ABSORPTION OF I^{131} USING OIL PALM ACTIVATED CARBON FOR RADIOACTIVE SPILLAGE DECONTAMINATION AND WASTE MANAGEMENT

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Dissertation submitted in partial fulfillment
of the requirements for the degree
of Bachelor of Health Science (Medical Radiation)

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CERTIFICATE

This is to certify that the dissertation entitled Absorption of Spillage of I^{131} using Activated Carbon from Palm Kernel for Radioactive Contamination and Waste Management are the bona fide record of research work done by Ms Noryasmin Yusrina binti Samsuddin during the period from September 2019 to July 2020 under my supervision. I have read this dissertation and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation to be submitted in partial fulfillment for the degree of Bachelor of Health Science (Honours) (Medical Radiation).

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DECLARATION

I hereby declare that this dissertation is the result of my own investigations, except where otherwise stated and duly acknowledged. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at Universiti Sains Malaysia or other institutions. I grant Universiti Sains Malaysia the right to use the dissertation for teaching, research and promotional purposes.

………………………………

(NORYASMIN YUSRINA BINTI SAMSUDDIN)

Date: ………………………..

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TABLE OF CONTENTS

CERTIFICATE i

DECLARATION ii

ACKNOWLEDGEMENT iii

TABLE OF CONTENTS iv

LIST OF TABLES vii

LIST OF FIGURES viii

LIST OF ABBREVIATIONS ix

ABSTRAK i

ABSTRACT iii

CHAPTER 1 INTRODUCTION 1

1.1 BACKGROUND OF STUDY 1

1.2 PROBLEM STATEMENT 3

1.3 RESEARCH QUESTION 4

1.4 RESEARCH OBJECTIVE 4

1.4.1 GENERAL OBJECTIVE 4

1.4.2 SPECIFIC OBJECTIVE 4

1.5 RESEARCH HYPOTHESIS 5

1.5.1 NULL HYPOTHESIS 5

1.5.2 ALTERNATIVE HYPHOTHESIS 5

1.6 SIGNIFICANCE OF STUDY 5

1.7 CONCEPTUAL FRAMEWORK 6

CHAPTER 2 LITERATURE REVIEW 7

2.1 RADIOIODINE THERAPY 7

2.1.1 I131 7

2.1.2 TREATMENT FOR THYROID CANCER 7
2.1.3 SPILLAGE OF I131 8
2.2 PALM KERNEL SHELL 10
2.2.1 ACTIVATED CARBON 10
2.2.2 APPLICATION OF ACTIVATED CARBON 11
2.2.3 PALM KERNEL ACTIVATED CARBON 12
2.2.4 PROCESS OF PALM KERNEL ACTIVATED CARBON 13
2.3 RADIOACTIVE CONTAMINATION AND WASTE MANAGEMENT 14
2.3.1 RADIOACTIVE CONTAMINATION 14
2.3.2 RADIOACTIVE WASTE MANAGEMENT 15
2.4 CHARACTERIZATION USING SEM AND EDX 16
2.4.1 SEM AND EDX 16
2.4.2 CHARACTERIZATION OF FESEM 18
2.4.3 MORPHOLOGY & POROSITY OF ACTIVATED CARBON 19
CHAPTER 3 MATERIALS AND METHOD 21
3.1. MATERIALS 21
3.2. EQUIPMENTS 23
3.3. METHODS 26
3.3.1. PREPARATION OF PRECURSOR 26
3.3.2. SYNTHESIS OF PALM KERNEL SHELL ACTIVATED CARBON 27
3.3.3. PALM KERNEL CONCENTRATION PREPARATION 27
3.3.4. I131 RADIONUCLIDE EXTRACTION 29
3.3.5. KINETIC STUDY OF EXTRACTION 30
3.3.6. CHARACTERIZATION OF I131 RADIONUCLIDE OF USING SEM & EDX 31

CHAPTER 4 RESULTS & DISCUSSION 33

4.1 OBSERVATION DURING FILTRATION OF EXTRACTION I131 33

4.2 KINETIC STUDY OF EXTRACTION 36

4.2.1 SEDIMENT 37

4.2.2 WATER RESIDUE 40

4.3 CHARACTERIZATION OF I131 RADIONUCLIDE OF USING SEM & EDX 43

4.3.1 SEM ANALYSIS 43

4.3.2 EDX ANALYSIS 46

4.4 LIMITATION OF THE STUDY 48

CHAPTER 5 CONCLUSION 49

REFERENCE 50

LIST OF TABLES

Table 1: Concentration and volume of preparation of extraction I131 28

Table 2: The activity of water residue after filtration at 1st day, 4th day, 8th day, 12th day and 16th day... 35

Table 3: The activity of sediment at filter paper at 1st day, 4th day, 8th day, 12th day and 16th day. 36

LIST OF FIGURES

Figure 1: The schematic of Scanning Electron Microscopy (SEM) (Röhr, 2014) 17
Figure 2: SEM images of raw material and KOH-AC at x250 (Andas et al., 2017) 20
Figure 3: The raw palm kernel shell 21
Figure 4: The pure of I131.. 22
Figure 5: The dose calibrator (Biodex, Atomlab 500) 23
Figure 6: magnetic stirrer & hot plate 24
Figure 7: Inspector GM survey meter 25
Figure 8: Smith filter paper (left) and beaker 1000ml (right) 25
Figure 9: the SEM lab services of Pusat Pengajian Sains Kesihatan (PPSK), USM 26
Figure 10: granular palm kernel shell activated carbon 27
Figure 11: varies concentration of palm kernel shell 29
Figure 12: the filtration of extraction I131 30
Figure 13: one of the activities was measured using dose calibrator 31
Figure 14: Sample that had be coated with gold to characterize using SEM & EDX 32
Figure 15: The sediment and moist at the filter paper for every concentration 34
Figure 16: graph of activity of water residue after the filtration at 1st day, 4th day, 8th day, 12th day and 16th day. 42
Figure 17: Graph of the activity of sediment at filter paper at 1st day, 4th day, 8th day, 12th day and 16th day. 40
Figure 18: SEM images taken from the sample palm kernel maximum concentration with I131 44
Figure 19: Formation of pore on the surface sample using SEM 45
Figure 20: Graph from the EDX analysis that present some of the element in sample 46
Figure 21: Element that found in the sample based on the spectrum processing in EDX analysis 47

