



**NIGER DELTA UNIVERSITY  
WILBERFORCE ISLAND**

**20<sup>TH</sup> INAUGURAL LECTURE  
SORPTION  
A Prodigy of Life and Living**

**By:**

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*16 Nov, 2016*

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**ISSN : 240848667**

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## **DEDICATION**

To God Almighty and all my children, grand children and great grand children, born and yet unborn

## **PROTOCOL**

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Ladies and Gentlemen

## **PREAMBLE**

With humility and gratitude to God Almighty, my creator and the master of my destiny for his unparalleled love and wisdom, I stand before you to deliver my inaugural lecture, which is the 20th in the university, the second in the Faculty of Science and the first in the Department of Chemical Sciences.

Mr. Vice Chancellor sir, I am very grateful to you for making it possible for me to deliver this lecture being an opportunity and a privilege to introduce myself as a Professor to the university community and the public.

I had a major challenge while preparing this lecture because of the abstract nature of chemistry and the phenomenon SORPTION and how to impart to the understanding of all since over seventy percent of the audience here are not chemists. For that reason, I shall endeavour to simplify my lecture as much as possible to the understanding of all.

My PhD work was on Kinetics of Phytosorption of some heavy metals by biomass of Nipa Palm (*Nypa fruticans wurmb*). Since then, I have carried out a lot of researches in Nigeria and overseas and published widely on this very useful topic. My works in this area of study have exposed me more to the importance and applications of this phenomenon called SORPTION in our lives and everyday living, hence the title of this inaugural lecture: **SORPTION - A Prodigy of Life and Living.**

Sorption is the movement of materials or molecules from one phase to another. There are two types of sorption, namely "Adsorption" and Absorption. Adsorption is a surface phenomenon whereby molecules of substance are attracted onto the surfaces of other materials while absorption takes place when the atoms or molecules are distributed uniformly in the bulk of the interaction phase (i.e. dispersed throughout the bulk of the absorbing material) (Alberty and Silbey 1992). The variation in the heats of adsorption has led to the further classification of adsorption into two types namely physic-sorption (or physical adsorption) and chemisorption (or chemical adsorption) (Jewel, 1974; Cheng and Shang 1994). In physic-sorption, weak attraction resulting from Van Der Waals, dipole forces or hydrogen bonding exist while chemisorption is characterized by formation of strong chemical bonding. Physic-sorption is not specific and takes place in any system at or moderate temperatures but chemisorption is highly specific in nature and depends on the chemical properties of both the surface molecules and the adsorbed molecules (Atkins 1978). Many solids and liquids referred to as adsorbents have the property of binding or holding molecules known as adsorbates on both their surfaces or in the bulk of their interaction phases. Adsorbent can either be solids or liquids and adsorbates can be gases, liquids, solutes (solids) based on the kind of phases that constitute the interface (Anusiem 1999).

Sorption processes may be grouped under the following classes:

1. Solid-gas
2. Solid - Solid
3. Solid-liquid
4. Liquid -liquid
5. Liquid - gas

Sorption can be interpreted using various Equilibrium, Kinetic and Thermodynamic models in addition to other analytical methods which include Transmission Electron Microscopy (TEM), Energy Dispersive X – Ray Spectroscopy (EDX or EDS), Scanning Electron Microscopy (SEM), X – Ray Fluorescence (XRF), Electron Probe Micro Analysis (EPMA), Infrared Spectroscopy (IR) and some physical parameters such as specific surface area, iodine number, ash content / volatile matter, pH, moisture content, and porosity / density. (Wankasi 2013)  
Some important models for the interpretation of sorption data are as stated below:

#### EQUILIBRIUM MODELS

##### 1.Langmuir isotherm model

$$\frac{M}{X} = \frac{1}{abc_e} + \frac{1}{b}$$

##### 2.Freundlich isotherm model

$$\ln \frac{X}{M} = \frac{1}{n} \ln C_e + \ln k$$

##### 3. BET isotherm model

$$\frac{p}{v(p_0 - p)} = \frac{c - 1}{v_m c p_0} + \frac{1}{v_m c}$$

4. Flory – Huggins isotherm model

$$\log \frac{C_e}{C_0} = \log k_a + n \log(1 - \theta)$$

5. Temkin isotherm model

$$q_e = B \ln A + B \ln C_e$$

6. Thomas model

$$\ln\left(\frac{C_0}{C_e} - 1\right) = \frac{k q_0 m}{Q} - \frac{k C_0 v}{Q}$$

7. Dubinin – Radushkevich isotherm model

$$\ln q = \ln(q_D) - \beta \varepsilon^2$$

#### KINETIC MODELS

1. Zero – order kinetic model

$$q_t = q_0 + k_0 t$$

2. First – order kinetic model

$$\ln q_t = \ln q_0 + k_1 t$$

3. Pseudo first – order (Lagergren) model

$$\log(q_e - q_t) = \log q_e \left(\frac{k_1}{2.303}\right)^t$$

4. Second – order kinetic model

$$1/q_t = \frac{1}{q_0} + k_2 t$$

5. Pseudo – second – order kinetic model

$$t/q_t = \frac{1}{h_0} + \frac{1}{q_e} t$$

6. Third – order kinetic model

$$1/q_t^2 = \frac{1}{q_0^2} + k_3 t$$

7. Intraparticle Diffusion model

$$q_t = k_d t^{0.5} + C$$

8. Elovich model

$$q_t = \frac{I \ln(\alpha\beta)}{\beta} + \frac{I \ln t}{\beta}$$

9. Hills model

$$\frac{C_t}{C_\infty} = 4 \left( \frac{D_f t}{\pi r^2} \right)^{1/2}$$

## THERMODYNAMIC MODELS

1. Suzuki model

$$\ln \theta = \ln \frac{k_0 c_0}{T^{0.5}} + \frac{Q_{ads}}{RT}$$

2. Modified Arrhenius model

$$\ln (1 - \theta) = \ln S^* + \frac{E_a}{RT}$$

3. Apparent Gibbs free energy model

$$\Delta G^0 = -RT \ln k_0$$

4. Apparent Enthalpy and Entropy model

$$\ln k_0 = \frac{\Delta S^0}{R} - \frac{\Delta H^0}{RT}$$

5. Model for Adsorption Potential

$$A = -RT \ln \frac{C_0}{C_e}$$

6. Model for Adsorption Density

$$\rho = Zr C_e \exp - \left[ \frac{\Delta G_{ads}^0}{RT} \right]$$

7. Model for Standard Affinity

$$-\Delta\mu^0 = -(\mu_f^0 - \mu_s^0) = RT \ln \frac{[D]_f}{V[D]_s}$$

8. Activation Energy of Diffusion model

$$\ln \frac{D_1}{D_2} = \frac{E^0}{R} \frac{1}{T_2} - \frac{1}{T_1}$$

Sorption has come to find wide and extensive applications in our homes, laboratories, industries and generally life and living. Some specific applications include the measurement of surface area, purification of substances, deionization of water, removal of toxic gases, chromatographic separation and analysis, refrigerators, automobiles, air conditioners, decolourisation, catalysis, agriculture, art work, medicine, general purpose eye masks and in the paper, printing, dyeing, rubber, lubrication, cleaning, petroleum/petrochemical and other industries.

