

Jockey Club STEAM Education Resources Sharing Scheme

# UV, You and We

Laboratory Manual and Worksheets

Name: \_\_\_\_\_

Class: \_\_\_\_\_

School: \_\_\_\_\_

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# Contents

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<b>Background.....</b>	<b>1</b>
<b>Unit 1 – The Nature of EM Radiation .....</b>	<b>2</b>
<b>1. Introduction .....</b>	<b>2</b>
<b>2. Summary of Unit 1.....</b>	<b>2</b>
2.1 What is electromagnetic (EM) radiation? .....	2
2.2 Applications of EM radiation in our daily life .....	2
<b>3. References .....</b>	<b>5</b>
<b>Student Worksheet .....</b>	<b>6</b>
<b>Unit 2 – UV, You and We .....</b>	<b>9</b>
<b>1. Introduction .....</b>	<b>9</b>
<b>2. Summary of Unit 2.....</b>	<b>9</b>
2.1 What is Ultraviolet (UV)? .....	9
2.2 Applications of UV .....	9
<b>3. References .....</b>	<b>12</b>
<b>Student Worksheet .....</b>	<b>13</b>
<b>Unit 3 – DIY UV-box.....</b>	<b>16</b>
<b>1. Introduction .....</b>	<b>16</b>
<b>2. Summary of Unit 3 and Activity 1 .....</b>	<b>16</b>
2.1 What is a UV-box? .....	16
2.2 Safety for using UV tools .....	16
<b>3. Duration .....</b>	<b>17</b>
<b>4. Objective .....</b>	<b>17</b>
<b>5. Equipment.....</b>	<b>17</b>
<b>6. Materials .....</b>	<b>17</b>
<b>7. Procedures .....</b>	<b>17</b>
<b>8. Result and Discussion .....</b>	<b>18</b>
<b>9. References .....</b>	<b>18</b>
<b>Unit 4 – UV in Laboratory .....</b>	<b>19</b>
<b>1. Introduction .....</b>	<b>19</b>
<b>2. Activity 1 .....</b>	<b>19</b>
2.1 ATP-Bacteria Test .....	19
2.2 Duration.....	19
2.3 Objective .....	19
2.4 Equipment .....	19
2.5 Materials.....	19

2.6	Procedures .....	20
2.7	Result and Discussion .....	20
<b>3.</b>	<b>Activity 2</b> .....	<b>21</b>
3.1	Gel Electrophoresis .....	21
3.2	Duration.....	21
3.3	Objective .....	21
3.4	Equipment .....	21
3.5	Materials.....	21
3.6	Procedures .....	21
3.7	Result and Discussion .....	22
<b>4.</b>	<b>Activity 3</b> .....	<b>22</b>
4.1	Thin Layer Chromatography.....	22
4.2	Duration.....	22
4.3	Objective .....	22
4.4	Equipment .....	22
4.5	Materials.....	23
4.6	Procedures .....	23
4.7	Result and Discussion .....	24
<b>5.</b>	<b>References</b> .....	<b>24</b>

# Background

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## Introduction

*“UV, You and We”* is one of the core modules in the scheme to enhance your interest in learning STEAM via a project, which integrates KLAs from different subjects.

This module consists of four units covering science, technology, engineering, arts and mathematics:

- ◆ Unit 1 – The Nature of EM Radiation
- ◆ Unit 2 – UV, You and We
- ◆ Unit 3 – DIY UV-box
- ◆ Unit 4 – UV in Laboratory

By applying different knowledge and techniques in STEAM, the four units combined form a single project about studying and investigating the physical, chemical and biological knowledge and theories applied.

## Learning outcomes

Upon the completion of the module, you should be able to:

- ◆ Understand the nature of UV as a part of electromagnetic radiation
- ◆ List out different applications of UV in our daily life
- ◆ Explain the working principles of UV in some applications by applying the physical, chemical, and biological knowledge learnt
- ◆ Make a UV box
- ◆ Use the UV box in the later biological and chemical experiments

# Unit 1 – The Nature of EM Radiation

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## 1. Introduction

In Unit 1, the nature and different features such as wavelength, frequency and energy of electromagnetic (EM) radiation will be introduced and illustrated with real-life examples and applications. This unit would familiarise you with the physics of EM radiation, which is necessary for you to understand the next unit.

This unit would familiarise students with the fundamental knowledge of EM radiation, which is necessary for you to understand Unit 2.