LIST OF ABBREVIATIONS

AC	Activated Carbon
BET	Brunauer-Emmett Teller
EDX	Energy Dispersive X-Ray Analyzer
EFB	Empty Fruit Bunch
FESEM	Field Emission Scanning Electron Microscope
GAC	Granular Activated Carbon
HCL	Hydrochloric Acid
H_2O_2	Hydrogen Peroxide
H_2SO_4	Sulfuric Acid
H_3PO_4	Phosphoric Acid
I^{131}	Radio-iodine
IAEA	International Atomic Energy Agency
KM_NO_4	Potassium Permanganate
KOH	Potassium Hydroxide
NMO	Manganese Oxide Nanoparticles
PKS	Palm Kernel Shell
SEM	Scanning Electron Microscopy
SOP	Standard Operating Procedure
Tc^{99m}	Technetium-99M
wt	weights
$ZnCl_2$	Zinc Chloride

ABSTRAK

Pengenalan: Jabatan Perubatan Nuklear adalah salah satu jabatan yang menyediakan perkhidmatan diagnostik dan rawatan kepada pesakit kanser di mana kebiasanya menggunakan bahan radioaktif seperti Tc^{99m} dan I^{131} untuk merawat penyakit. Untuk rawatan pesakit tiroid, rawatan dilakukan dengan pemberian suntikan radioaktif I^{131} kepada pesakit. Risiko tumpahan bahan radioaktif I^{131} adalah tinggi semasa penyediaan radioaktif tersebut. Oleh itu, pengurusan pencemaran bahan radioaktif yang betul dan selamat adalah komponen yang paling penting dalam perlindungan radiasi di hospital. Oleh itu, kajian ini bertujuan untuk membuat satu teknik baru untuk pengurusan pencemaran radioaktif dengan menggunakan karbon aktif daripada kelapa sawit

Kaedah: Sampel I^{131} tulen dari makmal akan dicampurkan dengan karbon aktif daripad kelapa sawit dengan kepekatan yang berbeza-beza. Campuran yang terbentuk akan ditapis menggunakan kertas turas yang tersedia. Setelah menunggu selama 15 minit, mendapan pada kertas turas dan sisa air akan terbentuk. Radioaktiviti daripada sedimen atau pun mendapan dan sisa air untuk kepekatan yang berbeza-beza akan diukur menggunakan dos kalibrator. Pengukuran akan diulang pada hari keempat, kelapan, kedua belas dan keenam belas. Selepas itu, campuran dari kepekatan kelapa sawit yang paling tinggi akan diambil dan diimbas menggunakan SEM & EDX untuk melihat gambar morfologi dan elemen yang terdapat dalam sampel.

Keputusan: Radioaktiviti daripada sisa air dan sedimen yang terbentuk menunjukkan penurunan sepanjang tempoh masa yang ditetapkan membuktikan berlakumya proses agglomerasi dan pemejalan. Secara teori, semakin tinggi kepekatan, semakin banyak agglomerasi berlaku. Namun, keputusan ekperimen menunjukan beberapa kepekatan yang berbeza mempunya radioaktivit yang tinggi manakala dua kepekatang mempunyai radioaktiviti yang rendah di awal interaksi. Ini adalah

disebabkan oleh agglomerasi dan pemejalan yang berlaku pada dua kepekatan tersebut adalah rendah berbanding kepekatan yang lain. Selain itu, gambar dari mesin SEM juga menunjukkan berlaku agglomerasi dan struktur pori manakala analisi EDX menunjukkan elemen yang terdapat dalam sampel.

Kesimpulan: Karbon aktif dari kelapa sawit sangat berguna kepada semua penyerapan dan peneutralan radiasi dimana ia mampu untuk menyerap I^{131} dari makmal. Radioaktiviti daripada sedimen dan sisa air pada hari terakhir eksperimen iaitu hari ke enam belas menunjukkan hipotesis adalah berkait dengan keputusan dari eksperimen yang dijalankan. Gambar-gambar dari SEM dan Analisa EDX menunjukkan bahawa struktur morfologi dan elemen yang dijumpai di dalam sampel adalah salah satu perkara positif untuk pengurusan pencemaran radioaktif.

ABSTRACT

Introduction: Nuclear Medicine is one of the facilities that provide the diagnostic and treatment services to patients where usually used the radioactive material such as Tc^{99m} and I^{131} to treat the disease. For treatment of thyroid disease, it done with the administration of radioactive I^{131} to patient. When the administrated radioactive material occurred, the risk of spillage is high. Hence, the proper and safe contamination management of radioactive materials is important component of radiation protection in hospital. Thus, this study is purposed a new technique for radioactive contamination management by using palm kernel activated carbon.

Method: Sample of the pure I^{131} from the laboratory will be mixed with the palm kernel activated carbon with varies of concentration. The mixture that form will be filter using filter paper. After waited for 15 minutes, the sediment on the filter paper and the water residue will be form efficiency. The radioactivity of the sediment and water residue for varies concentration will be measured using dose calibrator. The measurement will be repeated at fourth, eighth, twelfth and sixteenth day. After that, the mixture of maximum concentration palm kernel will be taken and scan using SEM & EDX to see the morphology image and the element that found in sample.

Result: The radioactivity of water residue and sediment decreases along the time exponentially shows the agglomeration and solidification process is occurred. Theoretically, the higher the concentration of the mixture occur, more agglomeration are occurred. However, some of the concentration of mixture are higher activity and lower for other at initial interactions. It is due to the agglomeration and solidification that occur in the both concentrations are lower than others concentration. Besides, the images from SEM shows the agglomerated and pore structure while the EDX analysis show the element that found in the sample.

Conclusion: Palm kernel activated carbon is useful for all adsorption and neutralize the number of radiation where able to adsorb and evaporate the I^{131} from the laboratory. The radioactivity of sediment and water residue on sixteen day coincided to hypothesis and provided result. The image from the SEM and EDX analysis that show the morphology structure and the element that found in sample is one of the positively upcoming for the radioactivity contamination management.

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND OF STUDY

Nuclear Medicine is considered mainly as one of the facilities that provide the diagnostic and treatment services to patients. That services are a specialty in medicine where using the radioactive materials in the body to diagnose or treat the disease. The radioactive material that used is either in the form of radioisotopes or combine with certain pharmaceuticals where will place in the body patient by injection or oral intake. The radioactive material that currently or mainly used are Tc^{99m} and I^{131}. Tc^{99m} basically, is used for diagnosing the disease while I^{131} is used for treating the disease or as the therapy.