### 1.1 SORPTION IN LIFE AND LIVING

Mr. Vice-Chancellor Sir, Sorption is at the core of most technology we enjoy today and that the power of sorption science is what creates an enablement that delivers the food, medicine, good

water, fabrics for clothing, health care, printing and some industrial materials and products which are hallmarks of modern life and living.

In other words, the importance of this phenomenon in our everyday life and living is indisputably very significant because the science behind disciplines like agriculture, medicine, textiles, fine arts, engineering and the likes is to a greater extent dependent on it.

Mr. Vice-Chancellor sir, permit me to enumerate the importance and applications of this prodigy "SORPTION" in our everyday life and living.

## **2.0 SORPTION IN HEALTH (MEDICAL) RELATED PROCESSES**

A proper medical care is a must or sine qua non for a healthy living. Life is meaningless or in other words humans are lifeless without good medical care. One of the basic phenomena in the health related process in humans and other organisms is sorption.

Mr. Vice-Chancellor sir, permit me to enumerate some of the medical processes that are hinged on sorption.

### **2.1 ABSORPTION IN THE ALIMENTARY CANAL**

Food may be absorbed through two channels. They are (1) the capillaries of the mucosa via the portal vein to the liver and (2) the

lacteals which is transported by the lymph to the thoracic lymphatic duct which empties into the junction of the sub-clavian and internal jugular veins. Water, salts, glucose, amino acids and some fatty acid and glycerol are absorbed into the capillaries, while the larger proportion of the products of fat digestion is absorbed into the lacteals (Watson and Royle, 1991).

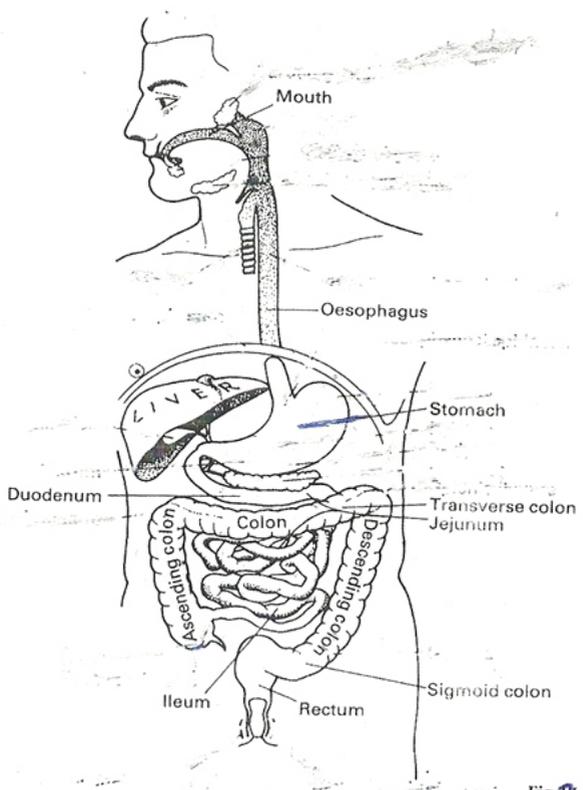


Fig 1 Structural divisions of

Fig. 2.1 Structural divisions of the alimentary canal

THE MOUTH:- No food is absorbed from the mouth but some drugs are taken into the blood through the buccal mucosa.

THE STOMACH:- There is relatively negligible absorption in the stomach but if the concentration of food is high creating a considerable gradient between the blood and the stomach, glucose, water and electrolytes may be absorbed. However, alcohol and some drugs are also absorbed from the stomach.

THE SMALL INTESTINE:- Minerals, vitamins, water, drugs, amino acids, simple sugars, fatty acids and glycerol are freely absorbed mostly in the upper part of the small intestine. The water-soluble vitamins B - complex and C are generally readily absorbed from the small intestine but the fat-soluble vitamin A, D, E and K are absorbed here if bile salts and pancreatic lipase are present.

THE COLON:- Large amounts of water are absorbed in the colon. Small amounts of glucose and salts are also absorbed by the large intestine and a number of drugs may be administered by this channel.

## 2.2 THE ROLE OF ADSORPTION (BINDING) IN FERTILIZATION

The majority of mammalian ova are covered in a layer of

granulose cells intertwined in an extra cellular membrane (ECM) that contains a high concentration of hyaluronan . When a capacitated sperm reaches the ovum, it is able to penetrate this layer with the assistance of hyaluronidase enzymes present on the surface of the sperm. Once this occurs, the sperm is capable of binding with the zona pellucida, and the acrosome reaction can occur (Albert, 2008).

### 2.3 THE ROLE IN DIABETES

Diabetes is one of the most widely misunderstood conditions because it is widespread and a life-long disease that affects the way the human body handles glucose, a kind of sugar in the blood. One of the causes of diabetes is that insulin is unable to attach or adsorb or adhere itself to the body cells and as a result the cells cannot absorb sugar. Absorption and adsorption which is sorption is key to this cause (<http://livendfeelhealthy>).

### 2.4 THE ROLE IN CANCER TREATMENT

Yttrium has a host of important applications. Over 30 isotopes of yttrium have been observed, all of which are radioactive. One of these, Y-90, a product of strontium decay is particularly effective in cancer treatment. The chemistry of this isotope enables it to bind with antibodies that seek out and bind or adsorb themselves to cancer cells, enabling the

yttrium cells to destroy them.

## 2.5 THE ROLE IN MEDICAL IMAGING

The isotope technetium-99m binds with or adsorb on cancer cells and can be detected because it emits gamma-rays. The techniques is known as IMMUNOSCINTIGRAPHY and used to study the brain, lungs, digestive system and bones. If it is combined with tin compound, technetium-99m can bind to or adsorb on red blood cells to indicate circulatory problems. It can also be used to highlight the extent of damage caused by heart attack.

Barium is a good absorber of x-rays, which is why this element is probably best known for BARIUM MEALS used in medicine to diagnose disorders of the digestive tract.

Gadolinium responds strongly to the magnetic fields generated inside a magnetic resonance imaging (MRI) scanners. Injecting a patient with a gadolinium compound formulated to be absorbed by certain part of the body, enhances the image of that body part in an MRI scan.

## 2.6 SURGICAL AND DENTAL APPLICATIONS

The element Erbium - based lasers give infrared light with a wavelength of 2.9 micrometers. This is readily absorbed by water, making it perfect for surgical and dental applications where shallow depth cut is essential.

## 2.7 THE ROLE IN RESPIRATION

Red blood cells are used by the blood to transport oxygen from the lungs, where it is absorbed from the air to the organs. It is then put to work in biochemical reactions that generate energy.

## 2.8 HERBAL MEDICAL APPLICATION

Japanese scientists have discovered that certain resinous substances or wood vinegar of some trees possess detoxifying functions. They found that the great absorbing power of certain herbs can be applied to remove toxins through the skin (osmotically) as well as for the easing of pains and swells.

## 2.9 NANOMATERIALS AND DRUG DELIVERY

Ordinarily it is difficult for drugs to move to the brain cells because of the BLOOD-BRAIN BARRIER but with the aid of nanomaterials, drugs can be delivered to the brain cells. This is possible by the sorption of these drugs by the nanomaterials and onward delivery to the brain cells.

