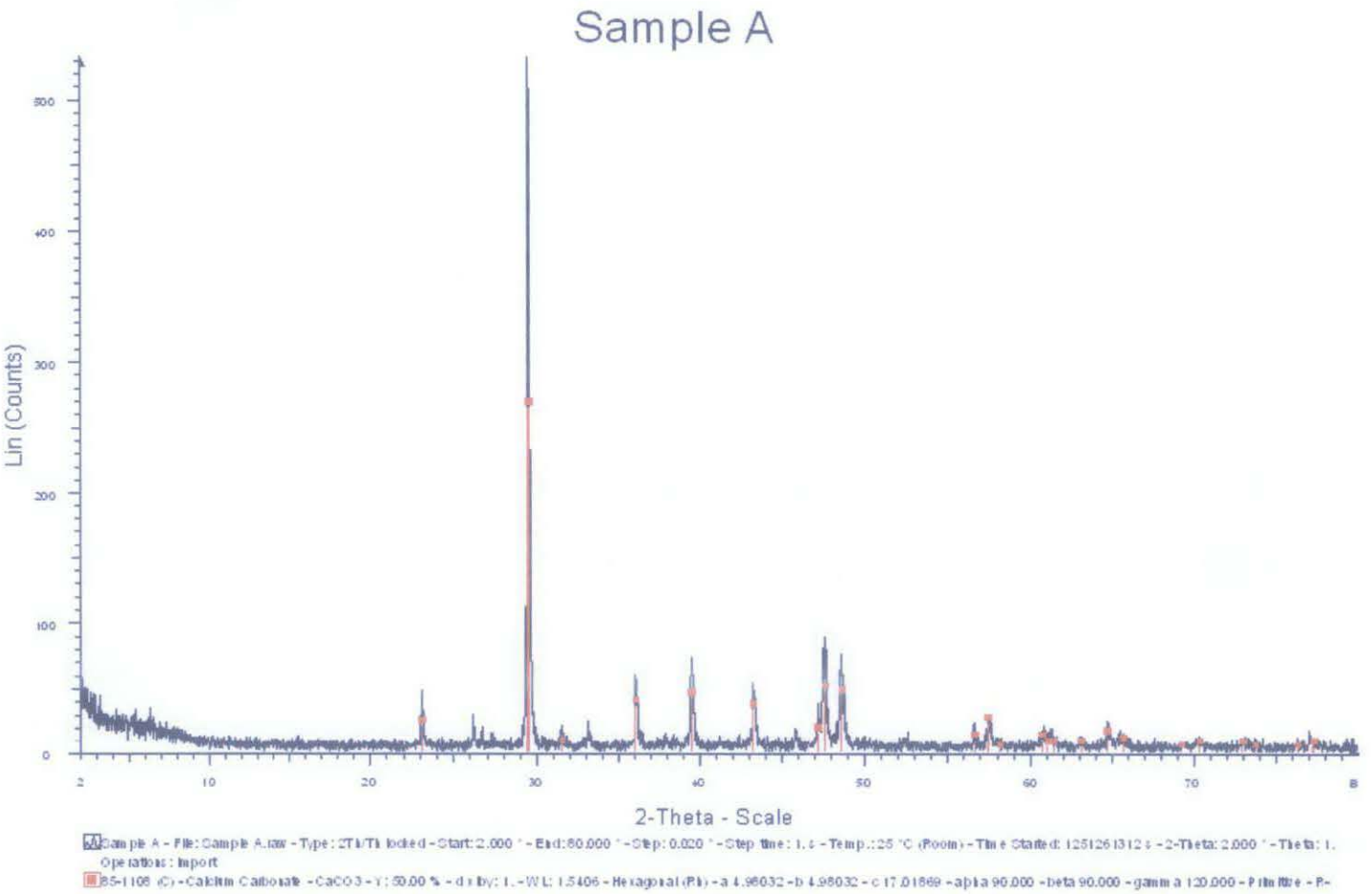

Figure 25: Sample A graph

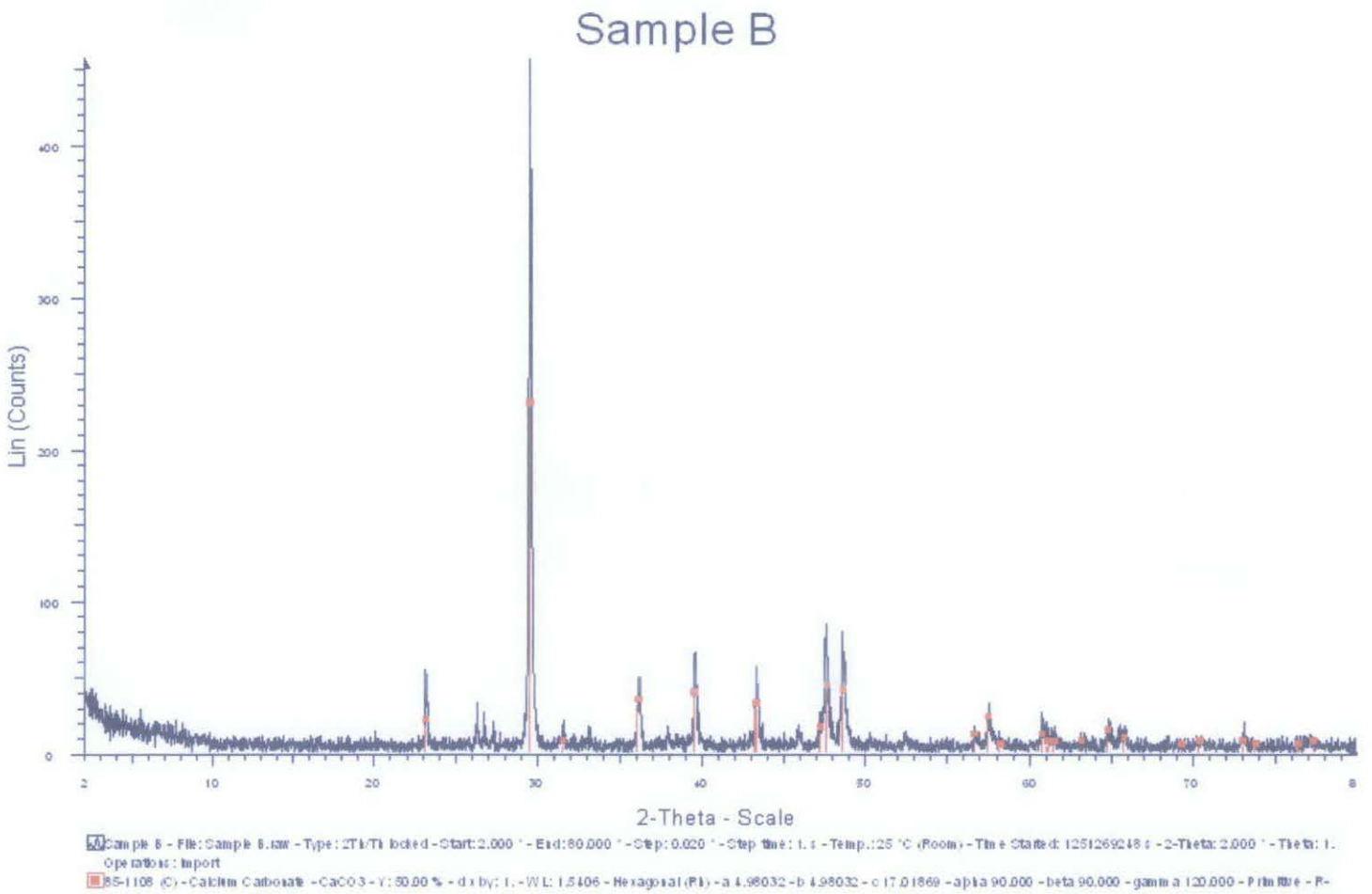

Figure 26: Sample B graph

From the observation, sample A and sample B give almost the similar result. This is expected due to the same sample with the different of location

The wavelength used in the XRD testing is $\lambda = 1.5401$ Á

The computer generated result showed that the sample contain mostly the Calcium Carbonate ($CaCO_3$)

The Bragg Law state that

$$n\lambda = 2d \sin \theta$$

Analysis

n usually 1

$\lambda = 1.5401$ Á

2θ = varies on the graph

The equation changed to

$$n\lambda = 2d \sin (2\theta/2)$$

For every single value of 2θ, the value of d must be calculated.

