# THE EXTRACTION OF IODINE-131 FROM THE SPILLAGE USING COCONUT SHELL ACTIVATED CARBON IN NUCLEAR MEDICINE

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**By**

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# CERTIFICATE

This is to certify that the dissertation entitled "THE EXTRACTION OF IODINE-131 FROM THE SPILLAGE USING COCONUT SHELL ACTIVATED CARBON IN NUCLEAR MEDICINE" is the bona fide record of research work done by SYABIL IRFAN BIN SHUKRI, matric number 134396 during the period of 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 Sciences (Honours) (Medical Radiation). Research work and collection of data belong to the Universiti Sains Malaysia.

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# DECLARATION

I hereby declare that this dissertation is the result of my own investigation, 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.

Signature

……………………………………………….

Syabil Irfan Bin Shukri

Date:  AUGUST 2020

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| | |
|---|---|
| AC | Activated Carbon |
| EDX | Electron Dispersive X-ray |
| FESEM | Field Emission Scanning Electron Microscope |
| $H_2SO_4$ | Sulphuric acid |
| $H_2O_2$ | Hydrogen peroxide |
| $H_3 PO_4$ | Phosphoric acid |
| HUSM | Hospital Universiti Sains Malaysia |
| $KMnO_4$ | Potassium permanganate |
| MBq | Megabecquerel |
| mg/ml | milligrams per milliliter |
| $^oC$ | Celsius |

# ABSTRAK

Tempurung kelapa adalah salah satu produk sampingan pertanian yang mempunyai banyak kegunaan seperti ia dapat bertindak sebagai bahan biosorben. Kajian ini dilakukan untuk mengkaji kemampuan penyerap karbon kelapa aktif (AC) untuk mengekstrak Iodine-131 dari tumpahan radioaktif dalam perubatan nuklear. Pengekstrakan radionuklid Iodine-131 telah dijalankan dalam penjerapan kelompok untuk mengkaji hubungan antara kepekatan karbon aktif dari tempurung kelapa dengan kadar radioaktiviti Iodin-131 selepas pengekstrakan. Kepekatan karbon aktif dari tempurung kelapa yang telah digunakan adalah 50 mg / ml, 100 mg / ml, 150 mg / ml, 200 mg / ml, 250 mg / ml, 300 mg / ml, dan 350 mg / ml. Eksperimen ini juga dilakukan untuk menentukan morfologi permukaan dan analisis elemen yang terdapat dalam karbon aktif dari tempurung kelapa dengan menggunakan Imbasan Mikroskop Elektron Pancaran Medan (FESEM) dan Serakan Tenaga X-ray (EDX). Berdasarkan hasil daripada eksperimen ini, terdapat hubungan yang signifikan antara kepekatan karbon aktif tempurung kelapa dengan kadar radioaktiviti Iodine-131 setelah pengekstrakan. Selain itu, kadar penyerapan karbon aktif dari tempurung kelapa juga dapat ditentukan dan terbukti bahawa kemampuan penyerapan AC tempurung kelapa meningkat jika kepekatan karbon aktif dari tempurung kelapa meningkat. Untuk morfologi permukaan, karbon aktif dari tempurung kelapa mempunyai ciri-ciri yang diperlukan oleh setiap bahan penyerap seperti liang pori yang banyak dan luas permukaan yang tinggi. Terakhir untuk analisis elemen, terdapat bukti bahawa Iodine-131 telah diekstrak oleh tempurung kelapa AC iaitu kehadiaran elemen Sodium (Na).

# ABSTRACT

Coconut shell is one of the agricultural by-products that have a lot of interest and uses such as it can act as biosorbents material. This study was carried out to examine the ability of adsorbents coconut shell activated carbon (AC) to extract the Iodine-131 from the radioactive spillage in nuclear medicine. From the literature review, the coconut shell was proven can be one of the precursors in activated carbon production. Then, the activated carbon also a common product that uses in many process applications including water purification, decolorization, deodorization, and aroma removal. Hence, coconut shell AC was also effective and efficient adsorbent for the extraction of the Iodine-131 from the radioactive spillage. The extraction of the Iodine-131 radionuclides was conducted in a batch experiment to investigate the relationship between the concentrations of the coconut shell AC and the kinetic radioactivity of iodine 131 after extraction. The concentrations of coconut shell AC that has been used were 50 mg/ml, 100 mg/ml, 150 mg/ml, 200 mg/ml, 250 mg/ml, 300 mg/ml, and 350 mg/ml. This experiment also was conducted to determine the surface morphology and element analysis of the coconut shell AC by using the FESEM and EDX. Based on the result of this experiment, there is a significant relationship between the concentrations of the coconut shell activated carbon and the kinetic radioactivity of iodine 131 after extraction. Besides, the absorption rate of the coconut shell AC also can be determined, and it stated that the absorption capabilities of coconut shell AC increase if the concentration of coconut shell AC increases. For the surface morphology, the coconut shell AC has the characteristics that each absorbent material needed, such as the highly pores and high total surface area. Lastly, for the element analysis, there was proof that the Iodine-131 has been extracted by the coconut shell AC, which is the present of the Sodium (Na) element.