## 2.10 THE ROLE IN UPTAKE OF ESSENTIAL MINERALS

The uptake of essential minerals into our body cells is largely dependent on the phenomenon SORPTION, as enumerated below.

**CALCIUM:-** Calcium is essential to almost all living things and forms the building blocks of the human skeleton (as calcium phosphate) and the shells of molluscs and crustaceans (as calcium carbonate).

Humans require between 1000 to 1500 milligrams of calcium daily from rich sources like dairy products, milk, chocolate, vegetables such as broccoli and cabbage, and red kidney beans. The phenomenon sorption is very important in the sustenance of calcium in the body because absorption is enhanced in the presence of sufficient supply of vitamin D which is found in fish oil, seafood, eggs and some dairy products.

**STRONTIUM:-** Strontium chloride is sometimes used in toothpastes for sensitive teeth because it forms barrier over areas of the tooth that have been exposed by gum recession. The human body absorbs strontium as though it were calcium and the two elements are very similar chemically. Dietary supplements containing strontium are sold as **BONEMAKERS** and a study carried out by the New York College of Dental Sciences using strontium as osteoblasts (bone cells) showed a marked improvement in growth. (Parsons and Dixon 2013).

### 3.0 SORPTION IN AGRICULTURE

Man needs the life of plants and other organisms for his existence. For that reason the study of life processes of plants and other organisms should be of great interest to man. The more man needs plant or animal life for his survival, the more the science behind their existence will have to be explored and developed. The essential questions like how water, gases and solutes enter plants and how food vegetative and reproductive parts are synthesized will have to be understood and answered if we have to develop these resources to support our daily life and living.

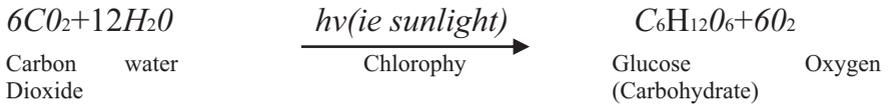
The phenomenon SORPTION is fundamental to the existence or survival of plants and animals.

Mr. Vice-Chancellor sir, permit me to state the importance of absorption and adsorption in the processes that occur in plants and animals for their growth and in turn for the survival and existence of man.

#### 3.1 ROLE OF SORPTION IN PHOTOSYNTHESIS

Photosynthesis is the single most important physico-biochemical process in the world on which the existence of life on earth depends (Pandey and Sinha, 2006). It is the oldest and most popular photochemical reaction where plant cells use their green pigments (chlorophyll) to absorb light in the visible wavelengths and use the absorbed light energy to

transform carbon dioxide and water into glucose as in the simplest equation for photosynthesis shown below (Fekarurhobo 2014).



Water is absorbed from the soil by roots of the terrestrial plants and by the general surface of hydrophytes.

The terrestrial plants absorb CO<sub>2</sub> from the atmosphere while hydrophytes obtain it from the water where it is found dissolved in, up to 0.3 percent or more (Pandey and Sinha 2006). It is the Carbohydrate and Oxygen produced by photosynthesis that directly or indirectly, the countless number of living organisms including humans depend on for their existence .

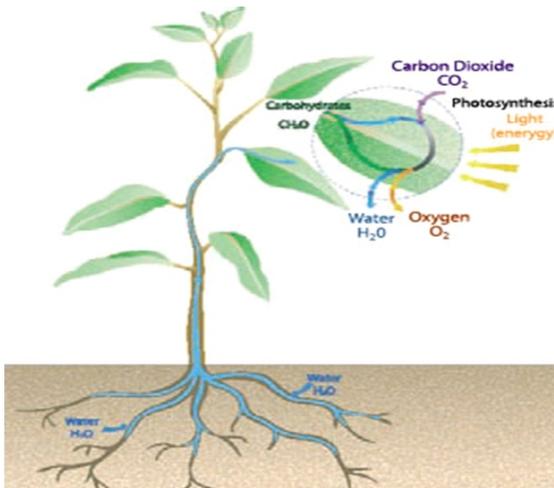


Fig 3.1 A plant

### 3.2 ABSORPTION OF WATER BY PLANTS

Water is sometimes referred to as the liquid of life or elixir of life. Infact it is essential to plant life. Water is found in different forms in the soil and plants absorb it from the soil by their roots, but the absorption of water by leaves and stem has also been found in some plants. The mechanism of water uptake through the root is by two different approaches or theories namely ACTIVE ABSORPTION and PASSIVE ABSORPTION.

Active absorption through the root is explained by the osmotic and non-osmotic theories. The Osmotic theory states that water is absorbed due to osmotic differences between soil water and cell sap. The non-osmotic theory suggested that absorption of water is an active process and occurs due to non-osmotic reasons even against diffusion pressure gradient. It requires an expenditure of energy obtained from respiration.

Passive absorption theory explains that the governing force of the absorption originates in the cells of the transpiring shoots rather than in the roots itself and the forces develop due to transpiration (Pandey and Sinha 2006).

The truth is that, the rate of water absorption is approximately equal to that of transpiration and so water is absorbed through the root and is pulled up to the transpiring surface rather than pumped into the plant by roots.

### 3.3 ABSORPTION OF MINERAL SALTS BY PLANTS

The earlier suggestions that osmotically active substances diffuse along concentration gradient from soil solution into the plant sufficiently explained the absorption of mineral salts by plants. The uptake of salts by the plants through the roots is predominantly active and not passive. The electrolytes penetrate into the plant in the form of ions with the monovalent cations such as K and Na absorbing more rapidly as compared to the divalent or polyvalent cations such as Ca and Mg. When there is an unbalanced ratio of cations and anion uptake, the plant in its cell sap, in order to maintain an equilibrium, produces organic acids resulting in more anions to balance any excess cations.

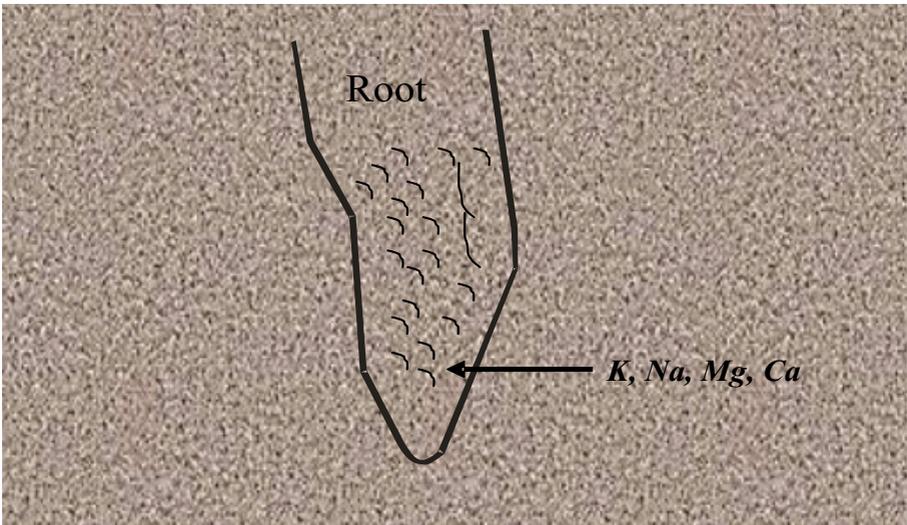


Fig 3.2 A root

**MAGNESIUM:-** Magnesium is essential for almost all living organisms and plays an important role in photosynthesis. It is the central ion of chlorophyll, the green pigment that allows plants to use light to convert carbon dioxide and water into glucose/energy and oxygen. Plants absorb magnesium from the soil. Deficiency of magnesium will result in the green leaves turning yellow-brown and red or purple patches.