4.1.3 Scanning Electron Microscopy (SEM)

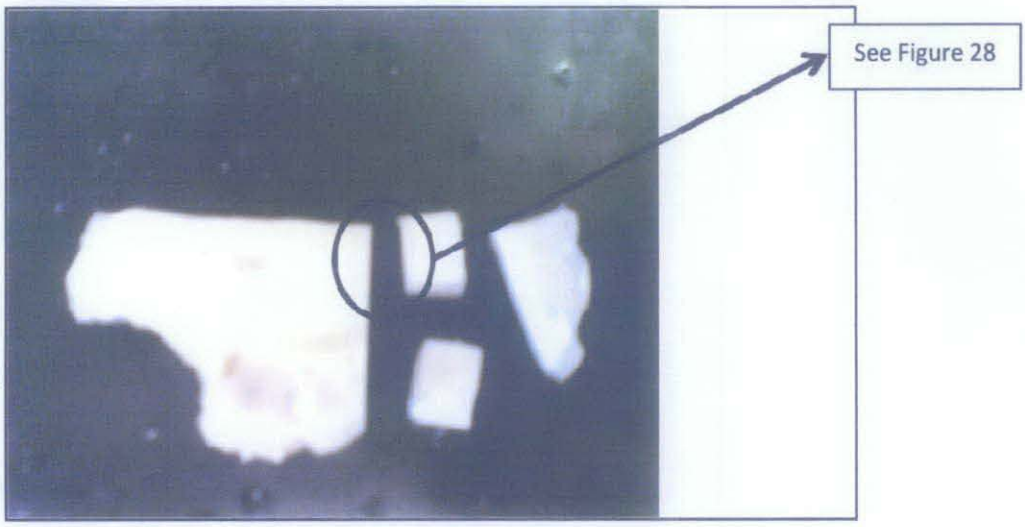

Figure 27: Cross section area

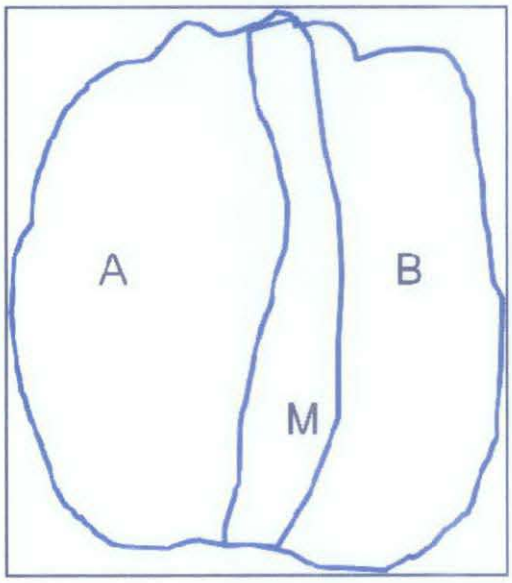

Figure 28: Cross section area that can be separated by naked eye

For every section called A,M and B, the author used 4 different magnification to show the microstructure of every sections. The magnification value are 30X, 50X, 100X and 500X respectively and the results as below.