Treatment for thyroid disease are usually done with the administration of radioactive I^{131} in the form of capsules or liquid. The I^{131} that form in a capsule is more simply procedure to handle rather than I^{131} in the form of liquid. It is due to liquid form of I^{131} has higher risk for spillage and need good handling in procedure especially, to avoid excess radiation to worker. I^{131} is a radionuclide that form in sodium iodine and undergo beta minus decay with 8 days physical half-life. It can kill the cells as it can penetrated other cells up to a few millimeters away. I^{131} is also emitting high energies where can use for the imaging. $I^{131}$is used in the treatment of thyroid disease such as thyrotoxicosis, hyperthyroidism and some types of thyroid cancer that can absorb the I^{131}.

The health worker in every nuclear medicine department are provided with the careful procedure for storage, handling like careful elution of radioactivity and other. Even though all effort is done to prevent the spillage of radioactivity, accident may be still can happen. The accident can be manage using the protocol that called as “standard operating procedure”. This protocol is learned by all worker in nuclear medicine department to ensure the spillage is managed with concern.

These protocols are to provide the guidance to minimize the impact in accident that involve the spillage of radioactivity especially in liquid form. Based on the statistic, about 1.2 percent of people in the United States have hyperthyroidism and that’s mean a little more than 1 person out of 100. So, many of I^{131}treatment is needed in this case and the spillage is more risk to occur (Mody et al., 2015). Hence, the proper and safe contamination management of radioactive materials is important component of radiation protection in hospital. In this experiment, the spillage of I^{131} will be extract using activated carbon that form from the palm kernel shell. Palm kernel shell are manipulated to be activated carbon using chemical and physical activation process.

Based on the statistic, there are about 4.98 Mty^{-1} of palm kernel shell (PKS) that contain 51.6% of carbon that produced in Malaysia. PKS was believed that it will be a good precursor in the production of activated carbon besides being the inexpensive agricultural waste material in Malaysia. It is opportunity for us to convert this agricultural waste material into useful product especially by researcher when this high carbon content produces high percentage of char and this increases the product yield. (Andas et al., 2017)

As an alternative, a study of absorption of spillage I^{131} using palm kernel is to reduce the time delay of radioactive I^{131} and for contamination management. Advantage of activated carbon are thermo-stability, high performance, high adsorptive effect, large surface area and well-developed structure. Activated carbon that use is prepared from the palm kernel shell with a chemical process. It will then be characterized to see any morphology changes when used the activated carbon.

1.2 PROBLEM STATEMENT

Since 1940s, radioactive I^{131} has been used for variety of treatment thyroid disease either it benign or malignant condition in worldwide. The treatment has been improved and has been used in wide world. So, the usage of I^{131} are increase at every Centre of medical services especially institute that treat the thyroid disease either in government or private. I^{131} that used in therapy is depends on the dose. There are two dose that can delivery to patient either low dose or high dose of I^{131}. For low dose I^{131}, it usually gives to low-risks patient to achieve the remnant ablation for the purpose of facilitating follow-up, and less common adverse effects, and a shorter hospital. While for the patient that receive high amount of dose of I^{131} will be ward for a few days and routinely administered for tumoricidal effect as an adjuvant therapy (Han et al., 2014).

The process of handling and delivery of I^{131} to patient must be careful or it will increase the risk of spillage I^{131}. So, Standard Operating Procedure (SOP) for radioactive contamination control are created by ministry of health at every country especially for Nuclear Medicine Department. It is procedure that to be applied to all radionuclide contamination survey and decontamination of workplace. Previously, the research about the spill of the liquid radioactive material that lead to the formation of releasing radioactive was performed by SSTC NRS with forced ventilation (V. Bogorad et al., 2016). Since the contamination of the radiation is one of the main threats to the hospital and biosphere, so it is important to us to develop some sorbent to extract the radionuclide from spillage or waste of I^{131}. So, based on the advantage of activated carbon, we will develop a new sorbent from activated carbon that form from the palm kernel shell.

Besides, every hospital needs their own sewage site or delay tank to delay and decay the radioactive waste that form from the patient that admit in hospital. Delay tank is a temporary container to reduce the activity of radionuclide before it transfers to sewage site. Delay tank in

Hospital University Science Malaysia only have two small and it limited to collect waste if the number of patients increase. Delay tank that use must base on the standard protocol according to the International Atomic Energy Agency (IAEA) for radiation safety that prevent from leakage and contamination. So, the patient that will undergo therapy will limited due to the size of tank. So, this study purpose also to solve the problem regarding the wastewater management. The activated carbon will use to absorb the radioactive waste from delay tank to reduce the time delay of radioactive waste to discharge to sewage site.

1.3 RESEARCH QUESTION

a) What method is used to synthesis activated carbon that prepared from palm kernel?

b) How to extract radioactive I^{131} radionuclide using palm kernel activated carbon?

c) What is the radioactivity of I^{131} after extraction by various concentration of palm kernel?

d) How to characterize the extraction of radionuclide I^{131} ?

1.4 RESEARCH OBJECTIVE

1.4.1 GENERAL OBJECTIVE

To extract the spillage of radioactive I^{131} using palm kernel activated carbon with varies in concentration for contamination and spillage management.

1.4.2 SPECIFIC OBJECTIVE

a) To synthesis activated carbon that prepare from palm kernel by using chemical activation process.

b) To determine the kinetic radioactivity of I^{131} after extraction.

c) To characterize the extraction of radionuclide I^{131} using SEM and EDX.

1.5 RESEARCH HYPOTHESIS

1.5.1 NULL HYPOTHESIS

There is no significant degree of spillage of radioactive I^{131} extraction using palm kernel activated carbon with varies in concentration for contamination and waste management.