## 2. Summary of Unit 1

### 2.1 What is electromagnetic (EM) radiation?

- ◆ It is composed of an oscillating electric field and a magnetic field
- ◆ Both fields are perpendicular to each other and also to the travelling direction
- ◆ All kinds of EM radiation are transverse waves
- ◆ Different types of electromagnetic radiation have different physical features such as wavelength, frequency and applications
- ◆ According to the wavelength and frequency, different types of electromagnetic radiation are listed in the electromagnetic spectrum
- ◆ Including radio waves, microwave, infrared, visible light, ultraviolet, X rays and gamma rays

#### **Properties of EM radiation:**

- ◆ Share some properties of a wave, such as reflection, refraction, diffraction and interference
- ◆ The speed of EM radiation is the same as light speed ( $3 \times 10^8 \text{ ms}^{-1}$  in vacuum)
- ◆ And the speed of EM radiation equals frequency times wavelength
- ◆ EM radiation with higher energy will have a higher frequency and shorter wavelength
- ◆ While EM radiation with lower energy will have a lower frequency and longer wavelength

### 2.2 Applications of EM radiation in our daily life

#### **Radio wave - Radio:**

- ◆ Radio consists of four main parts:
  - Receiver
  - Antenna
  - Demodulator
  - Speaker

#### **Receiver:**

- ◆ It receives the radio wave emitted from the radio station

- ◆ Since the range of frequency of radio waves is from  $10^6$  to  $10^8$  hertz
- ◆ The receiver can be tuned to receive only radio waves with a particular frequency

#### **Demodulator:**

- ◆ The hearing range of humans is from 20 Hz to 20,000 Hz
- ◆ But the radio can only receive radio waves from 1,000,000 Hz to 100,000,000 Hz
- ◆ Why can we still hear sounds from the radio?
- ◆ Because of amplitude!
- ◆ Amplitude is the maximum magnitude of displacement of an oscillating particle from its equilibrium position, and the unit is metre (m)
- ◆ In fact, the sound wave is embedded into the radio wave by changing the amplitude
- ◆ Without changing the frequency of the radio wave
- ◆ Therefore, a demodulator is used to resolve the received wave (sound wave + radio wave)
- ◆ Back to the sound wave only so that we can hear the sound

#### **Antenna and speaker:**

- ◆ An antenna is used to pick up the radio wave as much as possible
- ◆ So that the demodulator can better resolve the original sound wave
- ◆ Speaker is used to transmit the sound wave resolved to our ears
- ◆ By vibrating the air around us

#### **Microwave – Microwave oven:**

- ◆ It is used to convert electromagnetic energy into heat energy
- ◆ Using microwave which energy and frequency are higher than radio waves ( $10^8$  Hz to  $10^{11}$  Hz)
- ◆ The frequency of the microwave is suitable for causing the vibration of water molecules
- ◆ The vibration will produce heat energy and heat the water, and hence the food
- ◆ Main parts of a microwave oven:
  - High voltage transformer
  - Cavity magnetron
  - Cooling fan
  - Waveguide

#### **High voltage transformer:**

- ◆ A normal 220 V supply is not enough for the oven to generate microwave
- ◆ A transformer is used to convert 220 V to a few thousand volts for microwave generation

#### **Cavity Magnetron:**

- ◆ It is a vacuum tube
- ◆ Which is used to transform electrical energy into microwave radiation
- ◆ A lot of power is needed for the magnetron to work

**Waveguide:**

- ◆ It is located inside the food chamber
- ◆ Used to guide the microwave generated from the magnetron to the food chamber for heating the food

**Cooling fan:**

- ◆ It is used to cool down the magnetron
- ◆ Since the temperature would be high when the magnetron is generating microwave

**The working mechanism of the microwave oven:**

- ◆ The microwave generated by the magnetron will be guided into the chamber of the oven
- ◆ Since microwave is also electromagnetic radiation, there are electric and magnetic fields oscillating over time
- ◆ The fields can interact with water molecules and make them vibrate
- ◆ The electromagnetic energy will be converted into kinetic energy of the water molecules
- ◆ The more kinetic energy, the higher the temperature of the water molecules
- ◆ And finally, it will heat the food up

**Infrared – IR thermometer:**

- ◆ Any object with a temperature higher than absolute zero would emit infrared
- ◆ The higher the temperature, the higher the energy (e.g. frequency) of the infrared radiation emitted
- ◆ This radiation is also known as black body radiation

**The working mechanism of the IR thermometer:**

- ◆ Since the object with higher temperature will emit infrared with higher energy
- ◆ Therefore, we can check the energy of the infrared emitted and hence estimate the temperature of the corresponding object
- ◆ Main parts of an IR thermometer:
  - A lens
  - A thermopile

**A lens:**

- ◆ It is used to focus the infrared radiation emitted from the interesting object to the detector of the thermometer
- ◆ Usually, a convex lens is used

**A thermopile:**

- ◆ A detector called a thermopile is used to convert the radiation energy into heat energy and then into an electrical signal
- ◆ After receiving the electrical signal, the IR thermometer will display the temperature