Humans obtain magnesium from plants, or the animals that ingest them, and a good supply is essential for a number of key processes in the body (Parsons and Dixon, 2013).

**NITROGEN:-** Nitrogen is also an essential nutrient for plants, and most plants absorb it through their roots rather than taking it directly from air. Nitrogen from dead organisms enters the soil, much of which is then consumed and released as gas by bacteria.

### 3.4 ROLE OF SORPTION IN AQUATIC LIFE

There is constant exchange of gases between the atmosphere and hydrosphere. Most gases are soluble in water to some degree. This is evidenced by the presence of carbon dioxide as carbonic acid in rain water. The solubility of each gas is directly proportional to pressure it exerts on the water and varies greatly with water temperature. The sorped gases like oxygen and carbon dioxide sustain marine life. Fish and most

aquatic life are stifled by lack of oxygen. In other words insufficient oxygen causes death by suffocation.

Fish gills act as lungs. Fine red filaments attached to the gills arch bond contain numerous blood cells that absorb dissolved oxygen from water and give off carbon dioxide.

### 3.5 APPLICATION IN THE FISHING INDUSTRY

When sunlight heats up the shore and water surfaces of the ponds, lakes, rivers, seas etc, the oxygen is depleted along the shores and surfaces, therefore fishes and other aquatic life move to deeper water to obtain the dissolved oxygen.

At night fishes and other aquatic life are found around the shore but from mid-day, they are found in deeper waters.

Mr. Vice-Chancellor sir, this statement is corroborated by Jesus Christ in the Gospel according to St. Luke in the Bible. Luke chapter 5 verse 1 - 6 and I quote.

1. And it came to pass, that, as the people pressed upon him to hear the word of God, he stood by the lake of Gennesaret,
2. And saw two ships standing by the lake: but the fishermen were gone out of them, and were washing their nets.
3. And he entered into one of the ships, which was Simon's, and prayed him that he would thrust out a little from the land. And he sat down, and taught the people out of the ship.
4. Now when he had left speaking, he said unto Simon, Launch out into the deep, and let down your nets for a draught.
5. And Simon answering said unto him, Master, we have toiled all the night, and have taken nothing: nevertheless at thy word I will

let down the net.

6. And when they had this done, they inclosed a great multitude of fishes: and their net brake.”

## **4.0 SORPTION ENHANCED DAILY LIVING**

The application of sorption touches almost all facets of our daily living and are in the processes that enhance everyday lives.

Mr. Vice-Chancellor sir, I wish to identify some of the processes where this phenomenon is applied in our daily living.

### **4.1 NANOMATERIALS IN SOLAR CELLS**

Nanomaterials are embedded in solar cells because they have the ability to absorb the energy from the sun. The absorbed energy is then converted to electrical energy for various uses in either our homes or appliances such as calculators, wrist-watches etc.



Plate 4.1 Solar Panel

#### 4.2 SORPTION IN PRINTING

Mr. Vice-Chancellor sir, the inaugural lecture series would not have been possible without this very important phenomenon. Adsorption is the basic science that enables the ink to stick to the paper. The printing of books, posters and even writing on paper and black or white boards are made possible by this simple phenomenon.

#### 4.3 SORPTION AND BEAUTIFICATION

The various creams that are applied to our bodies and hairs can remain on the skin and hair by the principle of adsorption.

The very old dye their hairs to black and the colourful hairs worn

by our women are results of simple sorption. The painted lips and the applied colourful face powders by women are not exempted. Sorption is very well pronounced in the textile and leather industries. Various dyes owe their use to adsorption. The dyeing of clothings and leather can only be achieved if this principle is at work. The beautiful and colourful clothings, shoes and belts we put on are also results of this principle.



Plate 4.2 Old men with and without grey hair



Plate 4.3 woman with dyed hair



Plate 4.4 Women with heavy make-ups

#### 4.4 SORPTION IN PAINTING AND ARTWORK

There can be no sticking of substances on solid surfaces without adsorption and or absorption. Adsorption is therefore an essential part of the painting process. The paints on the walls of buildings or on the bodies of cars and other metals, wood or furniture is attributed to sorption. Molecules of liquid paint cling to wood, metal, plastic and other materials allowing it to dry in place. The anti-corrosion paints used on ships are protective. Most metal and solid surfaces will be unprotected if not painted or sprayed with varnishes.

Mr. Vice-Chancellor sir, can you imagine our President, Governors or even you the Vice Chancellor driving a rusty unpainted car.



Plate 4.5 Painted and unpainted buildings



Plate 4.6 Painted and unpainted - rusty car



Plate 4.7 Painted and unpainted artwork

Art work is considered to be incomplete without painting or spraying with the colourful varnishes. Sorption is key to the beautiful art works for decoration in our homes, offices and public places.

#### 4.5 SAFETYNOSEMASK

Safety nose masks are designed to protect the users from dangerous gases and fumes. They are called anti-dust, chemical or pollution masks. Absorbents are embedded in nose masks to selectively absorb poisonous gases.

The working principle of a nose mask is based on sorption. All gas masks are devices containing suitable adsorbent so that the poisonous gases present in the atmosphere are preferentially adsorbed and the air for breathing is purified.

#### 4.6 PRINCIPLE OF WATER PURIFICATION

The process of water purification based on the packing of the layers of various sizes of sand (silica) and activated carbon is completely dependent on sorption. The metallic oxides and undesirous odours from the organic matter are filtered through the sand and activated carbon beds by the principles of adsorption and absorption.