1.5.2 ALTERNATIVE HYPOTHESIS

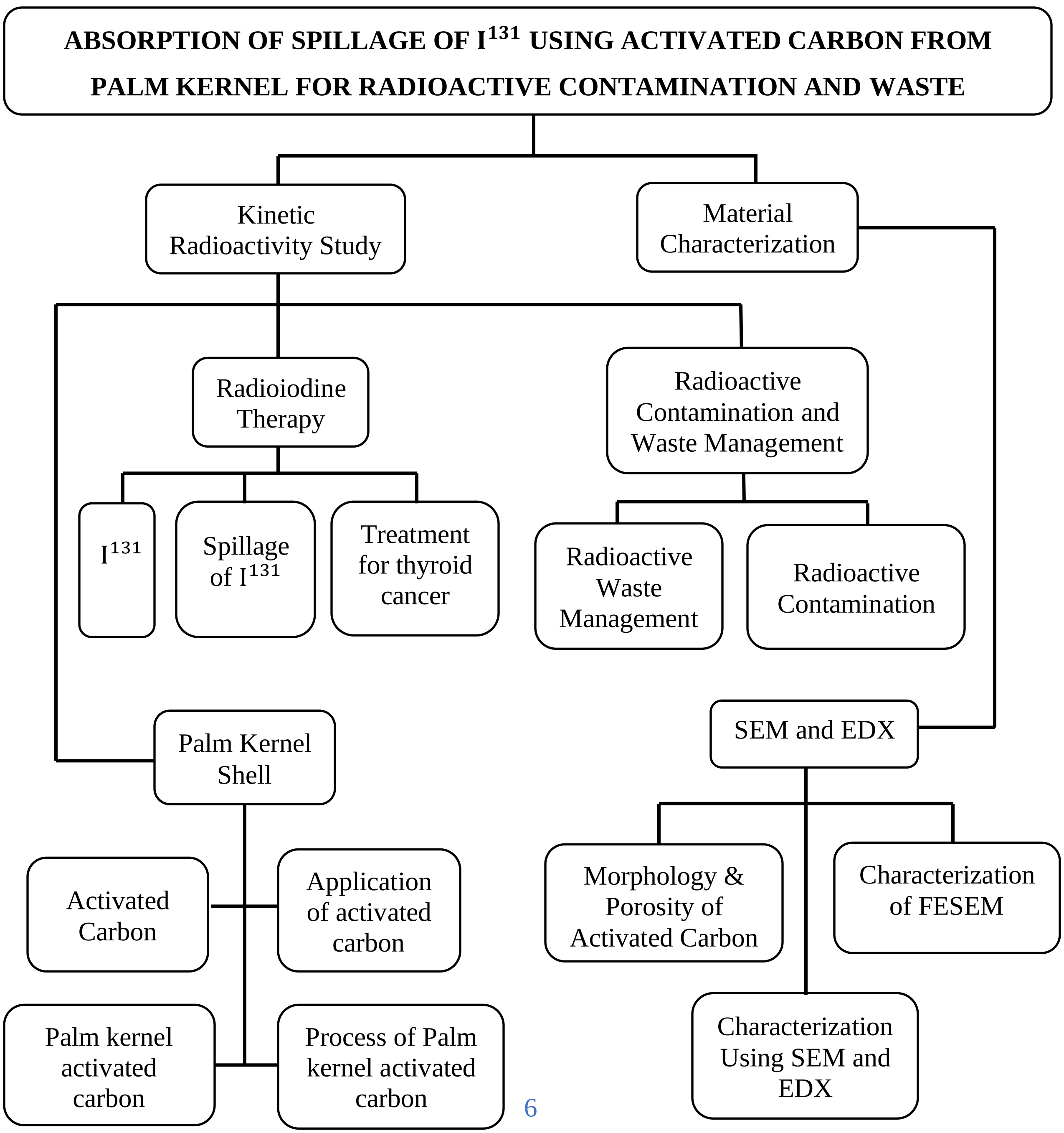
There is significant degree of spillage of radioactive I^{131} extraction using palm kernel activated carbon with varies in concentration for contamination and waste management.

1.6 SIGNIFICANCE OF STUDY

The significance contribution of these study is to overcome the contamination and wastewater management problem in nuclear medicine department HUSM. This study is proposed the activated carbon is used to extract the spills of I^{131} during handling or delivery to patients with economic substance or waste agricultural material. Besides, we can used to overcome the crisis of waste management in Nuclear Medicine department. It is to reduce the delay time radioactive waste in delay tank and easily waste to discharge to sewage site. Economic substance that had been used to extract I^{131} is palm kernel shell. Beside substance is cheap, palm kernel shell also is easier to purchase because our country had developed so many oil palms.

Advantage to use palm kernel is high good mechanical properties and develop well porous structure. Besides palm kernel is known as the absorbent for the removal of heavy metal ions through the biosorption mechanism. Since a few years ago, the oil palm industries has been contribute to the "waste to wealth production and green technology. So, the palm kernel that form into activated carbon are used as sorbent will help us in the contamination management especially for spillage accident. Moreover, because of the small size of delay tank in hospital, it hopes that this study also will help more the process of decay the radioactive waste and it can improve the radiation safety.

1.7 CONCEPTUAL FRAMEWORK



CHAPTER 2 LITERATURE REVIEW

2.1 RADIO-IODINE THERAPY

2.1.1 I^{131}

I^{131} is an important volatile radioactive isotope that produce from the iodine itself. In 1938, the scientists named Glenn T. Seaborg and John Livingood were discovered the I^{131}at the Berkeley radiation laboratory, University of California (McCready, 2017). The radiation beta minus (β^{-}) is used for the treatment while radiation gamma is used for diagnosis or diagnostic. Besides the iodine contain biological half-life (Tb) in the thyroid gland which is about 120 days and effective half-life (Te) in the living body about the 7.6 day (Wyszomirska, 2012). I^{131} also known as a radioactive I^{131} or radio-iodine 131. It can be used in the therapy as a nuclear medicine treatment for an overactive thyroid that has been called hyperthyroidism, thyrotoxicosis and to treat the thyroid cancer. The causes of hyperthyroidism are due to the Graves' disease or nodule at the gland while the thyrotoxicosis is when the blood had excessive level of thyroid hormone. In order to treat this disease, the iodine will be therapeutically administered as a capsule or orally to destroy the cancer by beta. The beta radiation is purposely as the active agent that travel small distance, kills the overactive thyroid and not effect outside patient's body. While the gamma radiation can travel within longer distance and may affect the outside body patient (Smith, 2018).