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**UV, You and We**  
**Unit 1 – The Nature of EM Radiation**

**Student Worksheet**

**1) Electromagnetic radiation is:**

- A. A kind of electricity
- B. A kind of magnet
- C. A wave
- D. A kind of sound

**2) Which of the following are the features of EM radiation?**

- (1) Wavelength
- (2) Frequency
- (3) Height
- (4) Amplitude

- A. (1) only
- B. (2) and (3)
- C. (3) and (4)
- D. (1), (2) and (4)

**3) What does EM radiation consist of?**

- (1) Electric field
- (2) Magnetic field
- (3) Light field
- (4) Heat field

- A. (1) and (2)
- B. (2) and (3)
- C. (3) and (4)
- D. (1) and (4)

**4) Which of the following waves are part of the electromagnetic spectrum?**

- (1) Sound wave
- (2) Radio wave
- (3) Infrared
- (4) Visible light

- A. (1) only
- B. (2) only
- C. (2) and (3)
- D. (2) and (3) and (4)

**5) Which of the following are the properties of electromagnetic radiation?**

- (1) Diffraction
- (2) Light speed
- (3) Reflection
- (4) Temperature

- A. (1) and (2)
- B. (1) and (2) and (3)
- C. (2) and (3) and (4)
- D. (1) and (3) and (4)

**6) What is the usage of a receiver in a radio?**

- A. Resolving the sound wave from the radio wave received
- B. Receiving the radio wave emitted from the radio station
- C. Getting power supply
- D. Receiving the sound wave directly

**7) What is the usage of a demodulator in a radio?**

- A. Resolving the sound wave from the radio wave received
- B. Change the amplitude of the radio wave
- C. Receiving the sound wave directly
- D. Transmit the sound wave to our ear

**8) What is the usage of a speaker in a radio?**

- A. Picking up the radio wave as much as possible
- B. Resolving the sound wave from the radio wave received
- C. Changing the amplitude of the radio wave
- D. Transmitting the sound wave to our ear

**9) Which of the following are parts of a microwave oven?**

- (1) High voltage transformer
- (2) Cavity Magnetron
- (3) Cooling fan
- (4) Antenna

- A. (1) and (2)
- B. (2) and (3)
- C. (3) and (4)
- D. (1) and (2) and (3)

**10) Why do we need a high voltage transformer in a microwave oven?**

- A. To save the power
- B. To reduce the voltage from 220 V to 110 V
- C. To convert the voltage from 220 V to a few thousand volts for microwave generation
- D. All of the above

**11) Why microwaves are used in a microwave oven?**

- A. The frequency of microwaves is higher than that of infrared
- B. The frequency of microwaves is suitable for vibrating water molecule
- C. Microwave has higher energy
- D. Microwave does not have an electric field

**12) What is the usage of a wave guide in a microwave oven?**

- A. To generate microwave
- B. To heat up the food
- C. To guide the microwave generated from the magnetron
- D. To cool down the magnetron

**13) What object will not emit infrared?**

- A. An object that is blue in colour
- B. An object with absolute zero temperature
- C. An object that is 30 °C
- D. An object that is 0 °C

**14) Which of the following statements related to infrared are correct?**

- (1) An object with a higher temperature will emit IR with higher energy
- (2) An object with a lower temperature will emit IR with lower energy
- (3) An object with a higher temperature will emit IR with lower energy
- (4) An object with a lower temperature will emit IR with higher energy

- A. (1) and (2)
- B. (2) and (3)
- C. (2) and (4)
- D. (1) and (2) and (4)

**15) What is the usage of a thermopile in an IR thermometer?**

- A. To focus on the IR emitted from the object
- B. To convert radiation energy into heat energy
- C. To display the temperature reading
- D. All of the above

## Unit 2 – UV, You and We

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### 1. Introduction

After acquiring some basic knowledge of EM radiation, students would start to learn the applications of EM radiation, especially UV, in daily life. Electromagnetic radiation, such as radio waves, microwaves, infrared, and visible light, are well known and commonly used around us. We listen to the radio, heat food using a microwave oven and check temperatures using an infrared sensor. How about UV radiation?

In Unit 2, the unique features of UV and its applications, such as fluorescence, production of vitamin D, UV disinfection tools, and water purification, will be introduced together with their design and working mechanisms. How the unique features of UV radiation are utilised for different purposes will be shown so that students will be further familiarised with the nature of UV radiation.