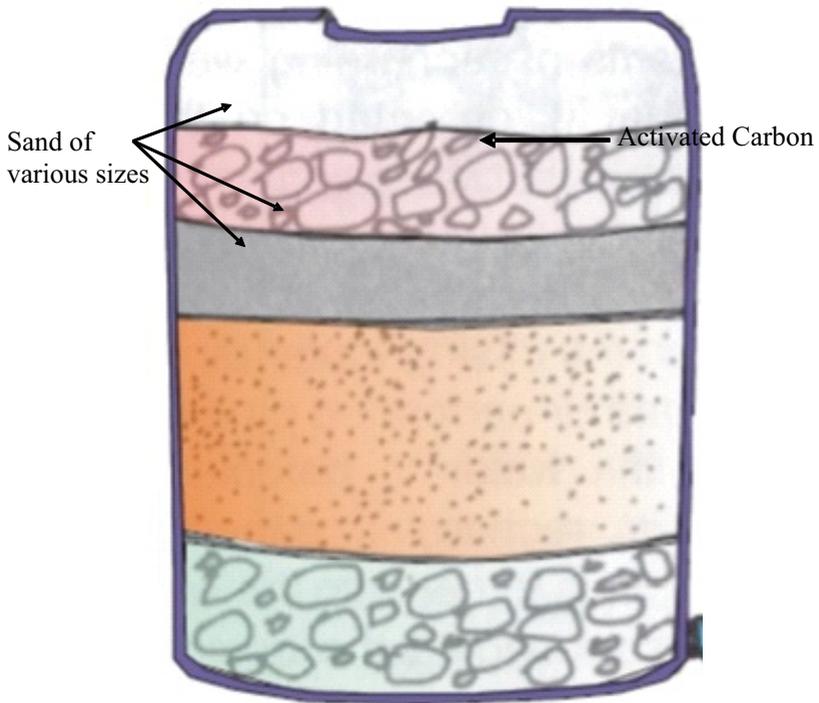


Fig 4.1 Water treatment tank

**WATER FILTER:-** The activated carbon inside a water filter adsorbs contaminants dissolved in the water, pulling them out and trapping them in the filter. It captures impurities including dissolved chemicals, bacteria and microscopic solid particles. The carbon is in powdered form, giving it an extremely large effective surface area. The large surface area gives the carbon a good chance of removing impurities. When enough water has passed through the filter, the carbon eventually becomes clogged with contaminants and the filter is then removed and replaced with a fresh one.



Plate 4.8 A water filter

#### 4.7 SORPTION IN CARPENTRY

The carpenter uses sand paper to remove the oily particles on the surface of wood to expose the pores before applying glue, paint or varnishes in order for adsorption to take place. All surfaces are covered with layers of gases, liquid or solid films. These have to be removed before the paint or varnish is applied. Adhesion is made possible with adsorption.

#### 4.8 ANALYSIS AND IDENTIFICATION OF ELEMENTS

Electrons circle the nuclei of atoms in orbits and each orbit has an extremely well-defined energy. If an electron absorbs energy, it can jump up to a higher energy level, dropping back to its original orbit a short time later. As it drops back, it emits a burst of radiation with energy exactly equal to the energy gap between the two orbits. Because the energy of radiation is directly linked to its frequency, this means that each atom gives off radiation with a very sharply defined frequency (Parsons and Dixon 2013).

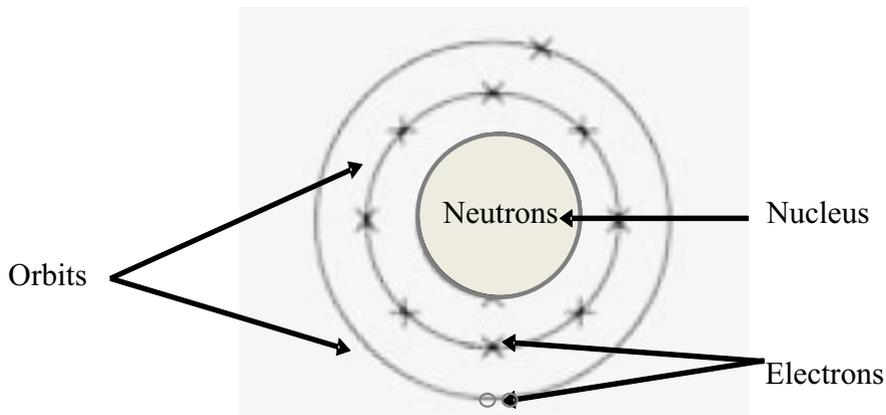


Fig. 4.2 Electronic Structure

**CHROMATOGRAPHIC ANALYSIS:-** The selective adsorption of certain substances from a solution by a particular solid adsorbent has helped to develop technique for the separation of the components of a mixture. This technique is called chromatographic analysis. In column chromatography, the long and wide vertical tube is filled with a suitable adsorbent and the solution of the mixture poured from the top and then collected one by one from the bottom. The separation is based upon the principle of competing adsorption.

#### 4.9 POWER AND LIGHTING SYSTEMS

The most commonly occurring isotopes of Einsteinium is Es-253. It is so radioactive that a gram of it gives energy at the rate of 1,000 watts. Einsteinium does not occur naturally on earth and is manufactured inside nuclear reactors. This is done by bombarding plutonium with neutrons, some of which are then absorbed by the plutonium. The irradiated nuclei then decay by beta emission to form the isotope Es-253.

Lighting engineers use the element thulium in the construction of green-coloured arc lamps. Thulium is used as coating in the bulb, where it absorbs energy from the spark inside the lamp and then re-emits it at the characteristic wavelengths corresponding to green light.

Dysprosium compounds in discharge lamps also produce very high-intensity light.

#### 4.10 SMOKE DETECTORS

Americium is a radioactive element with nineteen (19) isotopes. A typical household smoke detector contains a tiny silver of Am - 241 foil. The foil is radioactive, emitting alpha particles into a small chamber within the detector. These particles strip electrons from atoms and molecules in the air making the air electrically conductive so that a current can flow through it. If smoke particles enter the chamber, they absorb some of the alpha particle, lowering the air's conductivity and causing the alarm to sound (Parson and Dixon, 2013).

#### 4.11 CANNED AND BOTTLED DRINKS

Most gases are soluble in other liquids to some degree, and the solubility of each gas is directly proportional to pressure it exerts on the liquid (Hammer, 1975).

Nitrogen is a useful "inert" atmosphere that prevents damage caused by oxygen. For example, a piece of fruit stored in a sealed (but non-refrigerated) box of nitrogen will keep for up to two years. It forms the basis of "widges" in canned beers, which release a surge of nitrogen gas to "froth up" the beer. The human body is three percent nitrogen by

mass.

Bottle drinks such as Coca-cola and others will be very flat without the absorbed carbon dioxide and or nitrogen gases.

## 5.0 SORPTION IN INDUSTRIAL PROCESSES

Chemistry is a basic science which is applied in many industrial processes. The phenomenon SORPTION is at the centre of most of the industrial activities.

Mr Vice Chancellor Sir, Permit me to state some applications of sorption in the Industries

### 5.1 EXPLOSIVES

Nitrogen was discovered in 1772, by the British chemist, Daniel Rutherford. Nitrogen-based compounds crop up frequently in the history of explosives. **Nitroglycerine** is made by reacting nitric acid with glycerine to produce an explosive liquid detonated by impacts - invented in 1846, it was the first "high explosive".

Alfred Nobel invented dynamite in 1866 by absorbing nitroglycerine into kieselguhr - a soft powdered sedimentary rock - to create a much stable explosive. The fortune he made from dynamite funds the prizes that now bear his name. Ironically, a nitrogen-base explosive, called **azide**, has saved many lives through its use in car airbags. An accelerometer detects the impact and detonates the charge with an electrical impulse-filling the bags with gas in 25 thousandths of a second. It is estimated that between 1990 and 2000, airbags saved more than 6,000 lives in the USA alone (Parson and Dixon 2013).

## 5.2 SORPTION IN NUCLEAR REACTORS

Radioactive materials, though dangerous because of their effects and use in nuclear or atomic bombs, are useful in medical field especially radiotherapy for eradicating tumours and power generation (electricity) in addition to other applications.

