UNIVERSITY OF PORT HARCOURT

MAN, MATERIALS AND CIVILIZATION

An Inaugural Lecture

By

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DEDICATION

This inaugural lecture is dedicated to my uncle, Mr. Innocent Emeka Oforka, who saw me through Secondary School.

ACKNOWLEDGEMENT

My gratitude goes to God Almighty, the giver of life and all good things on earth. He has been granting me all that I request. Thank you Father.

My sincere gratitude goes to the Vice-Chancellor, Professor J.A. Ajienka and all the principal officers of the University, for this opportunity to give an inaugural lecture even though it is quite late.

My heartfelt thanks go to my uncle, Mr. Innocent Emeka Oforka, who sponsored my Secondary education. He insisted, “If it is not Christ the King College Onitsha (C.K.C) or Government College Umuahia, no Secondary School education for you”. I found myself in C.K.C.

I am grateful to all my Teachers in both the Primary and Secondary Schools. The foundation they laid gave rise to a solid building. I am proud of all of you. My Lecturers at the University level are hereby appreciated. They made Chemistry very easy for me. What they gave me; I am now giving back to the younger ones.

I wish to express my gratitude to the University of Port Harcourt for the Staff Development Programme that took me to Sheffield, England. I will never forget Prof. Francis Onofeghara (retired), the former Dean of School of Chemical Sciences, who approved Chemical Metallurgy as my area of specialization.

My sincere thanks go to my colleagues in the department of Pure and Industrial Chemistry. Our departmental board meetings sound as if we are in a parliament meeting. The arguments do not affect our relationships. Few minutes after, we are joking and smiling back to our offices.

My special gratitude goes to Prof. A.C.I. Anusiem, my “boss” for many years. Prof Anusiem will walk into my Lectures and sit at the back. Those spontaneous checks kept me on my toes, and gave him the confidence to allow me be part of the team, teaching year one general Chemistry courses. I was still learning to teach these courses even as a professor, till he retired in 2011.

I must appreciate the efforts of professor B.E. Okoli, the former Dean of Science in starting off my professorial promotion journey. The prima facie was done at the University of Calabar. He presented the submission from the Faculty to the Central A & PC. the submission scaled through and the University Council was dissolved.

At the time another council was constituted, we had a new Vice-Chancellor and a new Dean in the Faculty of Science. The submission was represented by the new Dean, Professor C.M. Ojinnaka. His photocopies of the external Assessors reports enabled me to be invited to the professorial interview.

I will not forget the former Vice-Chancellor Professor Don Baridan, who permitted the use of the photocopies. Thank you Sir.

I extend my heartfelt thanks to Professor Don Baridan and the University Council for the assistance given to me to travel to India for medical treatment. Our Father in heaven will reward you all.

MAN, MATERIALS, AND CIVILIZATION

By

PROFESSOR N. C. OFORKA

PROTOCOL

The Pro-Chancellor, Sir
The Vice-Chancellor,
Members of the Governing Council,
Deputy Vice-Chancellors,
Principal Officers of the University,
Provost, College of Health Science
Dean of School of Graduate Studies,
Deans of Faculty,
Distinguished Professors and Scholars,
Heads of Department,
Staff and Students of Unique Uniport,
Distinguished Guests,
Ladies and Gentlemen.

PREAMBLE

Inaugural Lecture Series is supposed to provide a platform to showcase and celebrate University of Port Harcourt's new professors. The individual lecture represents a significant milestone in an academic's career, providing official recognition of their promotion to professors, bringing benefits to the Lecturers and the Department. The lecture provides an opportunity to present an overview of the Lecturer's research career so far, update colleagues on current and future research plans.

1.0 INTRODUCTION

Mr. Vice-Chancellor Sir,

I see myself as a Material Chemist. After obtaining a B.Sc degree in Chemistry, I proceeded to the University of Sheffield, England for my Post Graduate Studies in Chemical Metallurgy under the Staff Development Program of this University.

At Sheffield, arriving with a Chemistry degree, I was asked to do a Post Graduate Diploma in Metallurgy as a conversion course. In June 1980, I came out of this program with 78 percent average which exempted me from the M.Sc class. I went in for a straight PhD program.

My Research topic was, Phase Equilibria and Thermodynamics of Aluminium-Chromium-Nickel Ternary Alloys at 1423K. The search for Aluminide coatings for nuclear plant components necessitated the need for this research. The literature review revealed that the phase equilibria of the binary alloys Ni-Cr, Al-Cr and Al-Ni were well established (Hansen and Anderko, 1958; Elliot, 1965 and Shank, 1969). No single phase diagram of the ternary system, Al-Cr-Ni existed in the literature.

Phase diagrams are used to record information concerning phase changes in alloys. All properly constructed phase diagrams record the phase relationships only as they occur under conditions of equilibrium. There is lack of information on the phase equilibria of Al-Cr-Ni alloys. This lead to the investigation of the system at 1423K. The Al-Cr-Ni is important in gas turbines, superalloy protection and aluminide coatings.

1.1 PREPARATION OF THE ALLOYS:

The alloys were made from 99.99% pure Al obtained from British Aluminium Company, carbonyl Ni was bought from Rowlands of Dronfield UK. The alloys were made by melting the metals together in a small vacuum furnace in an atmosphere of argon and chill cast into ingots approximately 25mm in diameter and 150mm long. The composition of the alloys was determined by chemical analysis. Carbon and metallic trace elements were not present at levels in excess of 0.01%. A portion of each ingot was cut off and used for optical metallography of the as-cast condition. Another portion of each ingot was sealed under a partial argon atmosphere in a silica tube, homogenized for one week at 1423 ± 3K and quenched in water. The homogenized alloys were used in this study.

1.2 PHASE IDENTIFICATION:

The ternary alloys were etched in a mixture of glycerol (33 parts), acetic acid (33 parts) and concentrated hydrofluoric acid (1 part). The Nickel rich binary samples were etched in a mixture of copper (II) sulphate (25grams), concentrated sulphuric acid (12.5cm^3) and water (250cm^3). The Cr-rich binary alloys were etched in a mixture of 60ml hydrochloric acid, 20ml concentrated nitric acid and 20ml of 1M iron (III) chloride solution. The microstructures were then examined in a metallurgical microscope.

The phases observed in these samples were identified by X-ray diffraction. X-ray diffractometry was carried out on bulk samples using Cukα radiation. Electron microprobe analysis was carried out on a Cambridge microscans microanalyser to determine the composition of the identified phases. Chemical analysis of the selected single phase alloys gave results which agreed with microprobe data to within ± 1%. The microanalysis of two-phase alloys gave results that agreed with the existing phase diagram data to within 1%.