### 2. Summary of Unit 2

#### 2.1 What is Ultraviolet (UV)?

- ◆ It has higher energy than radio wave, microwave and IR radiation
- ◆ It also has higher energy than the visible light region
- ◆ So that UV is invisible to human eyes
  
- ◆ The primary source of UV is the sun
- ◆ Sun emits not only visible light but also IR and UV
- ◆ Unlike visible light, both IR and UV are invisible to human eyes

#### 2.2 Applications of UV

- ◆ Since UV has very high frequency and energy
- ◆ Many advanced applications have been developed according to its unique features
- ◆ E.g. about  $10^{15}$  hertz to  $10^{16}$  hertz
- ◆ Examples:
  - Production of vitamin D
  - Fluorescence
  - Disinfection tools

##### **Production of vitamin D:**

- ◆ It was discovered in 1920
- ◆ One of the fat-soluble vitamins
- ◆ Precursor of vitamin D only available in fish and egg yolks
- ◆ In fact, no exact vitamin D can be found in all-natural foods

##### **How UV can help us to produce vitamin D:**

- ◆ There are three kinds of UV: UVA, UVB and UVC
- ◆ Since all UVC and about 90% of UVB are absorbed by the atmosphere, the UV reaching us is composed of about 95% UVA and about 5% UVB
- ◆ The UV that can help our body to synthesise vitamin D is UVB

#### **Production of vitamin D inside the human body:**

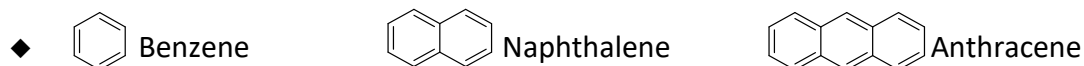
- ◆ A compound called 7-dehydrocholesterol or provitamin D<sub>3</sub> can be found in the epidermis layer of our skin
- ◆ It is a precursor for our body to synthesise vitamin D in the presence of UVB
- ◆ Once there is UVB reaches our skin, the provitamin D<sub>3</sub> will be converted to vitamin D<sub>3</sub>
- ◆ The vitamin D<sub>3</sub> produced will be transported from the skin to the liver and then to the kidney
- ◆ In the kidney, the vitamin D<sub>3</sub> will be converted to vitamin D

#### **Fluorescence:**

- ◆ Fluorescence means that an object can emit light after it absorbs a particular wavelength of light or EM radiation
- ◆ Both emitted and absorbed light could be visible or invisible depending on the wavelength
- ◆ Usually, the wavelength of the emitted light is longer than the absorbed light
- ◆ For example, an object could absorb UV radiation and then emit visible light

#### **What causes fluorescence?**

- ◆ Fluorescence occurs when there is a UV-active chemical molecule
- ◆ Although there are numerous UV-active molecules, most of them share a common functional group called the aromatic group



- ◆ These molecules/groups can absorb UV radiation (wavelength = 220 – 400 nm)
- ◆ After the UV absorption, they would emit light in the visible light region

#### **Applications of fluorescence:**

- ◆ Forensic
  - ◆ UVA (320 to 400 nm) is usually used for crime scene investigation
  - ◆ Various things such as blood, saliva, semen, wounds, and fingerprints (UV-active or potentially UV-active) can be visualised under UV light
  - ◆ A technique called fluorescence UV imaging is used for this purpose
  - ◆ A dark area is first illuminated with UV light
  - ◆ And then the fluorescence light will then be captured by using a special camera
- ◆ Laboratory use
  - ◆ Many testing and research laboratories use UV and fluorescence technology to do experiments
  - ◆ Apparatus such as UV-Vis spectroscopy, mass spectrometry and liquid chromatography use UV radiation to induce fluorescence

**UV disinfection tools:**

- ◆ It uses high energy (short wavelength) UV radiation to inactivate bacteria and viruses
- ◆ By destroying some biological materials such as DNA, RNA and proteins
- ◆ The highest energy UV, UVC (100 to 280 nm), is the most effective and commonly used
- ◆ However, UVA and B still exhibit some disinfection activities

**Why we do not use UVA and B for disinfection:**

- ◆ Both UVA and B are less effective than UVC for disinfection
- ◆ UVB is more dangerous for humans than UVC due to its high penetration power
- ◆ UVB is capable of causing DNA damage in humans, which might induce the development of skin cancer
- ◆ The disinfection power of UVA is much weaker than UVB and UVC
- ◆ While UVA is also capable of causing skin aging

**The working principle of UV disinfection:**

- ◆ UVC is used for disinfection by destroying some biological materials such as DNA, RNA and proteins
- ◆ To make them unable to harm, reproduce or replicate
- ◆ Therefore, the number of bacteria or viruses can be reduced after UV disinfection

**UV-based water purification system:**

- ◆ Main parts:
  - A tube
  - A UVC lam/LED
  - A lamp protector – Quartz sleeve
  - Water inlet and outlet