2.1.2 TREATMENT FOR THYROID CANCER

In the last 20 years ago, thyroid cancer is commonly malignancy of endocrine system. Based on the research, differentiated thyroid carcinoma (DTC) is one of the most curable cancer with 80% to 95% of 10 years survival rates include papillary and follicular type. The treatment of this cancer is followed by radio-iodine therapy where considered as ideal treatment for high risk tumors after done the surgical. Radio-iodine ablation or therapy for remnant thyroid is performed with radio-iodine. Function of I^{131} is to remove any residual of remnant thyroid tissues after done the surgical resection. Besides, it is to serves as an adjuvant treatment of potential residual tumors (Chung et al., 2010). However, all these cases should be focus on using the minimum effective dose. Adjuvant treatment can be used to reduce the risk of recurrence even though there are not sure about the optimal patient selection and dose. Recent research has focused on better patient selection and reduced radio-iodine doses for remnant ablation (Pryma and Mandel, 2014). The guidelines of the American Thyroid Association (ATA) in 2009 has recommend that I^{131} therapy in high-risk patients and low-risk patient that has been selected. It shows that one to four cm thyroid cancers that confined to the thyroid and has high risk features has been predicted to get the risk of intermediate to high recurrence or death from the thyroid cancer whereas no indication is found at the very low risk patient. So, to success the remnant ablation for low risk and high-risk patients, it is recommended that a minimum activity of 30–100 mCi (1.1– 3.7 GBq) and 100–200 mCi (3.7–7.4 GBq) (Clement et al., 2015).

2.1.3 SPILLAGE OF I^{131}

The I^{131} is widely used in the world for treatment of differentiated thyroid carcinoma. According to the article of the Prevention and Control of Radioactive Pollution and the Regulations on the Safety and Protection of Radioisotopes and Radiation Devices from the Law of the People's Republic of China, the radiation protection and safety issue must be considered when the radiopharmaceutical is used as chemical and biological properties of the drug (Haugen, 2017).The radioactive source and other device safety must be supervised and the ability to respond quickly when accident must be improved and controlled. Based on the article of the American Journal of Nursing Science (2020), spillage of the radioactive liquid can be occurred frequently. Besides, when the drugs are taken the radiation levels around the delivery is high and can be effect to the patient quality of the treatment and safety environmental of the hospital.

Based on the radiation safety management regulations, the staff should be receiving minimized radiation dose which is receive less than 20 millisieverts (mSv) per calendar year as annual dose limit for whole body exposure worker and they should stay in the control area if the patient is taken the radio-pharmaceuticals (Sarowi et al., 2014). Besides, if the measurement of radiation protection is performed improper during delivery to patients, the leakage of the liquid of radioactive materials will contaminate the staff beside it can pollute the surrounding environment and air. With the combination of the research, it indicates that the most beneficial to avoiding exposure to radiation are time, distance, shielding, and other protective measures. Besides, the thyroid volume that high is a long term of iodine deficiency after iodine repletion for years.

According to the International Committee on Radiological Protection (ICRP), it suggests that the medical staff must wear an appropriate protective measurement since the radiation dose that caused by treatment of I^{131} is the largest among staff, relatives and public. The study has showed that, the psychological tension and worry about I^{131} leakage by the patients during treatment or before taking the I^{131} can be related to the instructor. This is because the staff is rather to using the whole process monitoring video method during medication administration rather than providing face-to-face and hand-to-hand guidance for taking the I^{131} by patients (Zhou et al., 2020).

2.2 PALM KERNEL SHELL

Palm kernel shell is a useful product that had been produce many in Malaysia and it is inexpensive of agricultural waste material. Palm kernel shell (PKS) is a product that has a high carbon content, high density and low ash content. It was found that palm kernel shell is a material that suitable to produce activated charcoal to its low ash content but high in carbon and volatile content (23 ωt % and 61.7 %, respectively).

2.2.1 ACTIVATED CARBON

Activated carbon or activated charcoal is a form of carbon that has been process into small or low volume pore either by a combination of heat and pressure or with chemical to increase the surface area for the absorption molecules or chemical reactions. Besides, it can produce high good mechanical properties and develop well porous structure. Based on the research, activated carbon has known as the most effectives absorbents for remove the pollutants from wastewater. Its due to its excellent properties like thermo-stability, high performance, high adsorptive effect, large surface area and well-developed structure. Usually activated carbon is prepared from the solid carbon materials like nutshell, wood, coconut shell, saw dust and others (Andas et al., 2017)

The current research has been proved that activated carbon is effective in remove the various of pollutant from aqueous solution, heavy metal, organic pollutants including pharmaceutical and personal care products (PPCPs). In addition, activated carbon has been derived from biowaste into different categories based on the adsorbates. So, activated carbon that coming from the biowaste has high potential to be adsorbent in wastewater treatment. From recent research, the biowaste from the activated carbon is most focus in adsorption of dyes and heavy metals ion. There is great improvement of chemically activated carbon even though the multi-step of activation activated carbon precursor need to be verify (Wong et al., 2018).

Besides, based on the research Jung et al. (2004), activated carbon is also widely used in industrial application such as water purification and catalyst support. It is due to its porosity with high specific surface area, high mechanical strength, adequate pore size, chemical and physical porosity that can be adjust according research requirement (Jung et al., 2014). Recently, many researchers have been preparing the activated carbon using low cost and readily activated carbon from agricultural waste such as palm kernel shell, coffee husk, bamboo, coconut shell. It is because of their hardness and high mechanical strength beside the activated carbon that limited and is high cost. For an example palm kernel shell (PKS) was chosen for production of activated carbon since it has high carbon content and inexpensive resources in at Malaysia (Hidayu et al., 2019).

2.2.2 APPLICATION OF ACTIVATED CARBON

Due to it super adsorptive characteristic, activated carbon is widely used in all industry such as removing the toxicity from products, purifying like wastewater and air emission. Based on statistics, the consumption of the activated carbon has 400 000 tons where 41% in the US, 22% consumed in Western Europe while the rest is in Japan. Based on the statistic on the year 2000 Republic of China, the annual import of activated carbon is exceeded than 10 000 tons. The application of activated carbon into the research had been done since a long time ago. The activated carbon has been formed from many agricultural products. Based on the 2010 research, it shows that the bamboo activated carbon has 70% of adsorption efficiency more than the other is commercial activated carbon. The adsorption efficiency from bamboo activated is high due to the presence of the numerous of effective micropores that adsorbing in small I^{131} non-polar molecules gasses. While for coconut activated carbon, they are effective for adsorbing the large molecules due to macro-size of pore size (Chien et al., 2011).