Neutrons are the particles that perpetuate a nuclear reaction, thus being able to absorb them inside the reactors is crucial in order to control them. If not controlled, there will be chain reaction inside the nuclear power plant and the reaction boil over into a full-scale explosion.

Hafnium is one of the best neutron absorbers known and its principal application is in reactor control rods.

Gadolinium is another element that is an exceptional neutron absorber used to control activity in the cores of nuclear reactors.

## 5.3 INDUSTRIAL PRODUCTION OF SULPHUR

Sulphur is an economically important element because it is the raw material of sulphuric acid. This is useful in many aspects of industry, including fertilizer manufacturing, oil refining, wastewater processing and removal of rust from iron and steel and in the production of lead-acid batteries for cars. Sulphur can be found near hot spring and volcanoes as in Sicily. Large deposits of sulphur have been found in the USA, Indonesia and Japan, but most sulphur is produced by the removal of hydrogen sulphide from natural gas. The gas is run through a tower; which contains a solution of compound such as ethanalamine or zinc oxide the solution absorbs sulphur compounds from the gas as it passes through. The gas is then free of sulphur and ready for use, while the sulphur by-product is sold on for use in fertilizer.



#### 5.4 INDUSTRIAL PURIFICATION OF HYDROGEN GAS

Absorption is undoubtedly the single most important operation of gas purification process.

Palladium, a lustrous, silvery white metal has an unusual ability to store hydrogen gas. A solid chunk of the metal can absorb up to 900 times its volume in molecular hydrogen ( $H_2$ ) without any external pressure.

When a hydrogen molecule meets the surface of the palladium, it breaks into its component atoms and is able to penetrate and pass through the palladium atoms. Hydrogen atoms can also diffuse right through palladium, to recombine as  $H_2$ , which makes this a useful way of separating and purifying hydrogen.

#### 5.5 GAS DEHYDRATION

Dehydration of natural gas or light petroleum fraction is done by passing the gases through absorbers containing ethylene-glycol (mono, di or tri) mixed with slight ethanol-amines. They serve as best dehydrating agents, even comparable with lithium chloride though alumina or silica were popular adsorbents in the past (Campbell and Lawrence 1999).

Carbon dioxide is also absorbed from gases by ethanol amine or potassium carbonate.

#### 5.6 CATALYSIS

The action of certain solids as catalysts is best explained in terms of adsorption. The theory is called ADSORPTION THEORY. According to this theory, the reactants are adsorbed on the surface of the solid catalyst. As a result, the concentration of the reactants increases on the

surface and hence the rate of reaction increases. The theory is also able to explain the greater efficiency of the catalyst in the finely divided state and the action of catalyst promoters and poisons.

## **6.0 SORPTION IN PHYTOREMEDIATION**

The quality of life on earth is linked inextricably to the overall quality of the environment. The problems associated with contaminated environment now assume increasing prominence in many countries. Contaminated environment generally result from past human activities when awareness of the health and environmental effects connected with production, use and disposal of hazardous substances were less well recognized than today (Cairney, 1993). It is now widely recognized that contaminated environment is a potential threat to human health, and its continual discovery over recent years has led to international efforts to remedy many of these polluted sites. The conventional techniques used for remediation have been to dig up contaminated soil and remove it to a landfill or to cap and contain the contaminated areas of a site. These methods have some drawbacks (Vidali, 2001). Vegetation-based remediation shows potential for accumulating, immobilizing, and transforming a low level of persistent contaminants. In natural ecosystems, plants act as filters and metabolize substances generated by nature.

Phytoremediation is an emerging technology that uses plants to remove contaminants from soil and water. It is well suited for use at very large field sites where other methods of remediation are not cost effective or practicable. The term phytoremediation is relatively new, coined in

1991 (U.S. EPA 1999, U. S. EPA 2000 and Raskin and Ensley 2000).

There are five types of Phytoremediation techniques, classified based on the contaminant fate: phytoextraction (phytoaccumulation), phytotransformation, phytodegradation, phytostabilization, rhizofiltration, even if a combination of these can be found in nature (Vidali 2001).

6.1 PHYTOEXTRACTION OR PHYTOACCUMULATION is the process used by the plants to accumulate contaminants into the roots and above ground shoots or leaves. This technique saves tremendous remediation cost by accumulating low levels of contaminants from widespread area. The mass of plants and contaminants (usually metals) can be transported for disposal or recycling.

6.2 PHYTOTRANSFORMATION OR PHYTODEGRADATION:- refers to the uptake or absorption of organic contaminants from soil, sediments or water and subsequently their transformation to more stable, less toxic, or less mobile form. Metal chromium can be reduced from hexavalent to trivalent chromium, which is less mobile and non carcinogenic.

6.3 PHYTOSTABILIZATION is a technique in which plants reduce the mobility and migration of contaminated soil. Leachate constituents are adsorbed and bound into the plant structure so that they form a stable mass of plant from which the contaminant will not re-enter the environment.

6.4 PHYTODEGRADATION OR RHIZODEGRADATION is the breakdown of contaminants through the activity existing in the rhizosphere. This activity is due to the presence of proteins and enzymes produced by the plants or by soil organisms such as bacteria, yeast, and fungi. Rhizodegradation is a symbiotic relationship that has evolved between plants and microbes. Plants provide nutrients necessary for the microbes to thrive, while microbes provide a healthier soil environment.

6.5 RHIZOFILTRATION is a water remediation technique that involves the uptake of contaminants by plant roots. Rhizofiltration is used to reduce contamination in natural wetlands and estuary areas.

Notable accomplishments of these techniques include the clean-up of polluted water and land areas. Because phytoremediation seems to be a good alternative to conventional clean-up technologies research in this field is rapidly increasing.

## **7.0 MY CONTRIBUTION TO THE ADVANCEMENT OF SORPTION**

Mr. Vice-Chancellor sir, I wish to state some of my contributions to the study and applications of sorption science.

### **(i). BOOKS**

My book titled "Adsorption - A Guide to Experimental Data Analysis" was published in 2013 (ISBN: 978-30806-I-X). This book reviewed the various equilibrium, thermodynamic and kinetic models applied for the analysis of sorption experimental data.

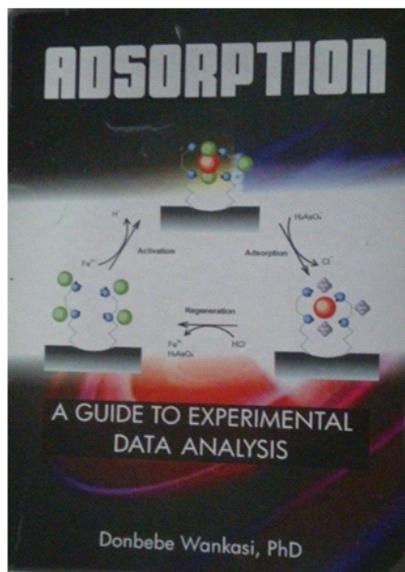


Fig 5.1. My published book

(ii). CONFERENCE AND WORKSHOPS

In addition to the numerous local conferences and workshops, I attended and delivered a lecture at the IUPAC International Conference on Chemical Research Applied to World Needs in Kuala Lumpur, Malaysia in September 2011.

I also attended and presented papers on sorption at the SACI conference in East London in December 2013.