**Advantages:**

- ◆ Inactivate pathogens
- ◆ No chemicals are used for disinfection
- ◆ Do not change the smell and taste of the water
- ◆ Fast and easy-to-use

**Disadvantages:**

- ◆ Cannot remove pathogens and contaminants
- ◆ Will heat up the water
- ◆ Electricity needed

**UV disinfection box:**

- ◆ Main parts:
  - A chamber
  - A UVC lamp/LED
  - A well-designed and UV-proof case
- ◆ Since the box is not so sophisticated, we will try to make it in the later unit

**Advantages:**

- ◆ Claimed to inactivate common bacteria up to 99.99%
- ◆ No chemicals are used for disinfection
- ◆ Fast and easy-to-use

**Disadvantages:**

- ◆ Cannot remove pathogens and contaminants
- ◆ Will heat the object
- ◆ UVC can degrade some materials like plastic
- ◆ Electricity needed

**Some cautions about using UV disinfection tools:**

- ◆ Avoid direct exposure to UV, especially UVB and UVC
- ◆ UVC can degrade some materials like plastic
- ◆ Strong UVC can generate ozone, which is an irritant to our respiratory tract

### 3. References

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**UV, You and We**  
**Unit 2 – UV, You and We**

**Student Worksheet**

**1) Which of the following statements are correct?**

- (1) The frequency of radio waves is higher than that of UV
- (2) The wavelength of IR radiation is shorter than that of UV
- (3) Both UV and IR are invisible to human eyes
- (4) The energy of UVC is higher than that of UVA

- A. (1) and (2)
- B. (2) and (3)
- C. (1) and (4)
- D. (3) and (4)

**2) Which type of UV can stimulate the production of UV in the human body?**

- A. UVA
- B. UVB
- C. UVC
- D. UVD

**3) The precursor of vitamin D in the human body is:**

- A. Previtamin D
- B. Provitamin D<sub>3</sub>
- C. Previtamin D<sub>3</sub>
- D. Provitamin D<sub>2</sub>

**4) The organ that synthesises vitamin D in the human body is:**

- A. Skin
- B. Liver
- C. Kidney
- D. Lung



**5) Which of the following statements about fluorescence are correct?**

- (1) An object can emit light after it absorbs a particular wavelength of EM radiation
- (2) The emitted light must be visible
- (3) Usually, the wavelength of the emitted light is longer than that of the absorbed light
- (4) After an object absorbs visible light, it will emit UV

- A. (1) and (2)
- B. (2) and (3)
- C. (1) and (3)
- D. (2) and (4)

**6) Which chemical functional group is usually UV-active?**

- A. Hydroxy group
- B. Amino group
- C. Aromatic group
- D. Thiol group

**7) Which type of UV is the most effective one for disinfection?**

- A. UVA
- B. UVB
- C. UVC
- D. UVV

**8) Why are UVA and UVB seldom used for disinfection compared to UVC?**

- (1) Both UVA and UVB are too energetic compared with UVC
- (2) UVB is more dangerous for humans than UVC
- (3) The disinfection power of UVA is weaker than UVC
- (4) UVA and UVB do not have any disinfection power

- A. (1) and (2)
- B. (2) and (3)
- C. (1) and (3)
- D. (2) and (4)

**9) Which of the following biological materials can be destroyed by using UV:**

- (1) DNA
- (2) RNA
- (3) Protein
- (4) Water

- A. (1) and (2)
- B. (2) and (3)
- C. (1) and (2) and (3)
- D. (2) and (3) and (4)

**10) A UV-based water purification system consists of:**

- (1) Water inlet and outlet
- (2) A UVC lamp/LED
- (3) A lamp protector
- (4) A thermometer

- A. (1) only
- B. (1) and (2)
- C. (1) and (2) and (3)
- D. All of the above

**11) The disadvantages of a UV-based water purification system are:**

- (1) Would change the smell and taste of water
- (2) Cannot remove pathogens and contaminants
- (3) Would heat the water
- (4) Chemicals are used during the disinfection process

- A. (1) only
- B. (1) and (2)
- C. (2) and (3)
- D. (3) and (4)

**12) A UV disinfection box consists of:**

- (1) A chamber
- (2) A UVC lamp/LED
- (3) A UV-proof case
- (4) A UVA lamp/LED

- A. (1) and (2)
- B. (2) and (3)
- C. (1) and (2) and (3)
- D. (1) and (2) and (4)

## Unit 3 – DIY UV-box

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### 1. Introduction

In Units 1 and 2, you have been familiarised with the nature and some unique properties of EM radiation. Real-life examples such as radio, infrared temperature sensors and UV disinfection tools have also been introduced with working mechanisms and scientific knowledge. In this unit, you are provided with a chance to make EM radiation application called UV-box. This box is made of a UV lamp and an A4 paper box. However, you are required to design the structure of the box so that it would be convenient to use. The box can be used as a disinfection tool for objects such as cell phones, keys and wallets and also in the later biological and chemical experiments in Unit 4.