An isothermal section at 1423K was determined for Al-Cr-Ni system in the composition range 10-50 at % Al. (fig 1).

The following phases are involved in the phase equilibria: γ-Ni, γ'(Ni_3Al); β(NiAl); α-Cr and γ_I(Cr_5Al_8). The existence of a ternary intermediate phase in the system was not observed. The binary intermediate phases γ', β and γ have substantial ranges of solid solubility within the ternary system. (Oforka and Haworth, 1987).

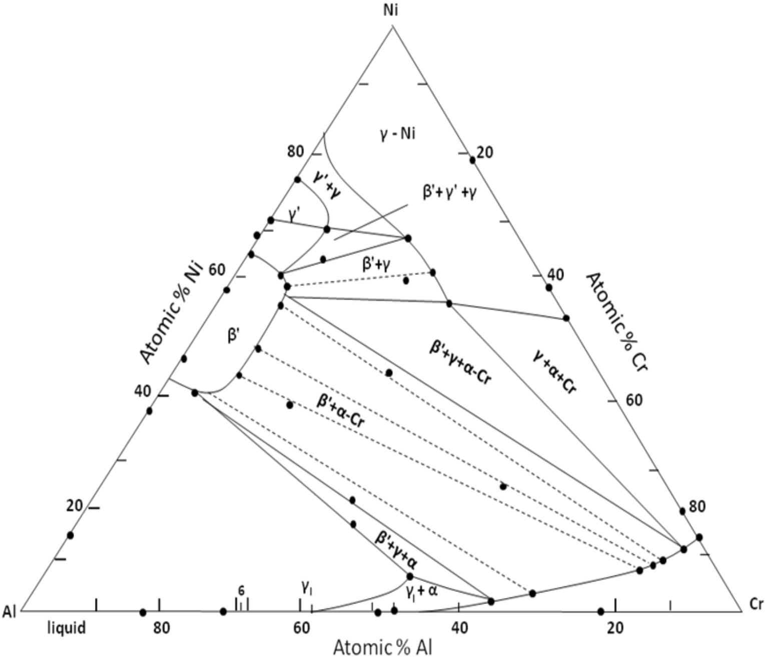

Fig 1: Isothermal section of Al-Cr-Ni system at 1423K of alloy composition and experimental points.

1.3 THERMODYNAMICS OF AL-CR-NI ALLOYS:

The second segment of my PhD work was the determination of the thermodynamic properties of the Al-Cr-Ni ternary alloys. In alloy development, selection and usage, phase equilibria and thermodynamic studies are very vital. Importance of these alloys in gas turbines, superalloy protection and aluminide coatings had been discussed. The addition of a third element to a binary system will improve the properties utilized in the above applications, namely mechanical strength, high temperature oxidation and corrosion resistance. The thermodynamic properties are also important for calculation of phase diagrams of metallic systems. The phase equilibria and thermodynamic properties of the binary and ternary systems must be known.

The phase equilibria of the binary systems were well established but thermodynamic information was quite scanty. But the research was only on the thermodynamics of Al-Cr-Ni ternary system at 1423K.

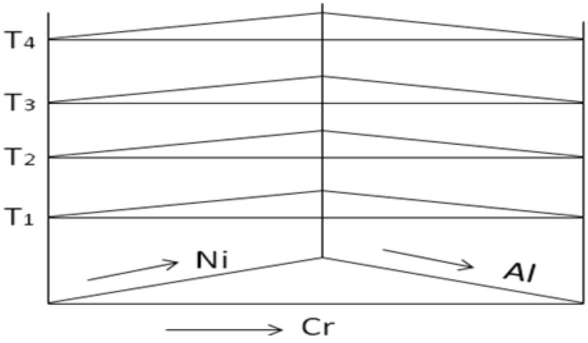

Fig. 2: intended isothermal sections for Al-Cr-Ni ternary alloys.

Construction of the phase diagram of Al-Cr-Ni system is possible if we know the phase equilibria and thermodynamic properties of the system at various temperatures (isothermal sections). (Fig. 2).

The thermodynamic properties of the Al-Cr-Ni system at 1423K were successfully concluded. In determining these data, the VG micromass 70-70 Knudson cell mass spectrometer was used. Its main advantage is the high resolution which can be achieved with detection limits as slow as 10^{-8} torr.

The measurement of the partial pressure (P_i) of a component i, of an alloy and (P_i^o) of the pure component leads to the determination of the activity (a_i) of component i as the ratio of the two partial pressures (Eqn. 1)

$$a_i = P_i / P_i^o \ldots\ldots\ldots \quad (1)$$

In the Knudson cell mass spectrometric technique, the partial pressure of the species is related to the intensity of the species by (Eqn.2)

$$P_i = K.I_i^+T\ldots\ldots\ldots\ldots \quad (2)$$

Where K is a constant and contains all instrumental and geometrical factors, I_i^+ is the intensity of the species i (counts per second) and T the absolute temperature at which the measurement is made. The measurements were repeated at various temperatures and the results of least-square fits to standardized intensities in the form of Eqn. (3) were used to calculate intensities at 1423K.

$$In(IT) = A+B/T\ldots\ldots\ldots\ldots \quad (3)$$

In Eqn. (3), I is the intensity, T is the absolute temperature, A and B are constants. The ratio of the intensity of specie in an alloy to that in pure standard gives the activity of that specie. The standards used were pure solid nickel, pure solid chromium and liquid aluminium. The activities determined were treated to get the partial and excess partial molar quantities. The partial molar free energy change for the species i when dissolved in a solvent is given by Eqn. (4).

$$\overline{\Delta G_i} = RTIna_i \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Where R is the gas constant, T is the absolute temperature and a_i is the activity of that component. The deviation of a partial component from its value in an ideal solution is the excess partial quantity and is given by Eqn. (5).

$$\overline{\Delta G}_i^{ex} = \overline{\Delta G}_i - \overline{\Delta G}^{id}$$

$$= RT\text{In}a_i - RT\text{In}X_i = RT\text{In}\gamma_i \ldots\ldots\ldots\ldots\ldots (5)$$

Where $\overline{\Delta G}_i^{ex}$ is the excess partial free energy of mixing, $\Delta G_i^{\mathbf{id}}$ is the ideal partial free energy of mixing, γ_i is the activity coefficient of $_i$ (=a_i / x_i) and x_i is the concentration of component i (in mole fraction).

The calculated activity data can also be used to compute the integral Gibbs free energy (ΔG) and integral excess free energy (ΔG_i^{ex}) of mixing according to the following relationships

$\Delta G = RT\ [X_A\text{In}a_A + X_B\text{In}a_B]$ for a binary alloy A-B.

$\Delta G_i^{ex} = RT\ [X_A\text{In}\gamma_A + X_B\text{In}\gamma_B]$.