Section A

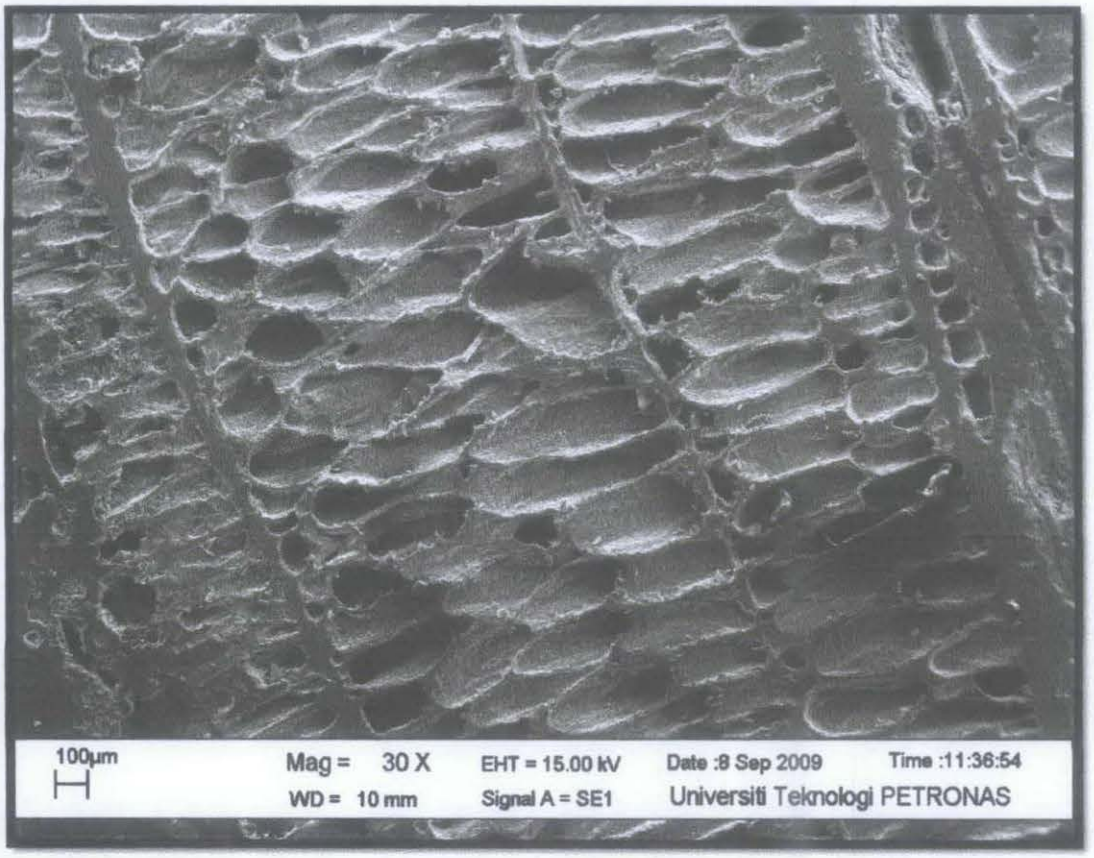

Figure 29: Part A with 30X magnification

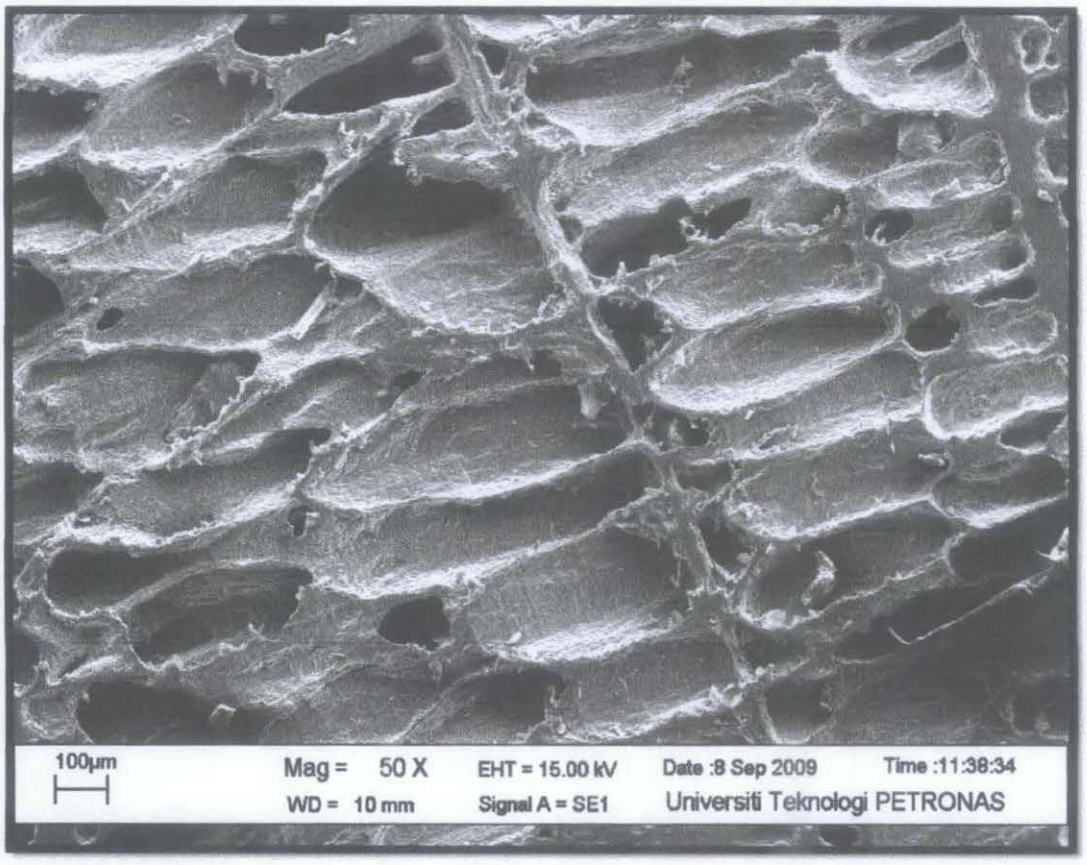

Figure 30: Part A with 50X magnification

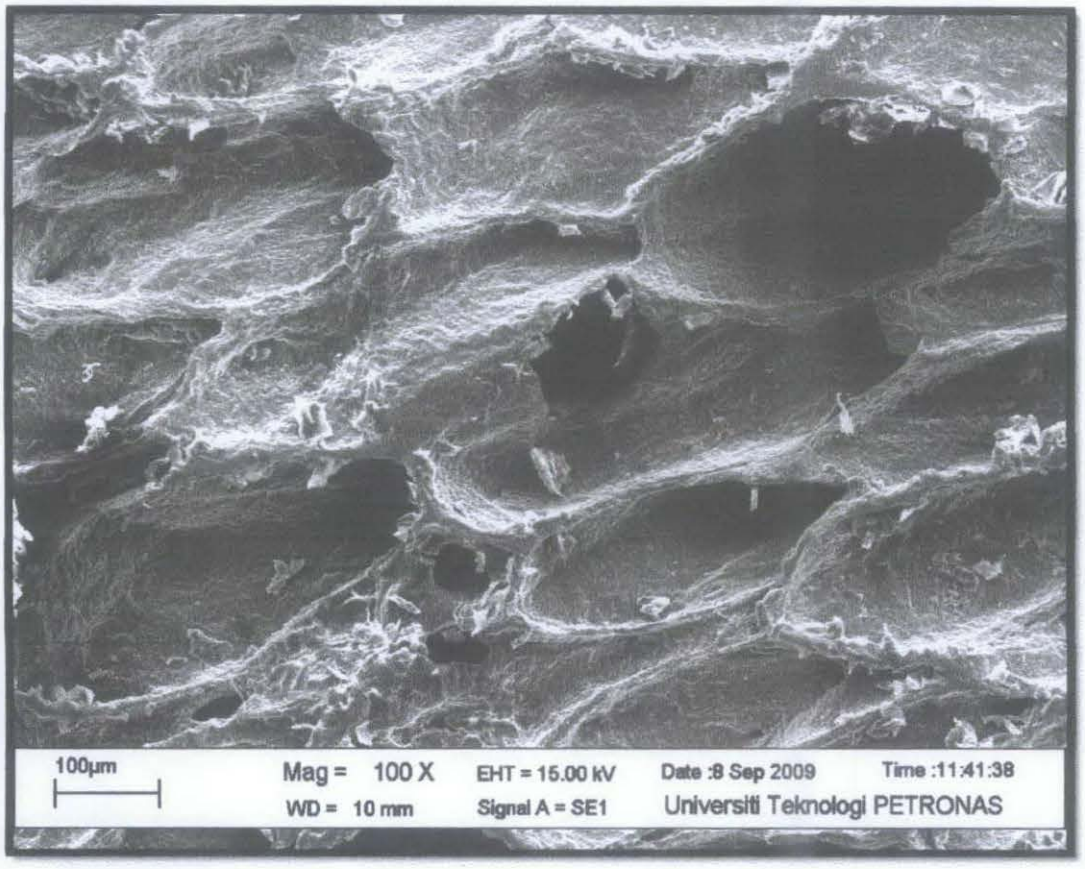

Figure 31: Part A with 100X magnification

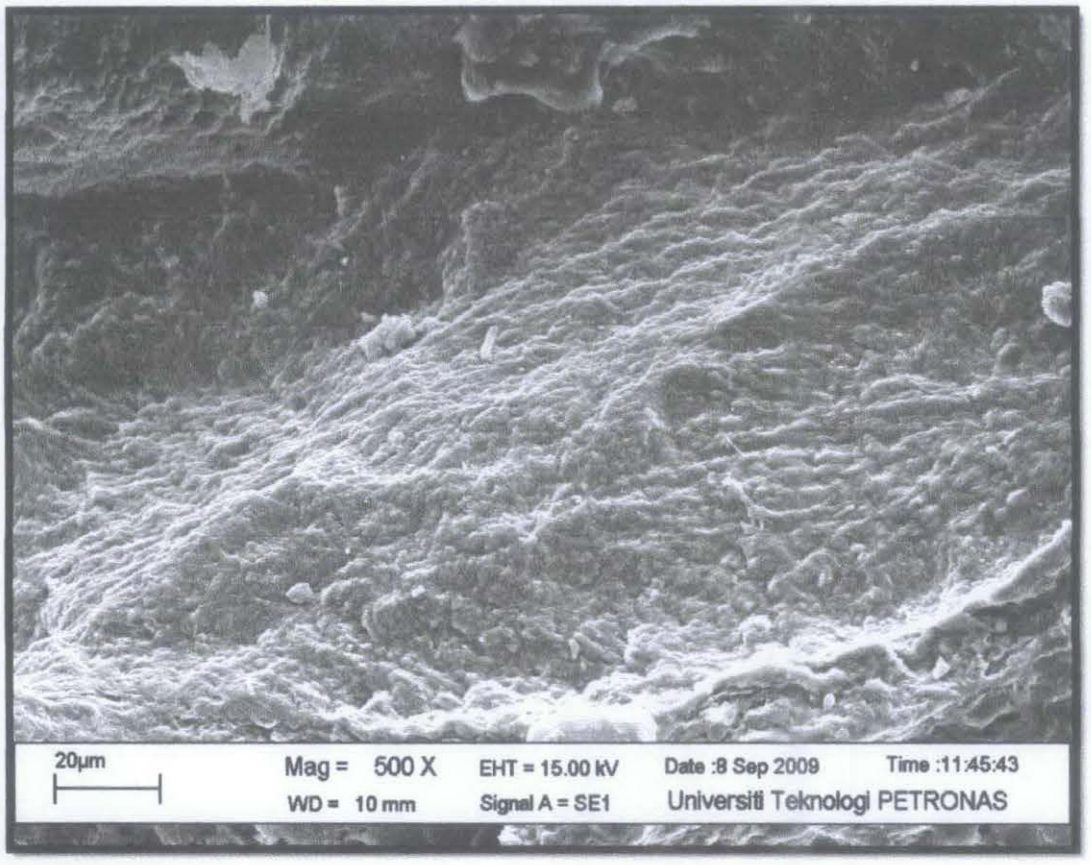

Figure 32: Part A with 500X magnification