### 2. Summary of Unit 3 and Activity 1

#### 2.1 What is a UV-box?

- ◆ UV-box utilises UVC radiation for disinfection
- ◆ Among three types of UV, UVC is the one with the highest energy (100 to 280 nm) and is the most effective and commonly used for disinfection
- ◆ UVC is capable of affecting the chemical structures of some biological molecules such as DNA, RNA and proteins of pathogens
- ◆ Thus, to make the pathogens unable to harm humans, reproduce or replicate themselves anymore
- ◆ The main parts of a UV box:
  - A chamber
  - A UVC lamp/LED
  - A well-designed and UV-proof case

#### 2.2 Safety for using UV tools

- ◆ Avoid direct exposure to UV, especially UVB and UVC
- ◆ UVC can degrade some materials like plastic
- ◆ Strong UVC can generate ozone which is an irritant to our respiratory tract

### 3. Duration

60 minutes

### 4. Objective

To make and design a UV-box to facilitate the later experiments

### 5. Equipment

- ◆ Scissors
- ◆ Adhesive tape
- ◆ Cutter
- ◆ UV protection goggles

### 6. Materials

- ◆ UVB and UVC lamp/LED
- ◆ Jump wires/electrical wires with electrical 3-pin plugs
- ◆ Battery
- ◆ Paper cardboard or A4 size paper box
- ◆ A4 size black paper
- ◆ A4 size foam board



### 7. Procedures

1. Cut the paper cardboard according to your design or simply use the A4 size paper box
2. Cut a peephole (1.5 cm x 1.5 cm) in the middle of the upper lid of the A4 paper box

3. Cut a hole (3.5 cm x 1.5 cm) at the lateral side of the lid to connect the UV lamp with the electric wire
4. Place an A4 size black paper on the upper lid
5. Set and fix the UV lamp in the upper lid as shown
6. Place an A4 size black foam board on the lower lid
7. This is the finished DIY UV-box



## 8. Result and Discussion

- ◆ To describe the nature and function of each type of UV (B and C)
- ◆ To explain why different types of UV are used
- ◆ Performance evaluation

## 9. References

DSE Phy textbook

DSE Chem textbook

DSE Bio textbook

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## Unit 4 – UV in Laboratory

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### 1. Introduction

In order to have a comprehensive understanding of the science of EM radiation, especially UV, you will need to do three different biological and chemical experiments in this unit with the aid of your DIY UV box.

In Unit 4, you will use your UV-box to disinfect objects such as cell phones, keys or glasses. After that, a biological test called the ATP-bacterial test will be used to check the disinfection effectiveness of the UV-box. Since a UV apparatus is usually used as a viewing device to visualise any UV-active molecules, one biological experiment about gel electrophoresis and one chemical experiment about thin layer chromatography will be introduced to you in this unit. The box will be used to visualise UV-active molecules on the agarose gel and the thin layer chromatography respectively.

### 2. Activity 1

#### 2.1 ATP-Bacteria Test

- ◆ It is a test to detect the presence of adenosine triphosphate (ATP) on an object
- ◆ Since ATP is the universal energy molecule and many organisms like bacteria, yeast and mould also use it, the presence of ATP could be an indicator of the presence of them

#### 2.2 Duration

45 minutes

#### 2.3 Objective

To determine the level of bacterial cells on the surface of the target object  
To check the effectiveness of the disinfection function of the UV-box

#### 2.4 Equipment

- ◆ A luminometer
- ◆ ATP sampling swab (e.g. UltraSnap)
- ◆ A DIY UV-box from activity 1

#### 2.5 Materials

- ◆ N/A

## 2.6 Procedures

### **Sampling procedure:**

1. Take one ATP sampling swab.
2. Swab the target object for sampling (Target area should be first determined and calculated for some large objects).
3. Swab the target object in two directions, first is the parallel one and then the horizontal one.
4. Place the swab in the swab tube.

### **Measurement:**

1. Before measurement, break the Snap-Valve, which is on top of the swab bending the bulb.
2. Shake the swab for 5 – 10 seconds.
3. Make sure that the liquid from the bulb comes into contact with the swab bud while shaking
4. Insert the entire swab tube into the luminometer within 30 seconds after shaking.
5. Record the result.

### **Sweeping:**

1. Sweep the target object by using a dry tissue.
2. Conduct the ATP-bacteria test again.
3. Compare the data obtained before and after the treatment.