1.4 STABILITY OF THE PHASES:

The integral free energies of mixing (ΔG) of the nickel-chromium-aluminium alloys indicate a strong negative deviation from the ideal conditions. The ΔG values showed that β'(NiAl) phase is a highly ordered phase and the stability is attributed to this. γ-Ni is less stable than either β'(NiAl) or γ'(Ni_3Al) phase. α-Cr phase is the least stable of the phases identified in the nickel-chromium-aluminium alloys.

1.5 THE BINARY SYSTEMS:

The thermodynamic properties of the chromium-nickel, aluminium-chromium and aluminium-nickel solid and liquid alloys were investigated and results published in good journals. After the devaluation of the naira during Babangida regime, it became impossible to travel to Sheffield to continue with this kind of research.

The following facilities are needed.

1. Vacuum furnaces.

2. Metallography laboratory for grinding, polishing and etching of metal surfaces.
3. X-ray diffractometer
4. Electron probe microanalyser (used a Cambridge microscan 5 microanalyser)

My dream to produce a phase diagram of a ternary system died a natural death due to lack of facilities.

1.6 RESEARCH INTEREST:

This necessitated a shift in my research interest and in order to remain afloat in the system, we tried liquid-liquid extraction of some metals using pyralozone derivatives as ligands. Luckily we had a PhD student who investigated some of the targets we set in the area. Prof. Martin Ogwuegbu was the student. We also tried our hands in recycling of metallic waste. Another PhD student worked in this area. Dr. Fergusson, H. Tobins was the student. We investigated the recovery of metal values from Jos tin slag. Tantalum and Niobium were recovered from this slag.

We finally embraced Corrosion Inhibition Studies. Three PhD graduates were produced, namely Dr. O.K. Abiola, Dr. (Mrs.) K.O. Orubite and Dr. (Mrs.) A.O. James.

2.0 CORROSION INHIBITION STUDIES:

It is a common knowledge that everything on the surface of the earth degrades. Even we the humans, our stable state is the dust we were made from. We must all return to dust. The balance diet and excellent medication can be regarded as the materials that retard the rate of our returning to dust (Kinetics). Those good things delay the rate of our return to mother earth.

Materials deteriorate more especially metallic materials, due to a chemical or electrochemical reaction with its environment. This is called corrosion. Corrosion is extractive metallurgy in reverse.

$$Fe_2O_3 \underset{\text{Corrosion}}{\overset{\text{Energy}}{\rightleftharpoons}} Fe \text{ (pure)}$$

Non-metal products like plastics may swell or crack, wood may split or decay, granite may erode and portland cement may leach away. Corrosion is restricted to chemical attack of metals. Rusting applies to the corrosion of iron or iron-base alloys, with formation of corrosion products consisting largely of hydrated ferric oxide, $Fe_2O_3.H_2O$. Non-ferrous materials like zinc (Zn), copper (Cu) and chromium (Cr) corrode but do not rust. Rusting is corrosion but corrosion is not rusting.

Pure metals and alloys react chemically/ electrochemically with corrosive medium to form a stable compound, in which the loss of metal occurs. The compound so formed is called corrosion product and metal surface becomes corroded. Corrosion involves the movement of metal ions into the solution at active areas (anode), passage of electrons from the metal to the acceptor at less active areas (cathode), an ionic current in the solution and an electronic current in the metal.

The cathode process requires the presence of an electron acceptor such as oxygen or oxidizing agents or hydrogen ions. Corrosion can be minimized by suitable strategies which in turn stifle, retard or completely stop the anodic or cathodic reactions or both.

2.1 COST OF CORROSION:

Corrosion has a negative impact on the economy. In fact corrosion costs society in three distinct ways.

(a) It is extremely expensive, financially.

(b) It is extremely wasteful of natural resources at a time of increased concern over damage to the environment.

(c) It causes considerable inconveniences to human beings and sometimes loss of life.

In 1997, NEPA recorded 21 failed transformers in Warri alone. This was due to stress corrosion cracking. NEPA had to fund a ₦5 billion scheme to replace worn-out equipment in order to boost power supply. Towards the end of 1997 the Federal Airport Authority of Nigeria (FAAN) spent ₦9.3 billion on navigational and landing aids, which had become obsolete and needed replacements.

In 1994, the Nigerian Breweries earmarked over ₦2 billion and Nestle Foods PLC, over ₦500 million for anti-corrosion gadgets installation. Investigations have shown that the total annual costs of floods, hurricanes, tornadoes, fires, lightning and earthquakes are less than the cost of corrosion (Kamma, 2006).

Studies in a number of Countries have attempted to determine the national cost of Corrosion. The most extensive of these studies was the one carried out in the United States in 1976, which found that the overall annual cost of metallic corrosion to the U.S economy was $70 billion or 4.2% of the gross national product. To get a feeling for the seriousness of this loss, we may compare it to another economy impact everyone in America is worried about-the importation of foreign crude oil which cost $45 billion in 1977. The United States Federal Highway Administration (FAWA) released a two year study conducted in 1999 and ending in 2001, and found the total cost of corrosion was $276 billion corresponding to a nearly 3.1 percent of GDP.

Recent years have seen an increasing use of metal prosthetic devices in the human body, such as pins, plates, hip joints, pacemakers and other implants. New alloys and better techniques of implantation have been developed, but corrosion continues to create problems. Examples include failures through broken connections in pacemakers, inflammation caused by corrosion products in the tissue around implants and fracture of weight-bearing prosthetic devices. An example of the latter is the use of metallic hip joints, which can alleviate some of the problem of arthritic hips.

Mr. Vice-Chancellor, Sir, corrosion has many serious economic, health, safety and cultural consequences to our Society and must be controlled or minimized. We have made modest contributions in the department in the area of corrosion inhibition studies.

2.2 ORGANIC CORROSION INHIBITORS:

We have studied the use of 1-Phenyl-3-MethylPyrazol-5-one as a corrosion inhibitor against the corrosion of mild steel in trioxonitrate (v) acid (Omo-Odudu and Oforka 1999), alpha brass in acidic media (Tobins et al, 2003) and mild steel in hydrochloric acid solution (Abiola and Oforka 2002).

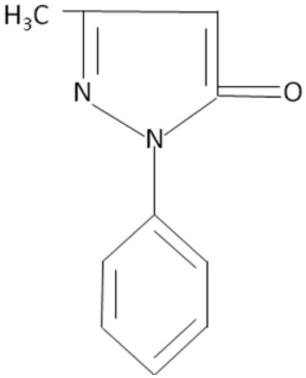

Fig.3: structure of 1-phenyl-3-methylpyrazol-5-one.