Participated in the workshop on Grant writing skills at Stellenbosch South Africa organized by Research African in February 2014

### (iii). VISITING RESEARCH SCHOLAR

I was a visiting Research Scholar to the Vaal University of Technology in VanderbijlPark South Africa from 2013 to 2015 where a lot of researches were carried out on sorption using nanomaterials and papers published. This has led to the Vaal University of Technology in South Africa signing memorandum of understanding (MOU) for collaboration with the Niger Delta University. Some of my PhD students and other lecturers in the Department of Chemical Sciences, Niger Delta University have benefitted from this collaboration by carrying out over 60% of their research work at the Department of chemistry, Vaal University of Technology in South Africa.

### 7.1 MY RESEARCHES IN THIS AREA OF STUDY

Mr. Vice-Chancellor sir, few of my research works are summarized as follows:

(I BIOMASS:- The assessment of metal and dye binding capacities of the biomasses from plants under various experimental conditions were done. The biomasses were found to be very effective adsorbents for the removal of metal ions from aqueous solutions. The summary of publications on this adsorbent and adsorbates are as follows:-

- ✓ Wankasi et al as in "African Journal of Biotechnology Kenya 2005"
- ✓ Wankasi et al as in "Journal of Pedagogy and Education Development 2005"
- ✓ Wankasi et al as in "Chemtech Journal 2005"

- ✓ Wankasi et al as in "Journal of Nigerian Environmental Society 2005"
- ✓ Wankasi et al as in "Electronic Journal of Biotechnology, Chile 2006"
- ✓ Wankasi et al as in "Chemitech Journal 2007"
- ✓ Wankasi et al as in "Nigeria Journal of Botany 2008"
- ✓ Wankasi et al as in School Science India 2008"
- ✓ Wankasi and Tarawou as in "Journal of Applied Science and Environmental Management (JASEM) 2009
- ✓ Tarawou et al as in Journal of Environmental Science and Engineering 2010".
- ✓ Yabefa et al as in "Achives of Applied Science Research USA 2010"
- ✓ Wankasi and Dikio as in "Res. J. Chem. Environ. USA 2015"
- ✓ Wankasi and Dikio as in "Asian Journal of Chemistry"

(ii) **ACTIVATED CARBON:-** Activated carbon was found to be very effective in the adsorption of metals and dyes from aqueous solutions. The summary of some publications on this adsorbent and adsorbates are as follows:

- ✓ Tarawou et al as in "Int. J. Biol. Chem. Sci. 2010(a)"
- ✓ Tarawou et al as in "Int. J. Biol. Chem. Sci. 2010(b)"
- ✓ Tarawou et al as in "Scientia Africana, An International Journal of Pure and Applied Sciences 2011".
- ✓ Tarawou et al as in "Journal of Nepal Chemical Society Nepal

2012".

(iii) NANOMATERIALS:- Nanomaterials proved to be very good adsorbents for metal and dye solutions as in the publications below:

- ✓ Osikoya et al as in "Digest Journal of Nanomaterials Bioresource, Romania 2014"
- ✓ Osikoya et al as in "Digest Journal of Nanomaterials Romania 2015".

(iv) METAL ORGANIC FRAMEWORK (MOF) - MOF also proved to be very good for the removal of metal ions from solution as shown below:

- ✓ Shooto et al as in chem. sci. Journal 2015
- ✓ Shooto et al as in "Asian Journal of Chemistry 2016".
- ✓ Shooto et al as in Digest Journal of Nano materials and Biostructures 2016

(v) PLASTIC WASTE:- Plastic waste of various compositions, utilized for the adsorption of metals and dyes from aqueous solutions proved effective.

- ✓ Wankasi and Dikio as in "Journal of Chemistry, USA 2014(a)".
- ✓ Wankasi and Dikio as in Journal of Chemistry, USA 2014(b)".
- ✓ Wankasi and Dikio as in "Asian J. Chem. India 2014".

(vi) LAYERED DOUBLE HYDROXIDES:- These hydroxides

were extensively used to remove or adsorb metal ions and dyes from aqueous solutions. They are very effective adsorbents.

- ✓ Ayawei and Wankasi as in "Journal of Environmental and Waste Management 2015".
- ✓ Ayawei et al as in "Rasayan Journal of Chemistry 2015".
- ✓ Ayawei and Wankasi as in "International Journal of Applied Chemistry 2015".
- ✓ Ayawei et al as in "International Journal of Applied Science and Technology 2015"
- ✓ Ayawei et al as in "International Journal of Applied Environmental Science 2015."
- ✓ Ayawei et al as in "Hemijska Industrija 2015".
- ✓ Ayawei et al as in "International Journal of Chemical Sciences 2015."
- ✓ Ayawei et al as in "Open Journal of Physical Chemistry 2015".
- ✓ Ayawei et al as in "European Journal of Scientific Research 2015".
- ✓ Ayawei et al as in "International Journal of Advanced Research in Chemical Science (IJARC) 2015".
- ✓ Ayawei et al as in "American Chemical Science Journal 2015"
- ✓ Ayawei et al as in "Oriental Journal of Chemistry 2015".
- ✓ Ayawei et al as in "Asian Journal of Chemistry 2015".
- ✓ Ayawei et al as in "European Journal of Science and Engineering 2015".
- ✓ Ayawei et al as in "American Journal of Applied Chemistry USA

2015".

- ✓ Ayawei et al as in "International Journal of Advanced Chemical Science Applications 2015".
- ✓ Ayawei et al as in "Asian Journal of Applied Science 2015".
- ✓ Ayawei et al as in "International Journal of Chemistry 2015".

(vii) FLY ASH:- Assessment of the removal of various dyes from aqueous solutions using fly ash as adsorbent was done. The adsorbent was very effective.

- ✓ Ebelegi et al as in "Research Journal of Chemistry and Environment 2015".
- ✓ Ebelegi et al as in "Chemical Science Transactions 2016".

## CONCLUSION

Mr. Vice-Chancellor sir, I believe that in the course of this lecture, I have been able to expose to this audience, the power of sorption science and its potential applications in our everyday life and living.

The **IZON** translation of the acronym **NDU** mean **LIFE** and the university has been a source of life and living to so many people, both her graduates and the workers. A university without links to other universities within and outside the country is not a living one. Through my sojourn as a result of this phenomenon (**SORPTION**) the Niger Delta is signing a memorandum of understanding (**MOU**) for a collaboration with the Vaal University of Technology Vanderbijl Park in South Africa. Two of our PhD students and some lecturers in the Department of Chemical Sciences have benefitted.

Sorption is not just a prodigy of life and living to humans, organisms or plants but also to the Niger Delta University which enhances the lives of people.

Mr. Vice-Chancellor sir, there is no doubt that sorption is indeed a prodigy of life and living.

## ACKNOWLEDGMENT

Mr. Vice-Chancellor sir, I cannot end this lecture without expressing my unreserved gratitude to persons the Almighty God has utilized in building me.

I wish to specially thank my wife, *Mrs. Helen Idubamo Wankasi*, a lecturer in the Bayelsa State College of Health Technology Otuogidi and a PhD student of the North-West University in South Africa, who has always stood by me in all my struggles.