# CHAPTER 1: INTRODUCTION

## 1.1. BACKGROUND OF STUDY

Nowadays, the use of radioactive material in medicine is gaining prominence especially in the nuclear medicine department at the hospital. In nuclear medicine, the radioactive material can be used for both purposes, which are diagnostic and therapeutic purposes. The most radioactive source that applies for this purpose is the Technetium-99m and the Iodine-131. This source can be either used with or without the carrier, especially for the Technetium-99m to become the radiopharmaceutical. When the radioactive material is inserted into the patient's body by injection or ingestion, the patient's body itself will act as a source and release the radiation. Besides that, the waste from the patient also will contain the radioactive material and will release the radiation such as the urine, feces, saliva, and sweat.

The radiation spillage is one of the examples of contamination that usually occur in the nuclear medicine department. There are two causes that usually contribute to spillage, which is the body fluid from the patient and the error of the radiation worker in handling the radiation source. Body fluid spillages include blood, body exudate, feces, urine, wound pus, and vomit (Fuller, 1993). The spillage can be categories into two type which is the major spill and the minor spill. A major spill is legally defined as a spillage equal to or greater than the level listed for the radioactive substance, as shown in Table 1.1 below.

**Table 1.1:** The minimum level of radioactivity for each radioactive substance to become a minor spill

| Radionuclides | Millicuries | Radionuclides | Millicuries |
|---|---|---|---|
| Fluorine-18 | 10 | Strontium-85 | 10 |
| Phosphorus-32 | 10 | Technetium-99m | 100 |
| Chromium-51 | 100 | Indium-111 | 10 |
| Cobalt-57 | 10 | Iodine-123 | 10 |
| Cobalt-58 | 100 | Iodine-125 | 1 |
| Iron-59 | 10 | Iodine-131 | 1 |
| Cobalt-60 | 1 | Ytterbium-169 | 10 |
| Gallium-67 | 100 | Gold-198 | 10 |
| Selenium-75 | 10 | Thallium-201 | 100 |
| Yttrium-90 | 100 | Samarium-153 | 100 |
| Strontium-89 | 100 | Cardbon-14 | 10 |

A minor spill is defined as any spillage where the activity is less than that of a major spill, involving removable contamination of diagnostic dose levels in a controlled area that is not spreading, and only a small radiation or contamination hazard to personnel exists.

The increase in the number of patients and the amount of that undergo the treatment will increase the chance of radiation spillage to occur. Thus, the effective method to clean up the spillage is very critical. This is because the safety of others, especially the worker during handling the patient will be affected. The conventional practice methods for cleaning up the radiation spillage is using the Radiac Wash. This Radiac Wash is not economically used because it is expensive and not available in large quantities.

Generally, the objective of this study is to provide another method that more efficient to clean up the spillage that occurs in the nuclear medicine department. This method is suggested to use the activated carbon made up of the coconut shell rather than the Radiac Wash. Activated carbon (AC) is one of the adsorbent materials widely used throughout the world (Jasni *et al.*, 2019). This activated carbon will treat the waste product of the patient by the biosorption process. The biosorption process is a biological method of environmental control that can be an alternative to conventional waste-treatment facilities.

The coconut shell is the biomaterial that wastes from agricultural operations that may have the potential to be used as low-cost adsorbents. The sorption properties of coconut shells due to the presence of some of the functional groups such as carboxylic, hydroxyl, and lactone (Amuda *et al.*, 2007).

## 1.2. PROBLEM STATEMENT

The objective of this study is to solve a few problems or issues regarding the spillage management of radionuclides in the nuclear medicine department. The radionuclide spillage management is essential because it is related to the safety of the peoples, especially the patients, workers, and other civilians that come to the nuclear medicine department.