The inhibition of corrosion of mild steel in hydrochloric acid by (4-Amino-2-methyl-5-pyrimidinylmethylthio) acetic acid and 3-[4-amino-2-methyl]-4-methylthiazolium chloride hydrochloride. Thiamine chloride or Vitamin B_1, was studied (Abiola and Oforka 2002).

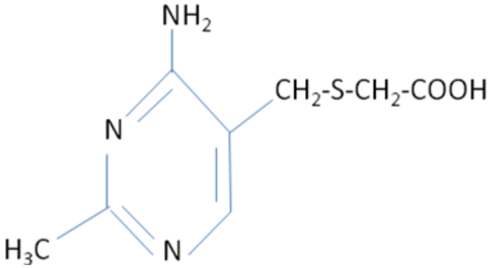

Fig.4: (4-Amino-2-methyl-5-pyrimidinyl methylthio) acetic acid

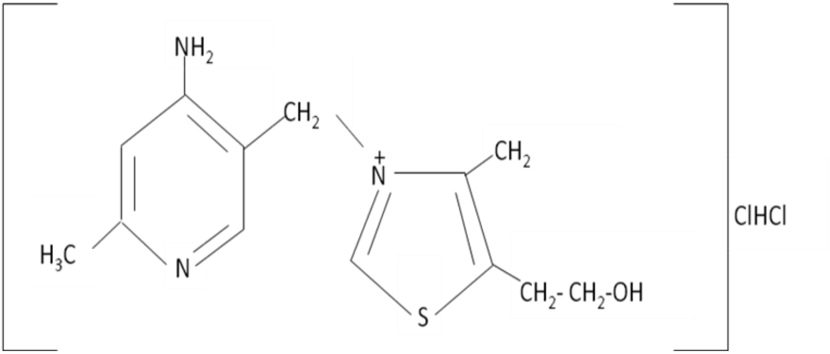

Fig. 5: 3-[4-amino-2methyl-5-pyrimidinylmethyl]-5-[2-hydroxyethyl]-4-methylthiazolium chloride hydrochloride. Thiamine chloride or Vitamin B_1

The following general statements can be made from the Literature dealing with inhibition of steel and aluminium in acid environment.

- Several N- O and S- containing organic compounds have been used as corrosion inhibitors for steel and aluminium in acid environment.
- The corrosion inhibition is a surface process which involves the specific adsorption of the organic compounds on the metal surface.
- The inhibition efficiency of organic compounds depends on chemical structure and mode of interaction with metal surface.

2.3 NATURAL PRODUCTS AS CORROSION INHIBITORS:

The use of inhibitors for the control of corrosion of metals and alloys which are in contact with aggressive environment is an acceptable practice. Large numbers of organic compounds were studied and being studied to investigate their corrosion inhibition potentials. All these studies reveal that organic compounds especially those with N, S and O showed significant inhibition efficiency. But unfortunately most of these compounds are not only expensive but also toxic to living beings.

There is the need for cheap, safe inhibitors of corrosion. Plant extracts have become important as an environmentally acceptable, readily available and renewable source for wide range of inhibitors. Some investigations have in recent years been made, into corrosive characteristic of some plant extracts including their leaves and tubers, and also into their corrosive inhibitive properties. Specifically in some areas, the inhibitive effect of some plants’ solution extract has been attributed to the presence of tannins, alkaloids and flavonoids in their chemical constituents.

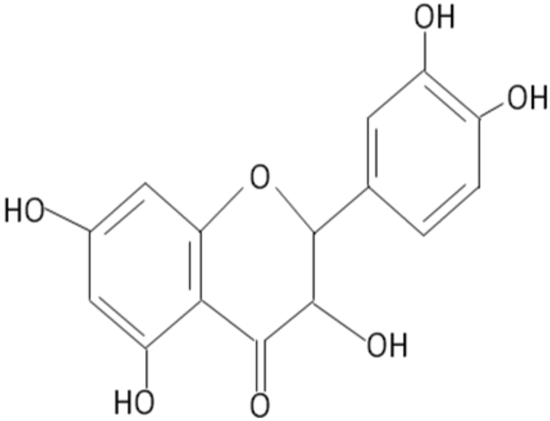

Fig. 6: Structure of flavonoid

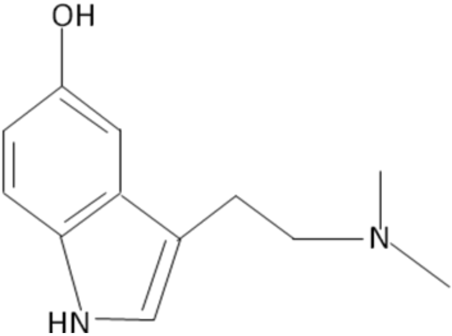

Fig. 7: The structure of Bufotenin, an Alkaloid

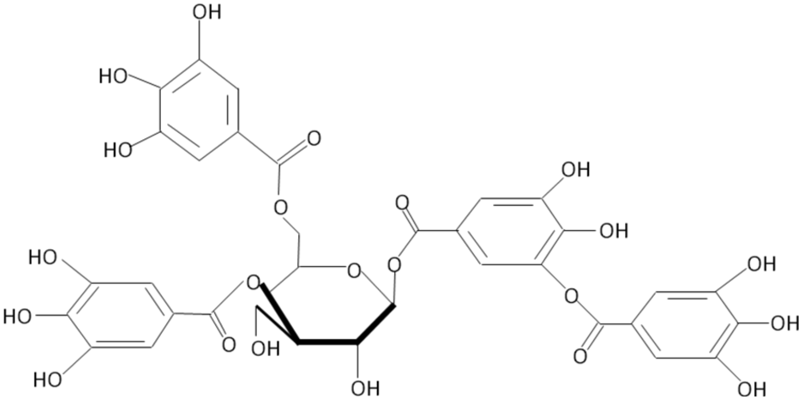

Fig. 8: The structure of tannic acid, a tannin

Infact the bitter taste in plant's barks or leaves has been attributed to the presence of tannins. We investigated the inhibitive action of <u>*Cocos*</u> <u>*nucifera*</u> juice in 5% hydrochloric acid solution (Abiola and Oforka, 2003).

The work showed that the inhibition of corrosion by the additive, retarded the dissolution of mild steel to an extent depending on the concentration of the additive.

The inhibition of the corrosion of mild steel in hydrochloric acid solutions by the extracts of leaves of <u>*Nypa fruiticans*</u> Wurmb was investigated in our laboratory (Orubite and Oforka, 2004). We did not remain in this area for long due to some problems. There is no Oil Company that will agree to inject a plant extract into the oil pipes. The Companies tend to use specific inhibitors that the constituents are known.