### **Hand gel disinfection:**

1. Apply 1 g of hand gel on the target object thoroughly.
2. Remove the gel by using tissue.
3. Conduct the ATP-bacteria test again.
4. Compare the data obtained before and after the treatment.

### **UV disinfection:**

1. Place the interesting object into the DIY UV-box.
2. Turn on the UV lamp for 10 minutes.
3. Turn off the UV lamp.
4. Take out the disinfected object.
5. Conduct the ATP-bacteria test again.
6. Compare the data obtained before and after the treatment.

## 2.7 Result and Discussion

- ◆ Rank the “cleanliness” of different selected locations or objects.
- ◆ Compare the data obtained before and after the UV disinfection.
- ◆ Evaluate the disinfection performance of the DIY UV-box.
- ◆ Performance evaluation

### 3. Activity 2

#### 3.1 Gel Electrophoresis

- ◆ It is one of the most common DNA separation techniques in biotechnology.
- ◆ Since DNA is invisible to human eyes, a UV-active dye called GelRed is used to make the DNA visible under UV.

#### 3.2 Duration

About 90 minutes

#### 3.3 Objective

To separate different DNA samples extracted from different sources.

To visualise the DNA molecules by using UV-active molecules and UV radiation.

To check the visualisation performance of the DIY UV-box.

#### 3.4 Equipment

- ◆ Agarose gel tank with the comb
- ◆ Buffer tank
- ◆ Power supply
- ◆ Auto pipettes and tips (0.1 – 10  $\mu$ L, 20 – 200  $\mu$ L)

#### 3.5 Materials

- ◆ Conical flask
- ◆ Parafilm
- ◆ Agarose powder
- ◆ TBE buffer
- ◆ GelRed
- ◆ 6x loading dye
- ◆ BenchTop 100bp DNA Ladder (ready-to-use)

#### 3.6 Procedures

##### **Sampling procedure:**

1. Add 0.2 g of agarose powder into a conical flask.
2. Add 20 ml TBE buffer to the conical flask.
3. Heat the mixture in a microwave oven until all the powder has been dissolved and the solution becomes clear.
4. Cool the agarose solution slightly under running water.
5. Add 2  $\mu$ L of GelRed to the solution and mix it well.
6. Place the comb into the casting tray and pour the agarose solution to the casting tray carefully.
7. Remove any air bubbles formed with a p200 pipet tip.



8. Wait for 25 minutes until the agarose gelled.
9. Pull out the comb carefully to form the wells.
10. Transfer the gel to a buffer chamber carefully.
11. Pour TBE buffer into the chamber until fully cover the gel.
12. Cut a piece of parafilm and add five drops of 1  $\mu\text{L}$  of DNA loading dye on it by using autopipette.
13. Mix 4  $\mu\text{L}$  of samples or negative control with the loading dye droplets slowly by pipetting the mixture up and down several times.
14. Carefully load 4  $\mu\text{L}$  of the sample mixture (with loading dye) and 1  $\mu\text{L}$  of DNA ladder into the wells as follow:

Well 1	Well 2	Well 3	Well 4	Well 5
DNA ladder	Negative control	Sample mixture	Sample mixture	Sample mixture

15. Connect the electrodes from the gel tank to the power supply.
16. Electrophorese the samples at 120 – 150 V for 25 – 40 minutes.
17. Visualise and photograph the gel under UV light.

### 3.7 Result and Discussion

- ◆ To describe how UV interacts with UV-active molecules for visualisation.
- ◆ To compare the results obtained by using the ChemiDoc™ MP Imaging System and the DIY UV-box.
- ◆ Performance evaluation

## 4. Activity 3

### 4.1 Thin Layer Chromatography

- ◆ It is one of the most common molecular separation techniques in chemistry.
- ◆ Since some molecules might bear UV-active functional groups, which can absorb UV and release visible light, the separation of the molecules could be visible under UV radiation without adding any UV-active dye.

### 4.2 Duration

About 60 minutes

### 4.3 Objective

To separate different chemical compounds according to their polarity.  
 To visualise the UV-active molecules in a reaction mixture by using TLC and UV radiation.  
 To check the visualisation performance of the DIY UV-box.

### 4.4 Equipment

- ◆ Pieces of thin-layer chromatography
- ◆ Beakers

- ◆ Petri-dishes
- ◆ Pipette fillers
- ◆ Pairs of forceps
- ◆ Round bottom flasks
- ◆ Stir bars
- ◆ Hot plates
- ◆ Condensers
- ◆ Stands and clamps
- ◆ Capillary tubes
- ◆ DIY UV-box

#### 4.5 Materials

- ◆ Hexane
- ◆ Ethyl acetate
- ◆ Salicylic acid
- ◆ Acetic anhydride
- ◆ Concentrated phosphoric acid
- ◆ Water
- ◆ Oil bath

#### 4.6 Procedures

##### **Preparation stage:**

1. Pre-cut the TLC into this dimension (5 cm x 2 cm).
2. Use a pencil to draw a line across a piece of TLC.
3. The line should be 0.5 cm away from the short edge of it.
4. Draw three spots on the line.
5. Name the spots as “S”, “M” and “P” from left to right.
6. Use a capillary tube to collect a drop of starting material, this time would be salicylic acid.
7. Put the starting material on the “S” and “M” spots on the piece of TLC.