In a situation, when the workload increased then factor safety and security radiation become ignored and caused on ignorance in handling a radiation source (Rahman *et al.*, 2013). The examples of spillages that usually occur are from the patient. For example, the spillage of radionuclide on the hospital gown or the contamination in the ward area caused by the patient's vomiting, blood, sweating, and sneezing. Other than that, this spillage also may occur due to errors from the worker that handles the radioactive sources.

Nowadays, there are not many alternative ways of managing radioactive spillage in the nuclear medicine department. The only method that has been used to manage the radioactive spillage in the nuclear medicine department is using the Radiacwash as the decontamination agent. Thus, there are a few deficiencies in the Radiacwash that make this method is not too efficient. Firstly, the cost needed to buy this decontamination agent is high. As the usage increases, more charges are required to purchase this reagent. Then, it also difficult to get in a large quantity. The Radiacwash also not effective for all surfaces that will be decontaminated. For various surface materials, materials cleanser that available in a manner commercial (radiacwash) has little or no benefit compared to normal water when used for decontamination (Rahman *et al.*, 2013).

Moreover, this study also can be used to solve the problem regarding radionuclide waste management, especially the waste in the delay tank storage. This method can speed up the process of managing this waste, and the delay tank can be used again for the other patient. This is because the method that currently uses, which is the delay and decay method required a long time to process this waste periodically.

Hopefully, this study may be helpful to solve the problem in the radioactive spillage management process and can be used as another alternative to manage the contamination rather than using the Radiac wash.

## 1.3. RESEARCH OBJECTIVE

### 1.3.1. GENERAL OBJECTIVE

The main objective of this study is to extract the Iodine-131 from the radioactive spillage using coconut shell activated carbon in nuclear medicine

### 1.3.2. SPECIFIC OBJECTIVE

I. To synthesis the activated carbon from the coconut shell.

II. To determine the relationship between the concentrations of the coconut shell activated carbon and the kinetic radioactivity of iodine 131 after extraction.

III. To characterize the extraction radionuclide using FESEM and EDX.

## 1.4. RESEARCH QUESTIONS

I. What is the relationship between the concentration of the coconut shell activated carbon and the kinetic radioactivity of Iodine 131 after extraction?

II. What is the optimum concentration of the coconut shell activated carbon in the extraction of Iodine-131 radionuclide?

## 1.5. RESEARCH HYPOTHESIS

I. Null hypothesis, Ho

There is no relationship between the concentrations of the coconut shell activated carbon with the kinetic radioactivity of Iodine-131 after extraction.

II. Alternative hypothesis, HA

The higher concentration of coconut shell activated carbon will increase the absorption capabilities of radioactive spillages.

## 1.6. SIGNIFICANT OF RESEARCH

This study is crucial as it will provide an effective method to solve the problem regarding the decontamination of the radioactive spillages in the nuclear medicine department at Hospital Universiti Sains Malaysia (HUSM). Hence this study is suggested to use the activated carbon that is made up of the coconut shell as the adsorbent material in extracting the Iodine-131 from the spillages. By using this method, it can overcome the uneconomical issue of using the Radiac wash as the primary material to manage the contamination. This method is not efficient because the Radiac wash is expensive and chemically reactive.

In contrast, activated carbon biomaterials are available in large quantities, or particular waste from agricultural operations may have the potential to be used as low-cost adsorbents because they represent abundant resources that are widely available and environmentally friendly. Besides saving our cost, using the coconut shell activated carbon also can save our world from the pollution.

The surface morphology and element analysis of coconut shell activated carbon will be done by using the FESEM (Field Emission Scanning Electron Microscope) and EDX (Electron Dispersive X-ray) to determine the characterization of the absorbability of this material. This is to see whether it is effective or not to absorb the radionuclide in the spillages.

# CHAPTER 2: LITERATURE REVIEW

## 2.1. Iodine-131

Iodine-131 is one of the common sources that use in nuclear medicine. Iodine-131 is a unique source because it is can be used for both purposes, which are diagnostic and therapeutic. The Iodine-131 isotope can emit two types of radiation simultaneously: radiation beta minus that used for the treatment and gamma-ray used for diagnosis (Wyszomirska, 2012). For the beta minus radiation, the energy is 606 keV while the gamma-ray produced by the Iodine-131 is 364 keV. The Iodine-131 also has the physical half-life 8.04 days. The radioactive iodine generated by nuclear fuel could be one of the biggest hidden dangers during the nuclear accidents due to its high volatility, long half-life (about 1.52 million years for $^{129}I$), easy accumulation in the thyroid gland, and affecting biological metabolism (Li *et al.*, 2019a). This production of Iodine-131 is from the fission of Uranium-235 isotope in the reactor. Currently, Iodine-131 is available as sodium iodide in gelatine capsules and drinking solution for oral application as well as in intravenous injection (Wyszomirska, 2012).