The recent trend of reporting the plant extracts as corrosion inhibitors has one main drawback. The pytochemical investigation is rarely carried out on the extract and efforts are seldom made to pinpoint the active ingredient present in the plant extract.

It is likely that a mixture of constituents present may potentiate the inhibitive effect of one particular constituent. But it is still amazing to see reports wherein inhibition to the extent of 98% efficiency is achieved. It is certain that natural compounds emerge out as effective inhibitors of corrosion in the coming years due to their biodegradability, easy availability, and non-toxic nature. Careful perusal of the literature clearly reveals that the era of green inhibitors has already begun.

2.4 INHIBITION EFFICIENCY

The performance of any inhibitor is assessed by calculating the inhibition efficiency. This calculation depends on the methodology used in studying the corrosion inhibition reaction.

The inhibition efficiency (%) of any inhibitor was determined using the equation:

$$\% I.E = \left[1 - \frac{w_1}{w_2}\right] \times \frac{100}{1} \quad \text{.........} \quad (6)$$

For weight loss technique, W_1 and W_2 are the weight losses of the metallic materials inhibited and uninhibited solution.

For the thermometric method, the inhibition efficiency (%I.E) was calculated from the percentage reduction in the reaction number (RN):

$$\% I.E = \frac{RN_{aq} - RN_{wi}}{RN_{aq}} \times \frac{100}{1} \quad \text{..........} \quad (7)$$

Where RN_{aq} is the reaction number of aqueous acid in the presence of the inhibitor and RN_{wi} is the reaction number without inhibitor (i.e blank).

(i.e. blank). The reaction number (RN) is defined as:

$$RN\ ({}^{o}Cmin^{-1}) = \frac{Tm - Tt}{t} \quad .... (8)$$

Where Tm and Ti are the maximum and the initial temperatures respectively and t is the duration time (min).

In the hydrogen evolution technique, inhibition efficiency was calculated using:

$$\%\, I.E = \left[1 - \frac{V_{t^i}}{V_{t^0}}\right] \times \frac{100}{1} .... \quad (9$$

Where Vt^i is the volume of hydrogen evolved at time 't' for inhibited solution and Vt^0 that for uninhibited solution.

Our observations in most of these corrosion inhibition studies revealed that the inhibitors studied, exhibited high inhibition efficiencies at room temperature. At higher temperatures, the inhibition failed. This simply means that we are still searching for the ideal inhibitor that will work at both low and high temperatures. We think that organic inhibitors with high molecular mass may be the answer. This choice has its own demerits. One of them is insolubility of the large molecules in water. Two PhD students at the moment are synthesizing and characterizing these large molecular additives. The works are still ongoing and we may not discuss them further.

3.0 MAN, MATERIALS AND CIVILIZATION

At the dawn of history, the only materials used by humans were taken directly from natural sources. Stones were used to erect crude shelters or structures; harder stones with cutting edges were used for arrowheads and spear points and for tools for cutting wood, bones and leather.

Clay was shaped into containers and bricks for building. The discovery that firing these clay items made them stronger and water resistant was probably the first step in a long procession of the adaptation of natural materials to the needs and uses of humanity. However humans' creativity and ingenuity were limited by the properties of the available materials.

Materials are all about us, they are engraved in our culture and thinking as well as in our very existence. Infact, materials have been so intimately related to the emergence and ascent of man that they have given names to the Stone, Bronze and Iron Ages of civilization. Naturally-occurring and man-made materials have become such an integral part of our lives that we often take them for granted, and yet materials rank with food, living space, energy, and information as basic resources of mankind. Materials are indeed the working substance of our society; they play a crucial role not only in our way of life but also in the well-being and security of nations.

3.1 WHAT ARE MATERIALS?

Materials are, of course, a part of matter in the Universe, but more specifically they are substances whose properties make them useful in structures, machines, devices or products. Today, humans make use of literally thousands of materials that are derived from nature, but they also use many more synthetic materials that do not come directly from natural sources.

All these amazing developments have come about because of increasing knowledge and understanding of the properties of materials. In the late 1800s we began to understand the arrangement of atoms and crystal structures and their behavior in various conditions. Today our knowledge and understanding of materials make it possible to develop and design materials to meet property requirements; challenging our creativity and ingenuity even further.

3.2 CLASSES OF MATERIALS

- Metals and nonmetals
- Ceramics and glasses
- Composites
- Plastics
- Elastomers
- Biomaterials
- Nanomaterials
- Semi-conductors
- Superconductors
- Thin films

These are the families materials can be divided into. Each of these families has properties that are different from those of the others, related primarily to how their atoms are bonded.

3.2.1 METALS AND NONMETALS

A metal must have some of the following properties:

1. Ability to donate electrons to form a positive ion
2. Crystalline structures
3. High thermal and electrical conductivity
4. Ability to be deformed plastically
5. Metallic luster or reflectivity.

Although metallic elements are more numerous and fulfill many requirements, plastics, rubber and other synthetic products are produced for the most part, from nonmetals. Some nonmetals such as carbon, germanium and silicon resemble metals in one way or another and are called metalloids.

They can have a metallic luster and crystalline microstructure, and they can be semi-conductors of electricity, but they cannot be deformed without fracturing because they are brittle, as are many nonmetals. The growth in solid-state electronic components has largely been based on the metalloids germanium and silicon.

When metals cool from the molten state and solidify, they generally form a crystalline structure called a space lattice. But metals can now be cooled rapidly from the liquid to the solid state so that there is no opportunity for a crystal structure to develop. These products are appropriately called **amorphous metals.**

Since it has very good electrical and magnetic properties amorphous metal is useful for making transformer cores.

Solidification of Metals:

During the solidification of a molten metal its atoms must form into the space lattice for that metal. The heat removal process is such that it requires the atoms to solidify in a three-dimensional treelike form called a dendrite (after the Greek word for a tree)

Plate 1: solidification of low-carbon steel, showing Dentritic growth

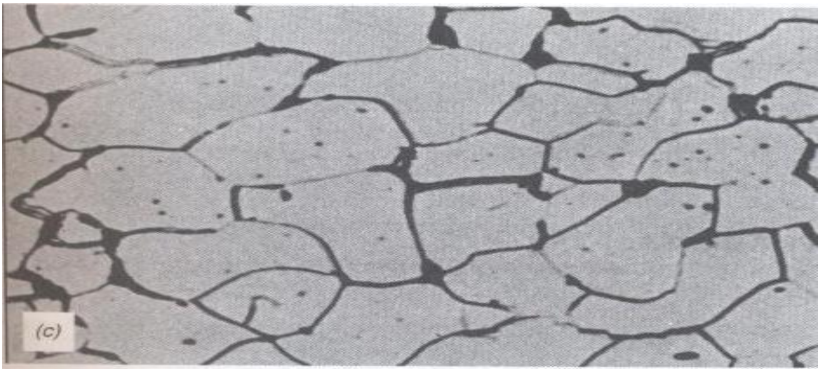

Plate 2: Annealed low-carbon steel exhibiting ferrite microstructure.