Section M

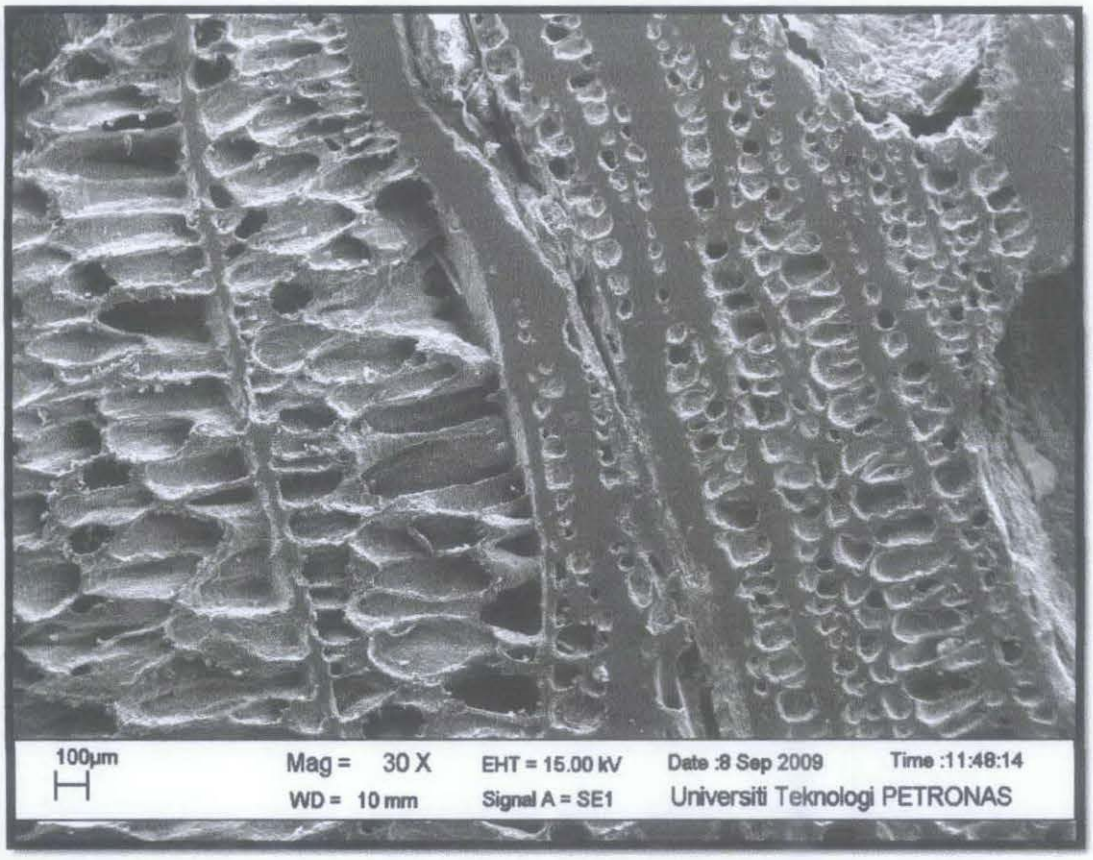

Figure 33: Part M with 30X magnification

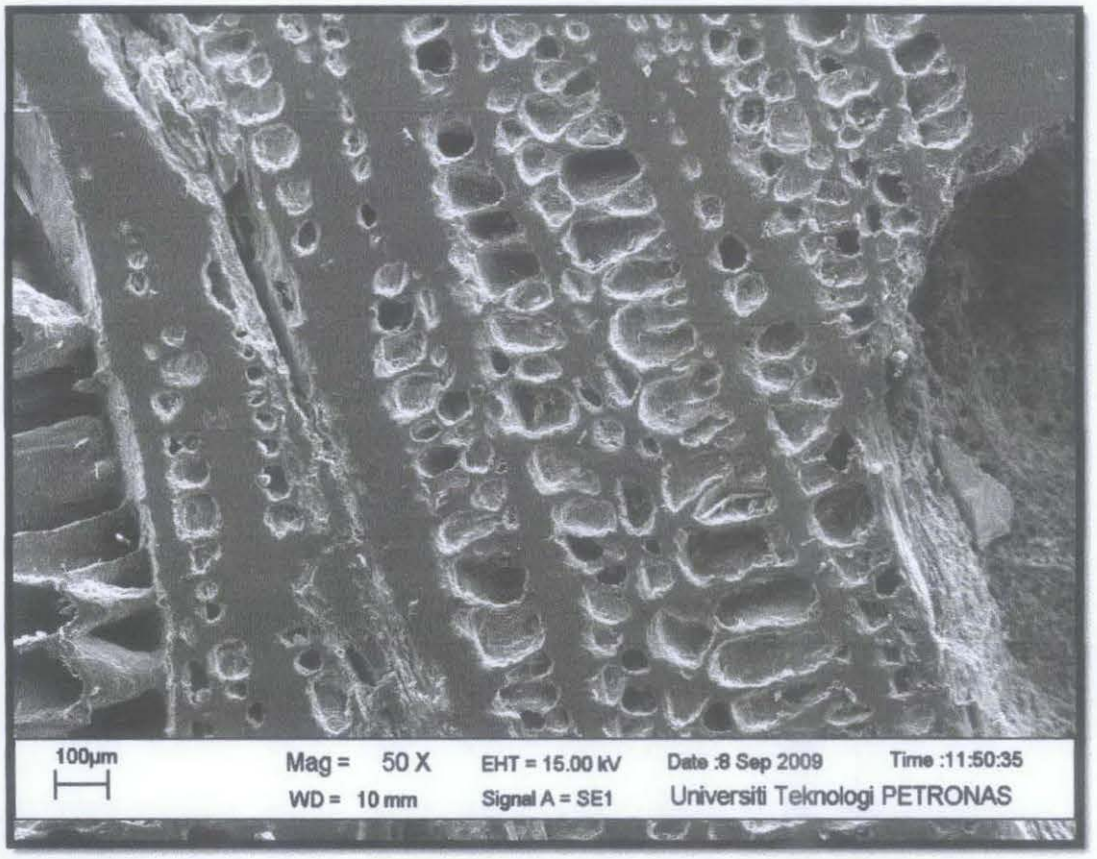

Figure 34: Part M with 50X magnification

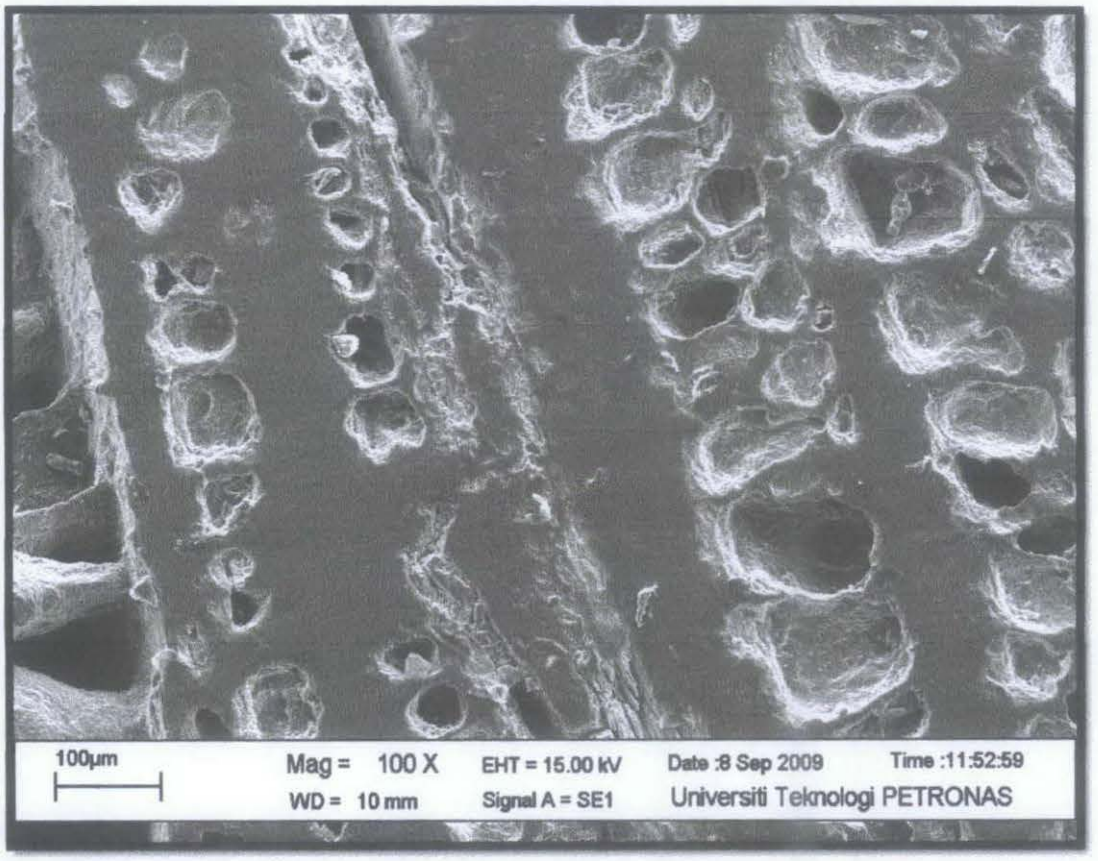

Figure 35: Part M with 100X magnification

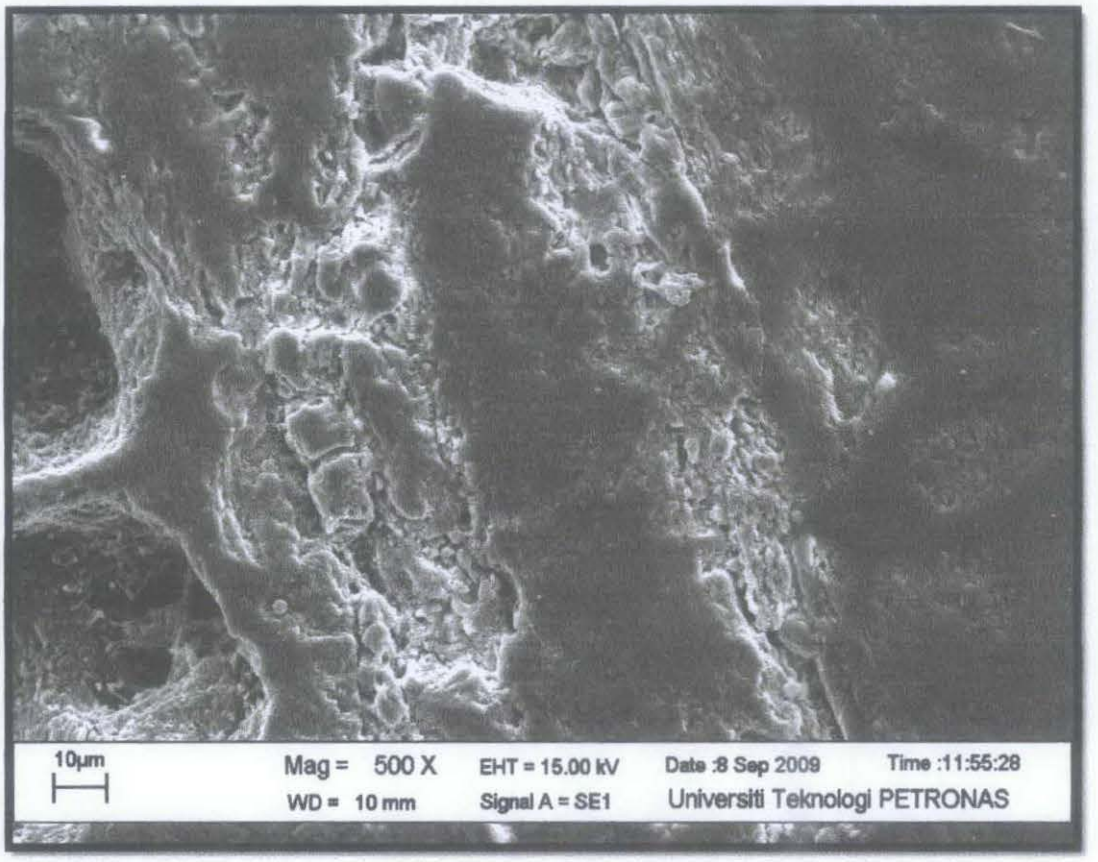

Figure 36: Part M with 500X magnification

Section B