For the patient that will undergo the iodine procedure (therapeutic or diagnosis), the patient will take the Iodine-131 orally. The Iodine-131 also usually will be used without any tracer for the thyroid target organ. This is because the thyroid is the critical organ for iodine and the iodine is taken up by the thyroid follicular cell (Ward, 2006). Besides, this is one of the reasons why Iodine-131 is used for thyroid imaging. For the therapeutic purpose, the Iodine-131 is suitable because the penetration of electrons in soft tissue is about 1 mm as shown in Figure 2.1.1 and this means that the energy of the electron radiation is absorbed very close to the source of radiation which is the thyroid organ (Wyszomirska, 2012).

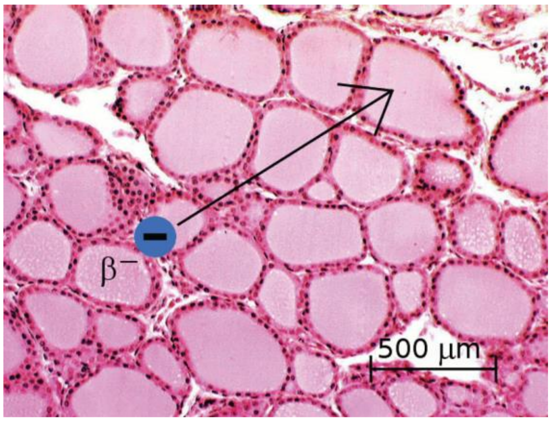


**Figure 2.1.1**: The distance of electron travel in thyroid tissue

I-131 radionuclide is widely used in radioiodine therapy to treat thyroid cancer. The patient will be warded and quarantined for a few days until the I-131 activity inside the patient's body is less than 30 mCi before being discharged (M.K.A.A. Razab, 2019). The use of iodine-131 comes with a few advantages which are good tolerability, ease of application, safety, and high efficiency (Wyszomirska, 2012).

## 2.1.1. Radioactive Decontamination

Due to the increased use of radioactive material, especially in medicine, the chance of contamination to occur also will be increased. Thus, the effective decontamination technique is very critical to be applied to clean the contamination. Contamination occurs when material that emits ionizing radiation is deposited on a person (skin, hair, clothing), or any place where it is not intended (Domínguez-Gadea and Cerezo, 2011). The contamination area also is the area that registers more than twice the previously determined background level and is considered contaminated (Domínguez-Gadea and Cerezo, 2011). The decontamination is important because the proper, completed, and rapid decontamination can limit the spread of contamination, and reduce morbidity and mortality (Domínguez-Gadea and Cerezo, 2011). Based on Dominguez-Gadea and Cerezo (2011), the decontamination method to be used depends upon the location, the isotope type, half-life, mode of radiation, and the form of contamination. There are two types of contamination which is the dry radioactive contamination and wet radioactive contamination.

For the dry radioactive contamination, it must be removed with a decontamination agent of which there are a variety of commercial preparations. These agents should consist of a base that will speed up hydrolysis, reduce surface tension and dissolve or disperse hydrophobic compounds, and a chelate that will dissolve insoluble precipitates of metal hydroxides and oxides (Mountford, 1991). Besides, the other aspect that needs to be considered when choosing which agent to purchase is whether it is biodegradable or not. The common decontamination agent that has been used is Radiac wash. In the decontamination procedures, the contamination area will be swabbed using tissues or disposable paper towels and it must start from the periphery of the contaminated area and move towards the center. This is because to avoid the contaminated washing is moving or running onto uncontaminated areas (Domínguez-Gadea and Cerezo, 2011). This process will be repeated until the radioactivity of the contamination is low.

Then, if the radioactive liquid has been spilled or wet radioactive contamination occurs, the tissues or disposable paper towels should be dropped onto the liquid immediately to contain its spread, and the spilled liquid should be mopped toward its center. After that, if the contamination remains excessive, the surface should be washed with a