##### **Reaction stage:**

1. Add 1.4 g of salicylic acid into a round bottom flask with a stir bar.
2. Add 3 ml of acetic anhydride into the round bottom flask.
3. Add 5 drops of concentrated  $\text{H}_3\text{PO}_4$  into the mixture.
4. Place a condenser on top of the round bottom flask.
5. Heat up the reaction mixture by using an oil bath and a hot plate for 15-30 mins hour.
6. Use a capillary tube to collect a drop of the reaction mixture in the round bottom flask.
7. Put the reaction mixture on the “M” and “P” spots on a piece of TLC (Remember to put the starting material, this time would be salicylic acid, on the “S” and “M” spots on the same piece of TLC).
8. Put the piece of TLC into a beaker with a thin layer of hexane/ethylacetate at the bottom of the beaker.
9. Cover the beaker with a lid and wait for the TLC development.

10. Once the solvent front reaches nearly the top of the piece of TLC, take it out by using a pair of forceps.
11. Place it on the table and record down the solvent front by using a pencil.
12. Wait for 1 minute.
13. Then, place it into the DIY UV-box for visualisation.
14. Repeat steps 5 to 12 for each 15 minutes.

#### 4.7 Result and Discussion

- ◆ To describe how UV interacts with UV-active molecule for visualisation.
- ◆ To check the visualisation performance of the DIY UV-box.
- ◆ Performance evaluation

## 5. References

DSE Phy textbook

DSE Chem textbook

DSE Bio textbook

[https://bio.libretexts.org/Courses/Northwest\\_University/MKBN211%3A\\_Introductory\\_Microbiology\\_\(Bezuidenhout\)/06%3A\\_Culturing\\_Microorganisms/6.03%3A\\_Culturing\\_Bacteria/6.3.04%3A\\_Aseptic\\_Technique%2C\\_Dilution%2C\\_Streaking%2C\\_and\\_Spread\\_Plates](https://bio.libretexts.org/Courses/Northwest_University/MKBN211%3A_Introductory_Microbiology_(Bezuidenhout)/06%3A_Culturing_Microorganisms/6.03%3A_Culturing_Bacteria/6.3.04%3A_Aseptic_Technique%2C_Dilution%2C_Streaking%2C_and_Spread_Plates)

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## Activity 1 – ATP-Bacteria Test Activity Report

Name: \_\_\_\_\_

### Disinfection method 1: Sweeping

Target object: \_\_\_\_\_

Swabbed area: \_\_\_\_\_

Test	1	2	3
Result before disinfection (RLU)			
Result after disinfection (RLU)			

### Disinfection method 2: Hand Gel

Target object: \_\_\_\_\_

Swabbed area: \_\_\_\_\_

Test	1	2	3
Result before disinfection (RLU)			
Result after disinfection (RLU)			

### Disinfection method 3: DIY UV-box

Target object: \_\_\_\_\_

Swabbed area: \_\_\_\_\_

Test	1	2	3
Result before disinfection (RLU)			
Result after disinfection (RLU)			

## Activity 2 – Gel Electrophoresis

### Activity Report

Name: \_\_\_\_\_

The reason why DNA molecule could be visualised under UV is:

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- The gel visualised using the ChemiDoc™ MP Imaging System:

- The gel visualised using the DIY UV-box:

### Activity 3 – Thin Layer Chromatography Activity Report

Name: \_\_\_\_\_

The reason why different molecules could be separated by using TLC is because of

\_\_\_\_\_

What should be applied on the spot “S”, “M” and “P”?

“S”: \_\_\_\_\_

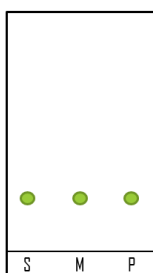
“M”: \_\_\_\_\_

“P”: \_\_\_\_\_

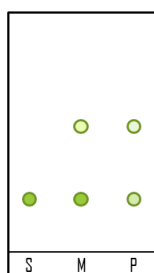


During the reaction:

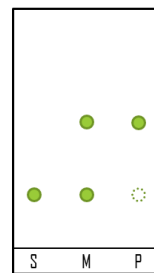
At the beginning



After 15 min



After 30 min



Try to explain the changes on the above TLC:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_