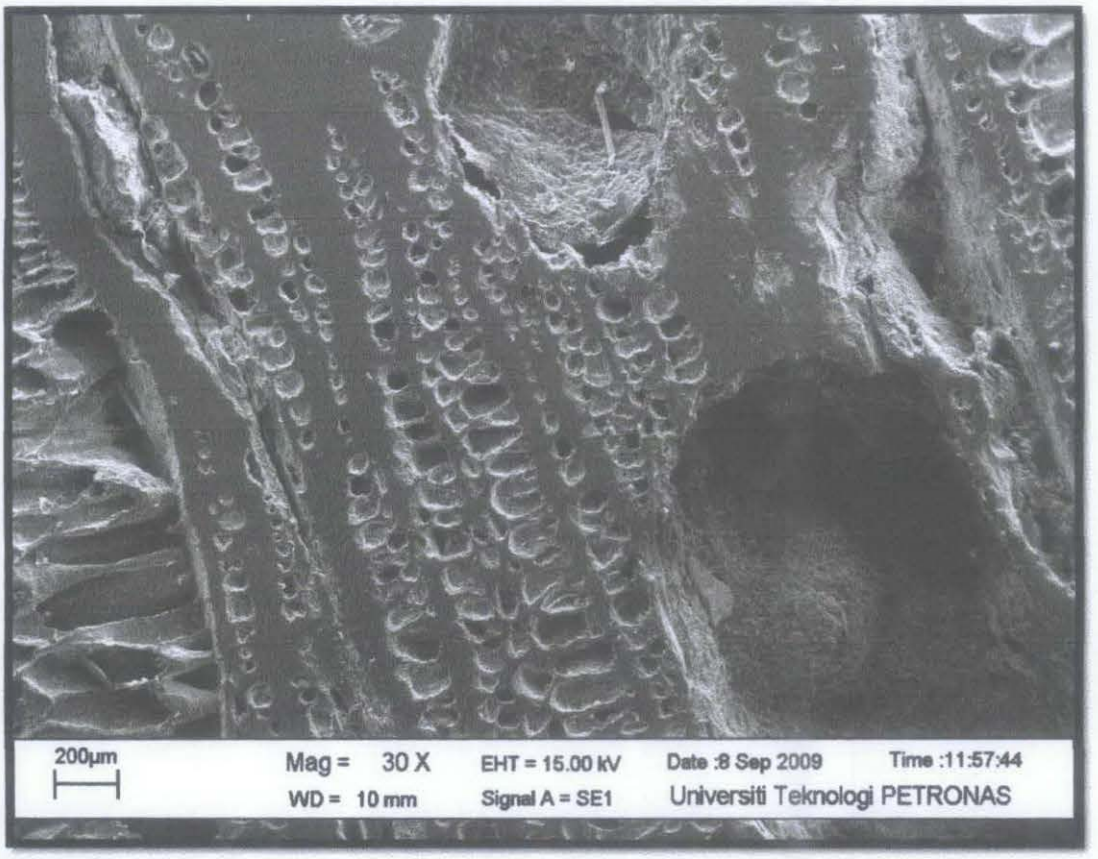

Figure 37: Part B with 30X magnification

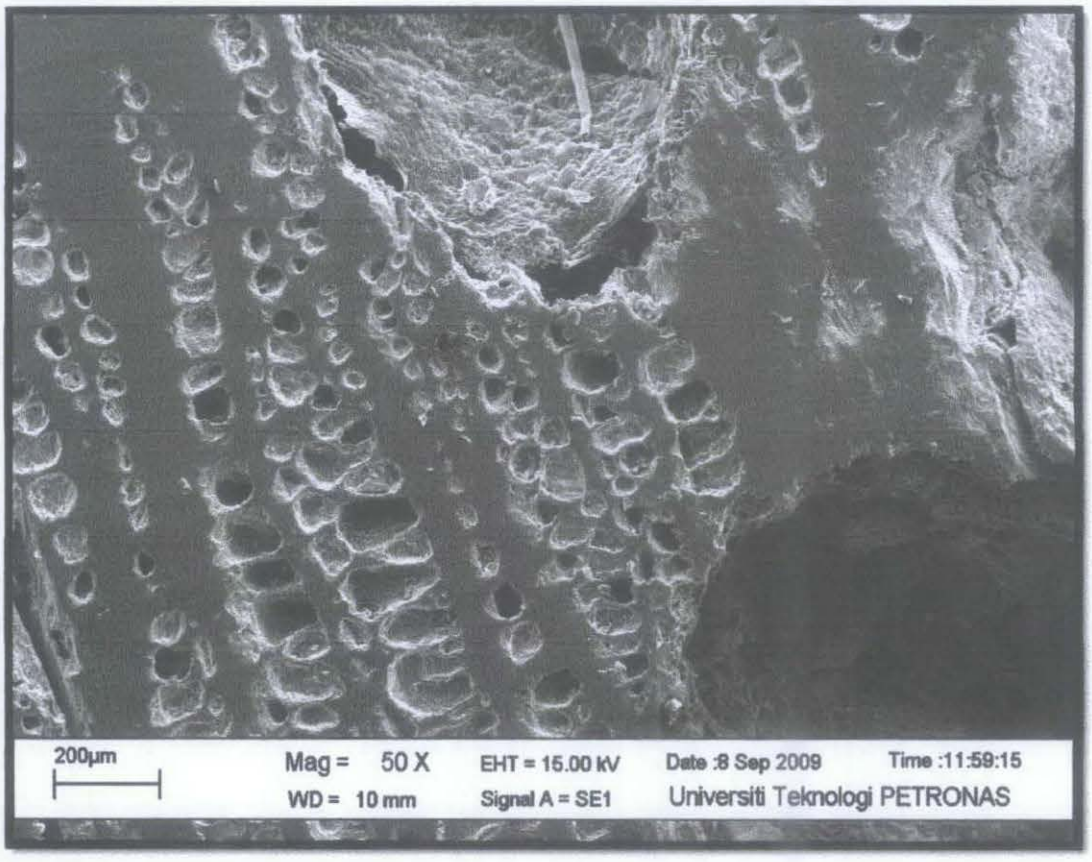

Figure 38: Part B with 50X magnification

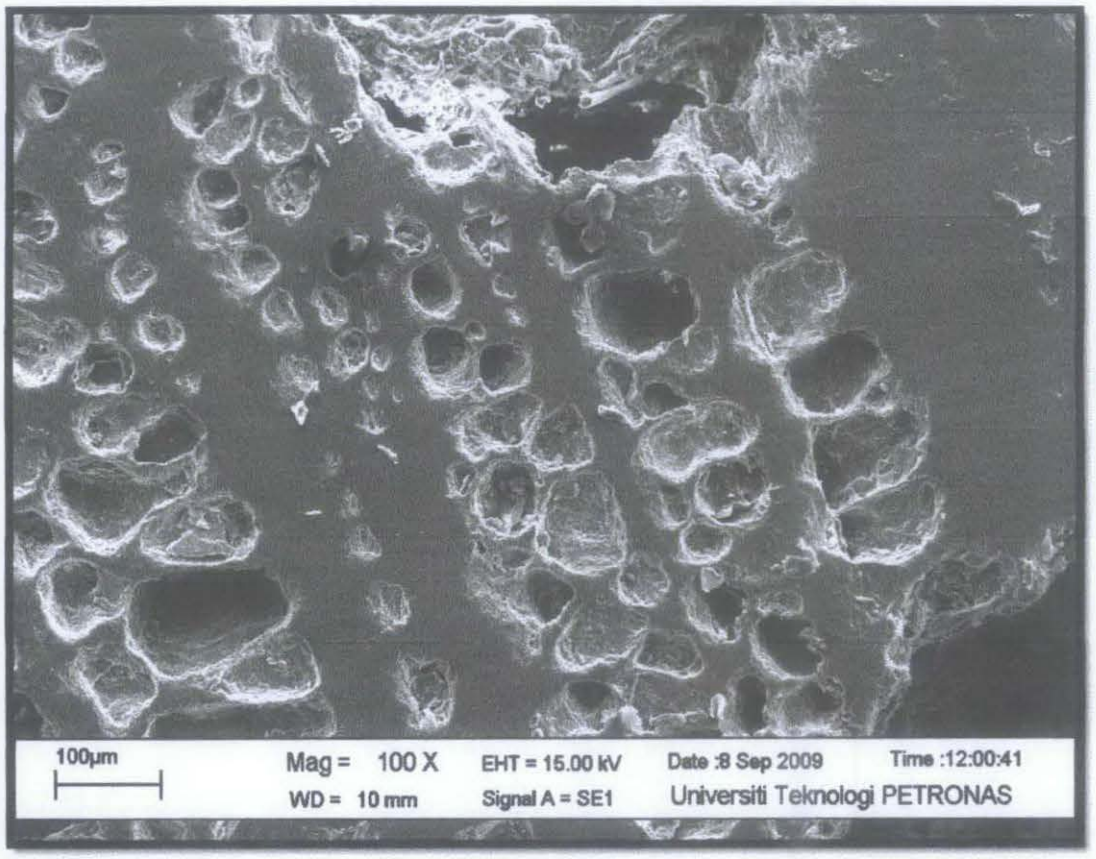

Figure 39: Part B with 100X magnification

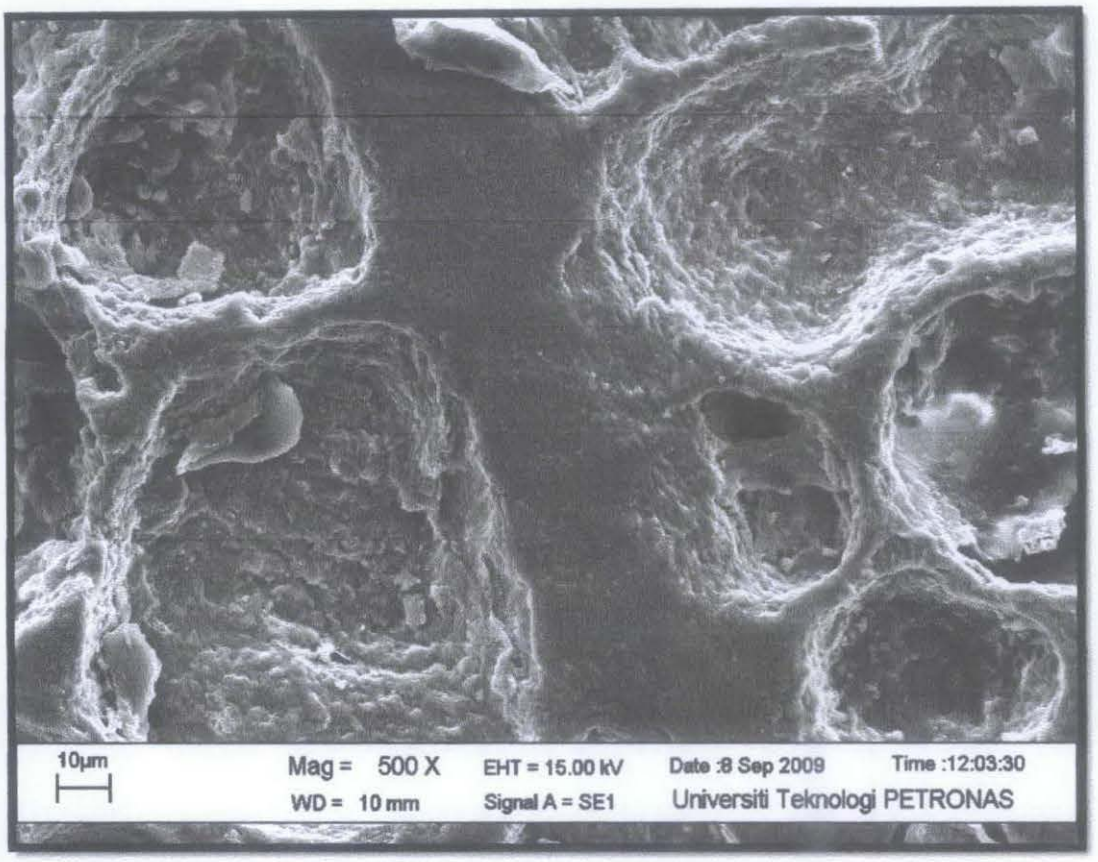

Figure 40: Part B with 500X magnification

4.2 DISCUSSION

4.2.1 SCANNING ELECTRON MICROSCOPY (SEM)

From the result, the three different layers have a very obvious shape and structure. The A part have more big pores than the rest while the M part are having small pores. There different type of shape for these three layers might a result from the time the barnacles is growing on the pipeline surface.