I further thank all my children especially Pereowei and Rosemary for their patience with me in my busy academic and official schedules for several years now.

I am most grateful and indebted to my supervisors during my PhD programme, *Prof. Mrs. Ayibaemi I. Spiff* and *Prof. Michael Horsfall Jnr.*, who introduced me to this very important and useful part of chemistry and built me up on it.

I am a man of many fathers and mothers and so it is my pleasure to appreciate my very senior colleagues and mentors who nurtured me. They are *Prof. W A. L. Izonfuo*, *Prof. C. N. Ndiokwere*, *Prof. K. D. Alagoa*, *Prof. B. L. Nyananyo*, *Prof. A. A. Abia*, *Prof. D. Zibokere*, *Prof. M. S. Akanni*, *Prof. D. A. Okorie*, *Prof.(Mrs.) O. Tawari*, *Prof. G. S. K. Fekarurhobo*, *Prof. S. Agoro*, *Prof. A. Olu-obi*, *Prof. K. K.*

*Imananagha, Prof. T. T. Asuka, Prof. T. T. Epidi, and Prof. A. Akaranta.*

Please permit me to sincerely acknowledge the first PhD and MSc graduates of the Niger Delta University *Dr. Nimibofa Ayawei* and *Mr. Augustus N. Ebelegi* respectively, whom I supervised.

I am sincerely grateful to all my colleagues and staff of the Faculty of science especially the Faculty officer *Ukie Youdubagha* for their understanding while I was the Head of Department and now the Dean of the Faculty.

I also express immense gratitude to all who have made tremendous contributions to my life to date especially *Prof. Ezekiel Dikio*, *Mr. Francis Ugo my Father In-law* and *Dr. S. S. Angaye* who was the Acting Head of Department when I was first employed at the Rivers State college of Education now Ignatius Ajuru University of Education Port Harcourt.

I lost my father at the early stage of my academic career, specifically at primary three. I was then picked up by my elder brother, *Mr. Martin Wankasi* who loved education and trained us, but died a year before myself and his first son obtained our PhD degrees. His first son *Dr. Mieebi M. Wankasi* is the acting Head of Department of Medical Laboratory science in this university. My Elder brother would have been very proud of producing the first Professor in Seibokorogha (Sabagreia) Town if he was alive.

May his soul rest in peace.

**Vice-Chancellor, Principal officers, Members of the Governing Council, Distinguished Staff and Students of our Great University, Ladies and Gentle men.**

**THANKS FOR LISTENING AND GOD BLESS YOU ALL**

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### **CITATION ON PROF. DONBEBE SOLOMON WANKASI**

Prof. Donbebe Solomon Wankasi was born on February 1, 1963 to the families of Late Wankasi Solomon Siaidongha of Tamuburudani compound, Sabagreia and Late Mrs. Rebecca Wankasi (nee Egbe) of Ayakoroama town, Opokuma all in Kolokuma /Opokuma L.G.A. of Bayelsa State.

He attended St. Peter's State School Sabagreia (1971 – 1974), St. Andrew's State School Diobu, Port Harcourt (1974 – 1976), Government Secondary School Asoama (1976 – 1981) and was appointed the Senior Prefect from 1980 – 1981, and also the best student in the West Africa School Certificate Examinations at that school in 1981.

He worked briefly with then Post and Telecommunications (P&T) and was sent to the P&T training school Oshodi, Lagos in 1982. He left the P&T in 1982 when he gained admission to the University of Port Harcourt to study Applied Chemistry.

He graduated in 1986 and had his mandatory National Youth Service at Anambra State College of Education (1986 – 1987). He went back to the University of Port Harcourt after the National Youth Service to pursue a Masters Degree in Pure and Industrial Chemistry in 1987 and graduated in 1989.

He taught briefly at Army day Secondary School, Bori camp, Port Harcourt and left for the Nigerian Stored Products Research

Institute (NISPRI) in Kano under the Federal Ministry of Science and Technology and worked as a Research Officer and Head of Department of the pesticide and chemistry section (1990 – 1992). He joined the services of the Rivers State College of Education, Port Harcourt as an Assistant Lecturer in 1992 and moved up to the rank of Lecturer I. Within the thirteen (13) years of his service period in the Rivers State College of Education, he gained admission to the University of Port Harcourt for PhD in Industrial Chemistry and completed it in 2005.

He transferred his service to the Niger Delta University in April 2005. He was promoted to the rank of Senior Lecturer in 2006 and was appointed the Acting Head of Department of Chemical Sciences the same year.

He was promoted to the rank of a Reader in Industrial Chemistry in 2011 and was eventually promoted to the rank of Professor of industrial Chemistry in 2014.

Having served as the Head of Department of Chemical Sciences for nine (9) years, he was appointed the Dean of the faculty of Science in February 2015.

He is a member of Senate of the Niger Delta University and was elected in 2015 as a Senate Representative to the Governing Council, a position he is still holding.

Prof. Donbebe Solomon Wankasi, in addition to the numerous

local conferences and workshops, attended and delivered a lecture at the IUPAC International Conference on Chemical Research Applied to World needs at Kuala Lumpur, Malaysia in September 2011.

He also attended and presented papers on sorption at the SACI Conference in East London in December 2013. He participated in the Workshop on “Grant Writing Skills” at Stellenbosch, South Africa, organized by Research Africa in February 2014.

Prof. Donbebe Solomon Wankasi was a visiting Research Scholar to the Vaal University of Technology in Vanderbijipark, South Africa from 2013 to 2015.

He was instrumental to the Vaal University of Technology, South Africa signing Memorandum of Understanding (MOU) for collaboration with the Niger Delta University.

Prof. Donbebe Solomon Wankasi has supervised the academic researches of many students which includes the first PhD graduate of the Niger Delta University, Dr. Nimibofa Ayawei. He has published in so many local and international journals and a book titled “Adsorption: A guide to experimental data analysis”. He was listed in the 7<sup>th</sup> edition of the MARQUIS WHO'S WHO in science and engineering, USA published in June 2004.

He is an active member of the Chemical Society of Nigeria (CSN)

Polymer Institution of Nigeria and Institute of Chartered Chemists of Nigeria (ICCON). He is also a member of the Clover Club of Nigeria (CCN) and the LITERATI Club of Britain, as a result of his scholarly publications with Emerald publishers in Britain.

His other contributions to the university and community service include:

**Diocesan Coordinator**

Anglican Communion Brigade

Diocese of Niger Delta West, Yenagoa, Bayelsa State

**Patron**

Boys Brigade, Diocese of Northern Izon

**Member**

Senate Committee on Curriculum and Instruction

2008/2009 Academic Session to date

Niger Delta University, Wilberforce Island, Bayelsa State

**Chairman LOC**

45<sup>th</sup> Annual Conference of Science Association of Nigeria

NDU 2010, 23<sup>rd</sup> – 27<sup>th</sup> May 2010

**INEC Collation / Returning Officer**

Southern Ijaw, Nembe and Brass LGAs during the 2011 General Election conducted by the Independent National Electoral Commission

Prof. Donbebe Solomon Wankasi is a Christian and happily married to Mrs. Helen Idubamo Wankasi and blessed with children.

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