However, the based on another article, the AC efficiency for removal of I^{131} gas without impregnation and with 2% wt of impregnant KI, $ZnCl^2$ and NaOH are more than 50% respectively. The disparity between removal efficiencies can be explained by the concentrations of I^{131} in two different series of experiments. Besides, from the pretests of impregnation with different percentages showed that the excellent absorption impregnation is 2%. It is due to the small amount of impregnation and lack of adequate coverage holes, so its strongly increased (Gourani et al., 2014). Based on the research, the application of activated carbon to remove iodide ion by Cu_2O/Cu had been done. The removal efficiencies of I^- by nano Cu_2O/Cu is increase as the mass ratio of Cu^{2+} to activated carbon is increase. However, when the mass ratio continued to increase, the removal efficiency of I^- by nano Cu_2O/Cu showed a decreasing trend. It is due to the increased ratio of nano Cu_2O/Cu loaded on the carbon is occupied the active sites that required for I^- adsorption (Zhang et al., 2017).

2.2.3 PALM KERNEL ACTIVATED CARBON

Palm kernel shell from the palm tree have been widely used in the production of the activated carbon due to its high carbon contents and low organic contents beside it available in the southeast Asia (Anyika et al., 2017). Besides, it has rich carbon structure. Palm kernel shell can be generated from oil palm milling process where on a fresh fruit bunch contain 27% palm oil, 6% -7% ,14%-15% fibers, 6%-7% shell and 23% empty fruit bunch materials. Palm kernel shell can used as boiler fuel with heating value of 17 MJ kg and exploited to produce higher value products like activated carbon. Because of that, it believes that palm kernel shell will act as a good precursor in the production of activated carbon (Rugayah et al., 2014).

Based on the research, palm kernel based activated carbon has been used to remove the organic pollutant and colored compound as well as tannin or lignin. To achieve the optimum pollutant removal, high dose and treatment time is needed for absorption. So, the usage of palm kernel activated carbon is fitted for this research where the Freundlich and Langmuir isotherm has been showed. The combination of the activated carbon with the primary aeration can continue to remove the pollutant until it achieved the breakpoint. So, from this research, it showed that the palm kernel activated carbon can be applied in various way such as treat the pollutant In fact from the study, the activated carbon that form from the palm kernel can be recycled up to eight cycles in continuous treatment. Due to the activated carbon that has low surface area, it should be focus on study activation method to enhance the capability of the adsorption (Jalani et al., 2016).

2.2.4 PROCESS OF PALM KERNEL ACTIVATED CARBON

The palm kernel that forms are about 10 to 15% of the dry weight where contains 73.2% cellulose. From the recent research, the physicochemical properties of palm kernel fiber have been showed that the nucleus of the palm kernel consists of two parts which are shell and the brain that change in terms of materials. So, the prepared of the activated carbon is done by thermochemical method from the crust of palm kernel shell. To produce palm kernel shell as a great absorbent, a high pore surface is important. So, they need done several methods to increase the pore surface. The activation process can be done in two method either physical or chemical process. For physical activation process, common activating agents that used is carbon dioxide, air, steam or their mixture. It is where carbonization and activation step are occurred at 700 - 1100 °C in the presence of activating agents. It is a process where air moisture will be taken out from the palm kernel using heating process for a few hours to reduce the waste weight so it will increase the pore surface. (Andas et al., 2017).

For chemical activation process, the precursor that prepared from the palm kernel is mixed with the certain chemicals. It is including like as zinc chloride ($ZnCl_2$), phosphoric acid (H_3PO_4) and potassium hydroxide (KOH) which acts as the activating agent. This process also done the carbonization and activation step, but they operate at 400 - 700 °C in the presence of activating agent. The advantage we use the chemical activation process is shorten the analysis time used, energy consumption that used is reduce and produce higher yield of product (Andas et al., 2017). However, even it produces the higher of product it still shows the very high porosity of activated carbon.

2.3 RADIOACTIVE CONTAMINATION AND WASTE MANAGEMENT

The risk of the radioactive contamination is increase since the usage of the radioactive materials are widely used for medical and industries. Besides, the large nuclear accident that current occur is presents the challenges of an unusual magnitude to decision-makers. It will occur the radiation effects are needed to avoid, and all decisions are required the skilled knowledge that quite scarce.

2.3.1 RADIOACTIVE CONTAMINATION

The development of methods for radioactive decontamination and capture or long-term storage of radioactive gases is importance in order to manage their emissions. In addition, the recent research has been showed about the porous solid sorbents for the capture of radioactive gases. To remove the iodine and noble gas like Krypton or Xenon, the wet and dry process are use with large DFs. Wet processes that typically use is a solvent to scrub iodine from the gas phase such as Iodox and Mercurex process, and fluorocarbon absorption. However, it has limitations for practical applications of removal iodine. However, the dry process or adsorption technique is comparatively better than the wet process for capture the radioactive iodine volatile gaseous. Activated carbon is one of the remarkable for porosity of the adsorbent for capture of radionuclide contaminants such as iodine, noble gases but the sorbent cannot be used for off-gas streams. So, the silver-impregnated sorbents has been used due to great potential to capture the iodine by chemical reaction with silver metal and has electrostatic potential in helium carrier gas (Nandanwar et al., 2016).

2.3.2 RADIOACTIVE WASTE MANAGEMENT

Safe management for radioactive waste has challenging to the waste management organization of the industries or hospital. So, the radioactive waste must have their special engineer container for packaging for storage and disposal (Crown, 2019). The objective of radioactive waste management is to deal with radioactive waste in good condition and manner. Besides, to protects human health and the environment without imposing an undue burden for future generations (Ojovan and Lee, 2007). Radioactive waste is classified according to its activity level and half-life of radioactive radionuclide. Activity level is to determine the degree of protection that will provided. Based on the research, the rearrangement of the contaminated materials and radioactive waste was done to achieve the reduction in cost while maintaining the safety level. The study had suggested that the decommissioning of activities must be planned and arranged with strict coordination with program to establish the radioactive waste disposal system without has contaminated materials. At the same time, they had applied the basic principle of radiation protection (Vedernikova et al., 2019).

Next, another way has been done to treat radioactive waste. Based on the article Abdellah et al. (2020), the modified activated carbon with synthesize manganese oxide/MnO_2 nanoparticles (NMO) were used remove the $^{99}TcO_4^-$ anions from low level radioactive liquid waste. Low-cost adsorbents of manganese oxide/MnO_2 nanoparticles (NMO) have been prepared successfully with different concentration. The major parameter that influence the efficiency of the process was successfully prove such the initial activity of the concentration, and contact time on the removal process, solution pH and the competing of ion concentration. From that its shows that the efficiency is more than 90% for every concentration that had been used in this research with contact time at 60 minutes. The kinetic study also showed that the adsorption isotherm is followed Freundlich isotherm model where the chemisorption between the concentration and $^{99}TcO_4^-$ is heterogeneous surface of the adsorbent. Finally, it can be concluded that composition of the NMO of activated carbon with different concentration are efficient sorbents for removal of the $^{99}TcO_4^-$ from low level radioactive liquid waste (Abdellah et al., 2020).