4.2.2 X-RAY DIFFRACTION (XRD)

From the result, the author finds that both part which is part A and B are having major components which are Calcium Carbonate ($CaCo_3$)

From the calculation, the crystal orientation of each element in the sample could be determined.

4.2.3 Fourier Transform Infrared Radiography (FTIR)

From the result, there are plenty of chemical components in the sample. The results show that there are more than 20 chemical components that exist in the sample. The varieties of the chemical component may be influenced by the element of the pipeline coating. The Alcohol, Primary Amines, Benzene and Vinyl are detected as major chemical properties in the Barnacles hard shell.

CHAPTER 5
CONCLUSION AND RECOMENDATION

Study of microstructure and chemical properties of barnacles grow at external surface of oil pipelines give the author information about the microstructure and texture as well as chemical constituents that present within the Barnacles hard shell.

The characterization tools show that the Barnacles hard shells contain a lot of pores. Besides the Barnacles hard shell is mainly built of Calcium Carbonate ($CaCO_3$). Organic compounds are also detected in the sample such as Alcohol group, Benzene rings, Vinyl group and Primary Amine group.

The variation in the chemical contents may have a relationship with the surface of the pipeline coating itself. It is recommended that the further research is conducted to find out the relationship between the chemical components especially in the bottom surface of the Barnacles colony and the coating of pipelines where the Barnacles is grown up.

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[5] http://en.wikipedia.org/wiki/Barnacle @ 24 June 2009 & 1123 hours

[6] http://en.wikipedia.org/wiki/Optical_microscope @ 2 May 2009 & 0023 hours

[7] http://science.howstuffworks.com/scanning-electron-microscope4.htm @ 4 May 2009 & 0054 hours

[8] http://en.wikipedia.org/wiki/XRF @ 20 April 2009 & 0123 hours

[9] http://en.wikipedia.org/wiki/XRD @ 24 April 2009 & 1430 hours

[10] http://science.howstuffworks.com/forensic-lab-technique3.htm @ 24 May 2009 & 1454 hours

[11] http://en.wikipedia.org/wiki/Barnacle @ 24 June 2009 & 1123 hours

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APPENDIXES

UNIVERSITI TEKNOLOGI PETRONAS

X-ray Fluorescence (XRF)

Advanced Materials & Processes Laboratory
Block 17
Mechanical Engineering Department
Universiti Teknologi PETRONAS
5-3687019
05-3687034

Name : MAARUF B MOHAMAD
ID No : 7572 Contact No: 019-5210645
Status : ☐ FYP ☐ MSc ☐ PHD ☐ RO
Department : ☐ ME ☐ EE ☐ CHE ☐ CV ☐ GPE

Project Title : MICROSTRUCTURE STUDY OF EXTERNAL PIPELINE GROWN BARNACLES

Batch No: ☐

Supervisor :AP DR BAMBANG ARI WAHJOEDI
E-mail :maarufm@gmail.com

No.	Samples Name & Description	Sample Label	Parameter
1.	Sample 1 (CARBONATE)	1	
2.	Sample 2	2	
3.			
4.			
5.			
6.			
7.			
8.			

Checked by:

SIGN

(Supervisor)

Approved by:

SIGN

M Zairi M Zohaidi
Lab. Executive (LFSU)
Mechanical Engineering Laboratory
Universiti Teknologi PETRONAS

For laboratory use only. (to be fill by technologist)

Date receives samples:

Expected date to complete test:

Remarks:

Acceptance of Results

Collected by:

Date:

UNIVERSITI TEKNOLOGI PETRONAS

X-ray Diffraction [XRD]

Advanced Materials & Processes Laboratory
Block 17
Mechanical Engineering Department
Universiti Teknologi PETRONAS
05-3687019
05-3687034

Name : MAARUF B MOHAMAD
ID No : 7572 Contact No: 019-5210645
Status : ☐ FYP ☐ MSc ☐ PHD ☐ RO
Department : ☐ ME ☐ EE ☐ CHE ☐ CV ☐ GPE

Project Title : MICROSTRUCTURE STUDY OF EXTERNAL PIPELINE GROWN BARNACLES

Batch No: ☐

Supervisor :AP DR BAMBANG ARI WAHJOEDI
E-mail :maarufm@gmail.com

No.	Samples Name & Description	Sample Label	Parameter
1.	Sample 1	1	
2.	Sample 2	2	
3.			
4.			
5.			
6.			
7.			
8.			

Checked by:

SIGN

(Supervisor)

Approved by:

SIGN

M Zairi M Zohaidi
Lab. Executive (LFSU)
Mechanical Engineering Laboratory
Universiti Teknologi PETRONAS

For laboratory use only. (to be fill by technologist)

Date receives samples:

Expected date to complete test:

Remarks:

Acceptance of Results

Collected by:

Date:

UNIVERSITI TEKNOLOGI PETRONAS

Scanning Electron Microscope (SEM)

Advanced Materials & Processes Laboratory
Block 17
Mechanical Engineering Department
Universiti Teknologi PETRONAS
05-3687034

Name : MAARUF B MOHAMAD
ID No : 7572 Contact No: 019-5210645
Status : ☐ FYP ☐ MSc ☐ PHD ☐ RO
Department : ☐ ME ☐ EE ☐ CHE ☐ CV ☐ GPE

Project Title : MICROSTRUCTURE STUDY OF EXTERNAL PIPELINE GROWN BARNACLES

Batch No: ☐

Supervisor : AP DR BAMBANG ARI WAHJOEDI
E-mail : maarufm@gmail.com

No.	Samples Name & Description	Sample Label	Parameter
1.	Sample 1	1	
2.	Sample 2	2	
3.			
4.			
5.			
6.			
7.			
8.			

Checked by:

SIGN

(Supervisor)

Approved by:

SIGN

M Zairi M Zohaidi
Executive
Mechanical Engineering Laboratory
Universiti Teknologi PETRONAS

For laboratory use only. (to be fill by technologist)

Date receives samples:

Expected date to complete test:

Remarks:

Acceptance of Results

Collected by:

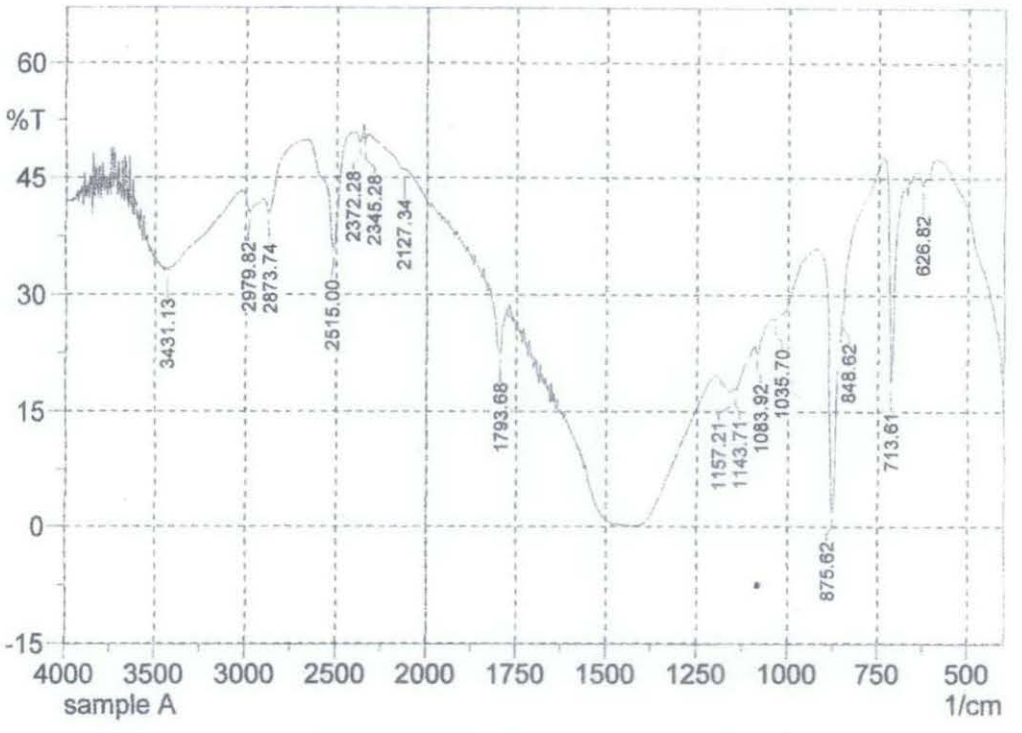
Date:

No.	Detail/ Week	1	2	3	4	5	6	7	8	9		10	11	12	13	14
1	Selection of Project Topic										mid-semester break					
2	Preliminary Research Work															
3	Submission of Preliminary Report				13-Feb											
4	Project Work															
	(literature review and data gathering)															
5	Submission of Progress Report								13-Mar							
6	Seminar								13-Mar							
7	Project work continues (literature review and data gathering)															
8	Submission of Interim Report Final Draft														24-Apr	
9	Oral Presentation															8-May

Gantt chart for FYP 1

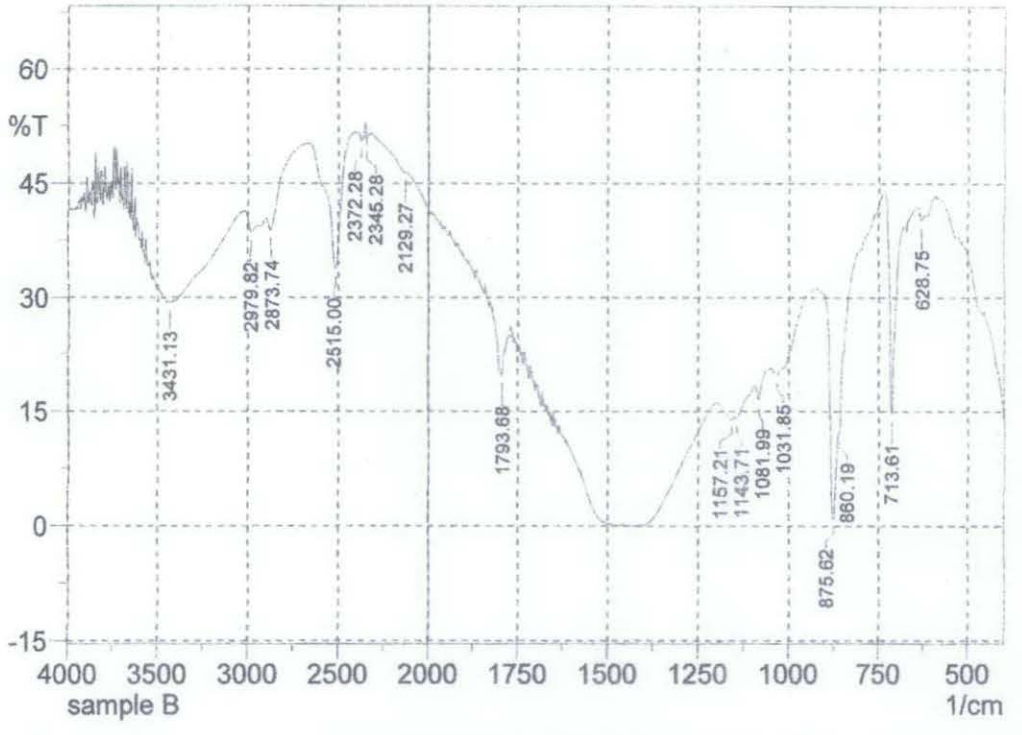
No.	Detail/ Week	1	2	3	4	5	6	7	8	9		10	11	12	13	14
1	Project work continues (find the elements)										mid-semester break					
2	Submission of Progress Report 1															
3	Project work continues (factor of growth)															
4	Submission of Progress Report 2															
5	Seminar (compulsory)															
6	Project work continues (finalize finding)															
7	Poster Exhibition															
8	Submission of Dissertation (soft bound)															
9	Oral Presentation															
10	Submission of Project Dissertation (hard bound)											7 days after oral				

Gantt chart for FYP 2



No.	Peak	Height	Corr. Height	Base (H)	Base (L)	Area	Corr. Area	
1	626.82	55.879	1.246	646.11	615.25	10.696	0.14	
2	713.61	81.191	27.612	732.9	675.04	25.456	5.752	
3	848.62	72.387	0.747	850.55	734.83	45.262	0.029	
4	875.62	98.082	29.151	916.12	850.55	50.029	17.394	
5	1035.7	73.136	0.514	1041.49	923.84	59.35	0.6	
6	1083.92	77.601	1.594	1091.63	1043.42	29.007	0.292	
7	1143.71	82.213	0.554	1147.57	1093.56	37.173	0.205	
8	1157.21	82.415	0.667	1195.78	1149.5	34.042	0.43	
9	1793.68	77.54	6.604	1826.46	1778.25	27.9	2.347	
10	2127.34	53.972	0.141	2310.56	2121.55	59.837	-0.12	
11	2345.28	50.831	2.268	2351.06	2335.64	4.596	0.116	
12	2372.28	50.375	1.85	2395.42	2351.06	13.186	0.383	
13	2515	64.347	14.846	2663.51	2410.85	86.777	11.634	
14	2873.74	59.612	2.964	2900.74	2727.16	59.073	1.059	
15	2979.82	59.422	2.017	3008.75	2931.6	29.514	0.751	
16	3431.13	66.762	0.125	3438.84	3425.34	6.446	0.011	

Sample A with table



No.	Peak	Height	Corr. Height	Base (H)	Base (L)	Area	Corr. Area	
1	628.75	59.867	1.162	642.25	619.11	8.998	0.133	
2	713.61	85.437	27.915	732.9	675.04	28.869	6.848	
3	860.19	87.975	0.987	864.05	734.83	61.961	0.052	
4	875.62	99.111	15.008	921.91	864.05	50.886	12.675	
5	1031.85	80.224	2.444	1051.13	923.84	77.006	2.3	
6	1081.99	83.483	2.338	1091.63	1053.06	27.86	0.502	
7	1143.71	85.916	0.468	1147.57	1093.56	42.698	0.193	
8	1157.21	86.056	0.64	1197.71	1149.5	40.034	0.53	
9	1793.68	80.418	6.833	1826.46	1778.25	30.16	2.736	
10	2129.27	53.707	0.13	2308.63	2125.41	57.04	0.071	
11	2345.28	50.021	2.314	2351.06	2335.64	4.489	0.118	
12	2372.28	49.564	1.871	2397.35	2351.06	13.447	0.397	
13	2515	66.273	17.266	2665.44	2397.35	92.749	14.141	
14	2873.74	61.229	2.624	2896.88	2682.8	72.488	0.884	
15	2979.82	61.481	1.892	3008.75	2945.1	25.762	0.631	
16	3431.13	70.647	0.133	3438.84	3425.34	7.173	0.014	

Sample B with table