The above cast structures need to be refined through heat treatments to improve the physical and chemical properties of the metallic material.

3.2.2 CERAMICS AND GLASSES:

Bonding in ceramics and glasses are using covalent and ionic-covalent types with SiO_2 (silica or sand) as a fundamental building block. Ceramics are soft as clays and as hard as stones and concrete. Usually they are crystalline in form. Most glasses contain a metal oxide fused with silica. At high temperatures used to prepare glass, the material is a viscous liquid. The structure of glass forms into an amorphous state upon cooling.

Windowpanes and eyeglasses are important examples. Fibers of glass are often also available. Diamond and carbon in its graphite form are considered to be ceramics. Engineering ceramics are known for their stiffness, high temperature and stability under compression and electrical stress. Alumina and silicon carbide and tungsten carbide are made from a fine of their constituents in a process of sintering with a binder.

Chemical vapor deposition can place a film of ceramic on another material. Cements are ceramic particles containing some metals. The wear resistance of tools is derived from cemented carbide with the metal phase of cobalt and nickel typically added to modify properties.

3.2.3 COMPOSITE MATERIALS

Composite materials are structured materials composed of two or more macroscopic phases. Applications range from structural elements such as steel-reinforced concrete to the thermally insulative tiles, which play a key and integral role in NASA's space shuttle thermal protection system, which is used to protect the surface of the shuttle from the heat of re-entry into the earth's atmosphere.

One example is reinforced carbon-carbon (RCC), the light gray material which withstands re-entry temperature up to 1510^{o}C (2750^{o}F) and protects the space shuttle's wing leading edges and nose cap. RCC is a laminated composite material made from graphite rayon cloth and impregnated with furfural alcohol to carbon. In order to provide oxidation resistance for reuse capability, the outer layers of RCC are converted to silicon carbide. Other examples can be seen in the "plastic casings" of television sets, cell-phones and so on. These plastic casings are usually composite material made up of a thermoplastic matrix such as acrylonitrile-butadiene styrene (ABS) in which calcium carbonate chalk, talc, glass fibres or carbon fibres have been added for added strength, bulk or electrostatic dispersion. These additions may be referred to as reinforcing fibres, or dispersants depending on the purpose.

3.2.4 PLASTICS/POLYMERS

Polymers are the raw materials (the resins) used to make what we commonly call plastics. Plastics are really the final products, created after one or more polymers or additives have been added to a resin during processing, which is then shaped into a final form. Polymers which have been around and which are in current widespread use include polyethylene, polypropylene, polyvinyl chloride (PVC), polystyrene, nylons, polyesters, acrylics, polyurethane and polycarbonates.

Plastics are generally classified as: **Specialty and Engineering plastics.**

PVC is widely used, inexpensive and annual production quantities are large. It lends itself to an incredible array of applications from artificial leather to electrical insulation and cabling, packaging and containers.

The versatility of PVC is due to the wide range of plasticizer and other additives that it accepts.

The term “additive” in polymer science refers to the chemicals and compounds added to the polymer base to modify its material properties. Polycarbonates would be normally considered as engineering plastics. Engineering plastics are valued for their superior strengths and other special material. They are usually not used for disposable applications unlike commodity plastics. Specialty plastics are materials with unique characteristics, such as ultra high strength, electrical conductivity, electro-fluorescence, high thermal stability etc.

The dividing line between the various types of plastics is not based on material but rather on their properties and their applications. For instance, polyethylene (PE) is a clear low friction polymer commonly used to make disposable shopping bags and trash bags, and is considered a commodity plastic, whereas medium-density polyethylene (MDPE) is used for underground gas and water pipes and another variety called ultra-high molecular weight polyethylene (UHMWPE), is an engineering plastic which is used extensively as the glide rails for industrial equipment and the low friction socket in the implanted hip joints.

3.2.5 METAL ALLOYS

Of all the metallic alloys of today, the alloys of iron (steel, stainless steel, cast iron, tool steel, alloy steels) make up the largest proportion both by quantity and commercial value, iron alloyed with various proportions of carbon gives low, mid and high carbon steels.

An iron carbon alloy is only considered steel if the carbon level is between 0.01% and 2.00%. For the steels, the hardness and tensile strength of the steel is related to the amount of carbon present, with increasing carbon levels also leading to lower ductility and toughness. Heat treatment process such as quenching and tempering can significantly change these properties. However, cast iron is defined as iron-carbon with more than 2.00% but less than 6.67% carbon. Stainless steel is defined as a regular steel alloy with greater than 10% by weight alloying content of chromium, nickel and molybdenum.

Other significant metallic alloys are those of aluminium, titanium, copper and magnesium, copper alloys have been known for a long time (since the Bronze Age), while the alloys of the other three have been relatively recently developed.

The alloys of aluminium, titanium and magnesium are also known and valued for their high strength-to-weight ratios and, in the case of magnesium, their ability to provide electromagnetic shielding. These materials are ideal for situations where high strength-to-weight ratios are more important than bulk cost, such as in the aerospace industry and certain engineering applications.

4.0 MATERIAL INDUSTRIES

As manufacturing organizations formed and grew during the Industrial Revolution, the various job functions within the organization became increasingly specialized, leading to the multilevel structure of today's manufacturing companies.

Manufacturing industries make up a large portion of total business and are the places of employment for a large segment of the labour force. There are many types of manufacturing industries, ranging in size from one- or two-person businesses to major corporations employing several hundred thousand employees. Material manufacturing Industries, like Iron and Steel and Petrochemical Industries are necessary for our economy.

4.1 IRON AND STEEL INDUSTRY

It was a beautiful decision to establish two steel companies in the Country, Delta Steel Company, Aladja and Ajaokuta Steel Company in the 1980s.

The Ajaokuta Steel Company uses the Blast Furnace method of Iron extraction. If that company is being planned today, the environmental activists may block its take-off. The raw materials for the blast furnace include coke, calcium carbonate, $CaCO_3$ which is calcined to get calcium oxide, CaO. The remaining raw materials are Iron ore and air.

All the sulphur found in extracted Iron, comes from coke and the burning of coke will yield the oxides of carbon (CO and CO_2) and sulphur dioxide SO_2. SO_2 escaping into the atmosphere will eventually cause acid rain. The carbon monoxide, CO is the reducing agent in the blast furnace and not coke. It is impossible thermodynamically for coke to reduce iron oxide, Fe_2O_3. The blast furnace is a reducing reactor and impurity like phosphorus, P cannot be removed, since it needs an oxidizing environment to remove P from liquid Iron.