2.4 CHARACTERIZATION USING SEM AND EDX

2.4.1 SEM AND EDX

SEM or known as Scanning Electron Microscope is a high magnification microscope where uses the focus scanned electron beam to produce the images in a raster scan pattern from the sample with the necessary sample preparation such as cross-sections. Then, it will cause the interaction between the electron beam and electron in sample. The some of the electron beam will be interact with specimen and undergoes scattering such inelastic and elastic scattering. Even though most of the energy of electron beam is change as heat, it will occur secondary effects where the effect is includes characteristic x-rays, backscattered and secondary electron that shown as in figure 1. The secondary electron is form when incident electron is changed the path and lose it energy to atom in the specimen and leave with small energy beside most used in imaging signal in SEM. However, the backscattered electron is form from the collision of incident electron and atom in the specimen. The backscattered electron also can generate secondary electron when exit the specimen. After the secondary produced the x-ray emission is occur from the de-energization of atom in the samples. So, the imaging in SEM is done by using the backscatter and emission of secondary electrons (Girão et al., 2017).

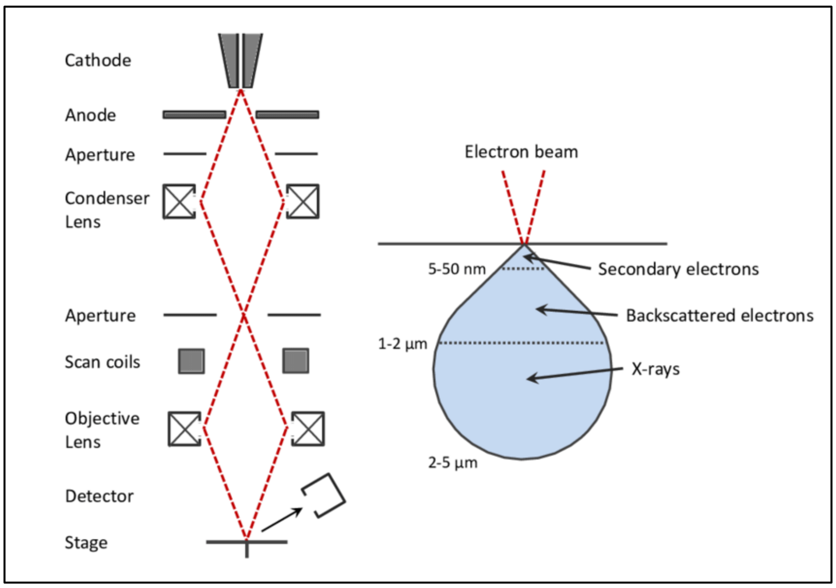


Figure 1: The schematic of Scanning Electron Microscopy (SEM) (Röhr, 2014)

For all the activated adsorbents, image result of the Scanning Electron Microscopy (SEM) indicated that the palm kernel shell activated carbon possessed more regular developed pores and morphology. It considered that the spaces for potassium oxide that deposited on the external surface of the adsorbent is enhance the surface chemistry of the activated carbon of the palm kernel. Moreover, the capacity of activated carbon to adsorption is greatly improved. Besides, the result of the Energy Dispersive X-Ray Analyzer (EDX) also confirmed that the activated carbon from the palm kernel shell is performed better that other adsorbent. Besides, it showed that palm kernel shell is exhibited better crystalline structures compared to other adsorbents where the structure of activated carbon of the palm kernel that spent is not affected after the adsorption process and high of removal efficiency (Habeeb et al., 2020).

2.4.2 CHARACTERIZATION OF FESEM

FESEM or known as the Field Emission Scanning Electron Microscope is the instrument that like the SEM which is provides a wide variety of information from the sample surface and has higher resolution and greater energy range. It is the microscope that works with electrons instead of light where liberated by a field emission source. The sample surface is then scanned by the electron beam according to the zig-zag pattern with a monitor display the information that we want on the detector available. Besides, it is to visualize very small topographic details on the surface or entire objects and observe the structure than can be as small as 1 nanometer. The example of visual that can see in FESEM is study organelles and DNA material in cells and coating on microchips (Janssen, 2019).

FESEM use field emission gun to provide extremely focus in high and low-energy electron beam. It also improves the spatial resolution and enable do the work at very low potentials. It helps us to reduce the charging effect on non-conductive specimens beside to avoid damage on sensitive sample. FESEM also use in-lens detectors where are to optimized work at high resolution and very low kV but getting highest performance from the equipment. To get the image from FESEM, electrons beams are liberated from a field emission source and accelerated in a high electrical field gradient. With the high vacuum column that called primary electrons, it focused and deflected by electronic lenses to produce a narrow scan beam that bombards the sample surface. As a result, secondary electrons are emitted from each spot on the sample surface. The angle and velocity of these secondary electrons are related to the surface structure of the object. Then the detector will catch the secondary electrons and produces an electronic signal where it will be amplified and transformed to a video scan-image. Scan image then can be seen on a monitor or to a digital image and can be saved for processed further.

2.4.3 MORPHOLOGY & POROSITY OF ACTIVATED CARBON

Function Scanning Electron Microscopy (SEM) is to observe the particle growth and determine particle size in nanoparticles. The physical morphology of the carbon surface due activation can have size of 300 nm to 1 µm. After the activation process is occur, the particle size was below 500 nm, on average. It show that the surface structures before and after of activation process were different while the activation result is better and more even in structure (Faisal et al., 2019). Based on the Rugayah et al. (2014), the activated carbon from palm kernel shell is produce from the carbonization and activation process. From this study it showed that the Brunauer-Emmett-Teller (BET) surface of that activated carbon bigger than the activated carbon in the market which is 541.76 m^2g^{-1} micropore surface area. From the SEM image, physically of activated carbon palm kernel has showed good developed pores and surface compared to raw palm kernel shell. So, it concludes that activated carbon has high potential due to low ash content even-though it has high volatile (Rugayah et al., 2014).