Phosphorus comes from the Iron Ore. The Iron Ore that has 0.07 percent P is a good ore. The Iron Ore with higher levels of P, is a bad ore. Since the P cannot be removed in a reducing reactor, it ends up in the extracted liquid iron. If such a material is used to construct any structure, structural failure is envisaged. Phosphorus easily precipitates on the grain boundary of a material, which can lead to fracture.

Delta Steel Company, Aladja uses a more modern extraction method, the direct reduction method using natural gas.

4.2 PROBLEMS WITH THE IRON AND STEEL INDUSTRY

The Nigerian Iron and Steel Sector has produced more millionaires than tons of steel. Iron Ore, which is one of the important raw materials, is locally sourced. In the country there are over 19 locations with iron ore deposits mostly in the North.

Why are some of these deposits not being developed? The Itakpe iron ore that is being used has only 15.65% Fe (total). The amount of silica SiO_2 in the ore is 44.0% almost 3x total iron. After beneficiation, the amount of iron in the concentrated ore will appreciate a bit. This quantity was not given in Table 1.0. What factors led to the selection of Itakpe iron ore? The only factor one can think of is the low phosphorus in the iron ore.

Table 1.0: Chemical Characteristics of Central Nigeria Banded Iron Ores.

S/N	Deposit	SiO_2 (%)	Al_2O_3 (%)	P_2O_5 (%)	S (%)	FeO (%)	Fe (%)	% Fe (concentration)
1	Itakpe	44.0	9.6	0.18	0.05	2.25	15.65	-
2	Ajabanako	36.0	3.5	0.07	0.05	2.50	37.7	65
3	Ochokochoko	45.6	6.4	0.007	0.08	11.9	33.5	NA
4	Agbdo Okudu	35.0	0.4	Trace	0.03	1.90	40.0	64
5	Agbaja Patti	8.55	1.0	0.9-1.5	-	-	47.8	52.1

NA = Not Available.

Source: Federal Ministry of Mines and Steel Development.

Iron Ore deposit at Ajabanako in the same State as Itakpe (Kogi) has 37.7% total Fe and up to 65% Fe after concentration. Some deposits in the far North have higher Iron ore content than Itakpe. Birnin Gwari/Jaruwa deposit in Bernin Gwari LGA of Kaduna State has about 70% Fe in the Iron Ore with high phosphorus content. Lamba Iron Ore in Darazo LGA of Bauchi State contains 75% Iron. (Federal Ministry of Mines and Steel Development). We are yet to produce flat sheets needed for making car bodies.

4.3 PETROCHEMICALS:

Chemicals made from crude oil, natural gas, and liquefied natural gas are the basic raw materials for many of the synthetic fibers, sealants, paints, synthetic rubbers, plastics and other products. These products are typically polymers that are made from small molecules called monomers. These are the building blocks of these synthetic materials. By the process called catalytic cracking, heat is used to induce a chemical reaction in the crude with the help of catalysts, usually composed of refractory oxides of aluminium, silicon and magnesium.

High temperature-boiling components of petroleum are broken down into gasoline and oils. The remaining gaseous material is made up of compounds having from one to four carbon atoms. Among these are ethylene, propylene and the butylenes. Natural gas, from which the liquefied gases butane and propane are derived, is also a source of propylene, ethylene, hydrogen and methane obtained by means of the process of thermal cracking Acetylene gas, made from the hydration of calcium carbide, is also a source of plastic and rubbery materials.

Most acetylene gas is now produced from methane rather than from calcium carbide. Chloroprene and polychloroprene (neoprene) are derived from acetylene.

Nitrogen fertilizers made from natural gas and pesticides made from other petrochemicals are both vital to food production. About 60% of the fibers used for clothing are synthetic and are mostly based on petrochemicals; exceptions are rayon, acetate and acetic anhydride.

Many of today's medicines are derivatives of petrochemicals. Examples are antihistamines, antibiotics, penicillin and aspirin. Automobiles use plastic gears and body parts; our homes have synthetic materials in such things as carpets, heating and cooling systems, furnishings and housewares.

5.0 NEW MATERIALS:

The constant research into nature of materials is yielding some fascinating results. Apart from the discovery of nanomaterials, a future novel magnetic, superconducting material has just been discovered.

5.1 SUPERCONDUCTING MATERIAL:

Scientists have reached a crucial milestone that could lead to a new class of materials with useful electronic properties, in a research reported in the September 5, 2011 issue of Nature Physics. The team sandwiched two nonmagnetic insulators together and discovered a startling result. The layer where the two materials met has both magnetic and superconducting regions-two properties that normally cannot coexist.

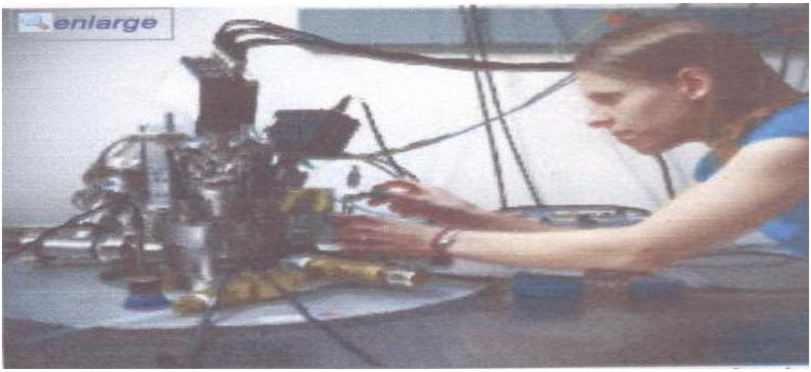

Plate 3: Julie Bert adjusting the imaging equipment

Technology have long hoped to find a way to engineer magnetism in this class of materials, called complex oxides, as a first step in developing a potential new form of computing memory for storage and processing. The finding was made by Julie Bert and her colleagues at the Stanford Institute for Materials and Energy Science (SIMES).

5.2 NANOMATERIALS

Nanomaterials generally fall into two categories, fullerenes and inorganic nanoparticles. Fullerenes are a class of allotropes of carbon which conceptually are graphene sheets rolled into tubes or spheres. These include the carbon nanotubes (or silicon nanotubes) which are of interest both because of their mechanical strength and also because of their electrical properties.

In April 2003, fullerenes were under study for potential medicinal uses, binding specific antibodies to the structure of resistant bacteria and even target certain types of cancer cells such as melanoma. The October 2005 issue of Chemistry and Biology contains an article describing the use of fullerenes as light-activated antimicrobial agents. In the field of nanotechnology, heat resistance and superconductivity are among the properties attracting intense research.