Another research has been done to characterize the activated carbon from Palm Kernel Shell. The image in figure 2 show that the surface morphology of the palm kernel shell was investigated using SEM. There was no formation of pores show in raw material while many pore developments in image of activated carbon with potassium hydroxide (KOH). Due to KOH as chemical activating agent, it creates more development of pores and removal of volatile at temperature 800°C. From the SEM analysis, it shows that raw material has smooth surface while for KOH-AC has developed the greatest number of pores as shown in figure 2 (Andas et al., 2017). The surface morphology of the raw palm kernel showed no formation of pores due to the presence of volatiles and contaminants on its surface. However, development and widening of pores is occur from the carbonized precursor to activated carbon. This result occur as space is created by the loss of the moisture and the chemical activate that remained in the cavities (Garba et al., 2015). Morphology of carbonized palm kernel shell visual the formation of well-developed pores which validated of potential of the activated carbon in the treatment of waste-water and the decontamination (Saber et al., 2018).

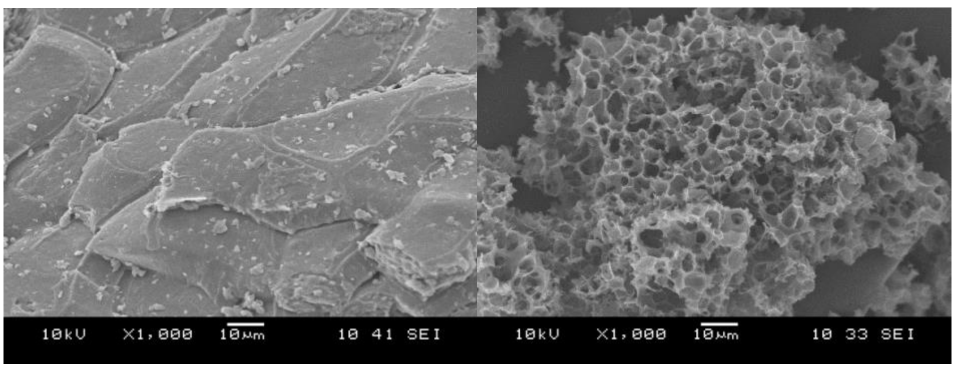


Figure 2: SEM images of raw material and KOH-AC at x250 (Andas et al., 2017)

CHAPTER 3 MATERIALS AND METHOD

3.1. MATERIALS

There are a few of materials that used in this study especially for extraction of the I^{131} and preparation to synthesis the palm kernel shell. First step of methodology is synthesis the activated carbon that prepared from palm kernel shell. Second step is done the extraction of I^{131}. The materials that involves in step 1 is natural agricultural waste which is palm kernel shell and chemical substances like zinc chloride ($ZnCl_2$), phosphoric acid (H_3PO_4)and potassium hydroxide (KOH). While in step 2, material that only used is I^{131} from pure I^{131} , distilled water and palm kernel shell activated carbon.

a) Palm Kernel shell

Palm kernel shell as figure 3 is a naturally high-grade solid biofuel and known as adsorbent for the removal of heavy metals ion and water filter. It has a high energy density and it supply from the Hanyang Factory from the China in granular condition. This material is suitable to produce activated charcoal due to its low ash content but high in carbon and volatile content Due to the experiment, the shell was washed and dried under the sun about 24 hours to remove the moisture.

Figure 3: The raw palm kernel shell

b) Chemical substances

Zinc chloride ($ZnCl_2$) and Potassium hydroxide (KOH) were used as the chemical activator. Other chemicals that can used as addition were Sulfuric Acid (H_2SO_4), Potassium Permanganate (KM_NO_4), 27 ml of Hydrogen Peroxide (H_2O_2). Potassium hydroxide (KOH) is important as chemical adsorbent because its function is used to develop the porosity and increase adsorption of affinity. Hydrochloric acid (HCl) solution also used in this experiment to leach out the activating agent.

c) Pure I^{131}

I^{131} is a volatile radioactive isotope and form as a pure radioiodine I^{131}. It is radioisotope with very short half-life of 8.02 days and its simultaneously emits two types of radiation which are beta minus and Gamma. Due to the experiment, the Six pure I^{131} radionuclide samples with 1 ml each were collected from the pure iodine in Nuclear Medicine department, HUSM. It was place in the special shield container to prevent from given the radiation to other worker and people. In this experiment, Pure I^{131} was survey and monitor by Geiger-Muller survey meter to get the background exposure (mSv/hr) for radiation safety before and after used.

Figure 4: The pure of I^{131}

3.2. EQUIPMENTS

There are a few equipment's that used in the experiment especially to run the process of extraction of radioactive I^{131} with using palm kernel shell that prepared as an activated carbon. For preparation the activated carbon, magnetic stirrer, beaker and test tube is needed for this process. While for the extraction of I^{131}, equipment that needed are Geiger-Muller survey meter, dose calibrator, pipette, filter paper and SEM and EDX.

a) Dose Calibrator

The dose calibrator is an important equipment in this experiment and any nuclear medicine laboratory. It as ionization chamber that used to assay the amount of the activity of sediment in the vials. Dose calibrator is essential well type of ionization chamber that capable in measuring quantities in the millicurie. It operates over a wide range of the activities in sediment from hundred up to a curie. This device is also included with the variable setting for each radionuclide that will be measured. The chamber is in cylindrical condition and hold defined volume of pressure inert gas such as argon and do not contain sodium iodide crystal.

Figure 5: The dose calibrator (Biodex, Atomlab 500)

b) Magnetic stirrer

Magnetic stirrer that used is this experiment is Hot Plate/ Magnetic stirrer type ERLA- Ems 7000. It is device that consist of rotating magnet that creates rotating magnetic field. The function of this equipment is to make a stirring or mixing the solution of the palm kernel activated carbon. It is one simplest way to prepare the mixture where the magnetic stirrer is rotate the magnet using an electric motor. Rotating magnet or stir bar has their own shape to easier the mixing mixture.

Figure 6: magnetic stirrer & hot plate

c) Geiger-Muller survey meter

The Geiger- Mueller (GM) survey meter is a device that commonly used for detection of the radioactive contamination. The survey meter that used is Internal Pancake G-M survey meter type of portable. The portable of survey meter is used to simplify the work and usually G-M meter is often as portable. For this study, the G-M survey meter used is to monitor the background of exposure of the radiation every time the radioactive material is used. The efficiency of GM for detect the radiation is depend on the survey meter such energy, type, amount of activity and direction of source radiation.