A common method used to produce fullerenes is to send a large current between two nearby graphite electrodes in an inert atmosphere. The resulting carbon plasma arc between the electrodes cools into sooty residue from which fullerenes can be isolated.

6.0 CONCLUSION

This inaugural lecture is an attempt to convince non-scientists in this hall, that this field of science not only has had an impact on civilization but is the engine that drives today’s world. Materials which are the stuff of existence have shaped events, ushered in eras and precipitated revolutions. From the age of stone to the era of high-technology, materials have made our world, with its skyscrapers and jumbo jets.

The comfort of man on earth is assured in materials. At the end of the day’s work one thinks of a good night rest on a bed made of material (wood). There is the urge to clean ones body when the day breaks and plastic bucket is handy. One brushes the teeth using a ceramic or a glass cup. The breakfast is served in a ceramic plate or plastic plate. One leaves the house built with materials and enters a car made of materials to drive to work. Materials have indeed shaped our world.

REFERENCES

1. HANSEN AND ANDERKO R. (1958). CONSTITUTION OF BINARY ALLOYS 2ND ED, MCGRAW-HILL, NEW YORK.
2. SHANK F.A. (1969). CONSTITUTION OF BINARY ALLOYS 2ND SUPPLEMENT MCGRAW-HILL, N.Y.
3. ELLIOT R.P. (1965). CONSTITUTION OF BINARY ALLOYS 2ND SUPPLEMENT MCGRAW-HILL, N.Y.
4. **OFORKA, N.C.** (MARCH 1986). THERMODYNAMICS OF ALUMINIUM-CHROMIUM SYSTEM AT 1423K, INDIAN JOURN. OF CHEMISTRY, VOL. 25A, 263-265.
5. **OFORKA, N.C.** (NOV. 1986). THERMODYNAMICS OF ALUMINIUM NICKEL ALLOYS, INDIAN JOURN. OF CHEMISTRY, VOL. 25A, 1027-1029.
6. **OFORKA, N.C.** (JUNE 1987). THERMODYNAMICS OF CHROMIUM-NICKEL ALLOYS TRANSACTIONS OF THE INDIAN INSTITUTE OF METALLURGY, VOL. 40, NO. 3, 235-239.
7. **OFORKA, N.C.** AND C.W. HARWORTH (1987). PHASE EQUILIBRIA OF THE Al-Cr-Ni SYSTEM AT 1423K, SCANDINAVIA JOURN. OF METALLURGY, V16, 184-188.
8. **OFORKA, N.C.** (1988). THERMODYNAMIC OF LIQUID CHROMIUM NICKEL ALLOYS, NIG. JOURN. OF BASIC AND APPLIED SCIENCES, NO. 12, 23-30.
9. **OFORKA, N.C.** (1990). THERMODYNAMIC PROPERTIES OF LIQUID ALUMINIUM-NICKEL ALLOYS, IFE JOURN. OF TECHNOLOGY, VOL. 7, NO. 2, 19-22.
10. OGWUEGBU, M.O.C.; **N.C. OFORKA,** AND A.I. SPIFF (1992). KINETIC STUDIES ON THE SOLVENT

EXTRACTION OF IRON (III) FROM AQUEOUS SOLUTION WITH 1-PHENYL-3-METHYL-4- (P-NITROBENZOYL) PYRAZOL-5- ONE DISSOLVED IN CHLOROFORM: RATE OF BACKWARD EXTRACTION, JOURN. OF NAT. SCIENCE COUNCIL, SRI LANKA, 20 (2), 301-308.

11. OGWUEGBU, M.O.C.; **N.C. OFORKA,** AND A.I. SPIFF (1992). KINETIC STUDIES ON THE SOLVENT EXTRACTION OF IRON (III) FROM AQUEOUS SOLUTION WITH 1-PHENYL-3-METHYL-4- (P-NITROBENZOYL) PYRAZOL-5- ONE DISSOLVED IN CHLOROFORM: RATE OF FORWARD EXTRACTION, INDIAN JOURN. OF CHEMISTRY, VOL. 31A, 981-983.
12. OGWUEGBU, M.O.C.; **N.C. OFORKA** (1994). SOLVENT EXTRACTION SEPARATION STUDIES OF IRON (III), COBALT (II), NICKEL (II) AND COPPER (II) FROM AQUEOUSSOLUTION WITH 1-PHENYL-3-METHYL-4- (P-NITROBENZOYL) 5-PYRAZOLONE, HYDROMETALLURGY, 34, 359-367.
13. OGWUEGBU, M.O.C.; **N.C. OFORKA,** AND A.I. SPIFF (JUNE 1994). SOLVENT EXTRACTION OF IRON (III) WITH 1-PHENYL-3-METHYL-4- (P-NITROBENZOYL) PYRAZOL-5- ONE, DISCOVERY AND INNOVATION, VOL. 5, NO. 2, 158-161.
14. OGWUEGBU, M.O.C.; **N.C. OFORKA,** AND A.I. SPIFF (1995). ENHANCED EXTRACTION OF NICKEL (II) WITH 1-PHENYL-3-METHYL-4- (P-NITROBENZOYL) PYRAZOL-5- ONE IN THE PRESENCE OF BENZYL ALCOHOL, S-AFR TYDSKR.CHEM, 49(1/2), 26-30.
15. TOBINS, F.H. AND **N.C. OFORKA,** (1999). RECOVERY OF TITANIUM FROM TIN SLAG

WASTE BY CHLORINATION, J. APPL. SCI. ENVIRON. MGT., VOL. 2, NO. 1, 25-38.

16. OMO-ODUDU, D.U. AND **N.C. OFORKA** (1999). INHIBITION OF THE CORROSION OF MILD STEEL IN TRIOXONITRATE (V) ACID MEDIUM NIG. JOURN. OF PHYS. VOL. 11, 148-153
17. NEELY AND BERTONE (2000). PRACTICAL METALLURGY AND MATERIALS OF INDUSTRY, 5TH ED, PRENTICE HALL INC.
18. TOBINS, F.H. AND **N.C. OFORKA** (SEPT. 2000). RECOVERY OF METAL VALUES FROM JOS TIN SLAG USING NAOH., GLOBAL JOURNAL OF PURE AND APPLIED SCIENCES, VOL, 6, NO. 4; 691- 696.
19. TOBINS, F.H. AND **N.C. OFORKA** (2000), THE RECOVERY OF TIN FROM TINPLATED CANS BY CHLORINATION, NIG. JOURN. OF ENGR. MGT. VOL. 1, NO. 4, 49-52
20. DUKHIN, A.S. AND GOESTZ, P.J. (2002). ULTRASOUND FOR CHARACTERIZING COLLOIDS ELSEVIER.
21. ABIOLA, O.K. AND **N.C. OFORKA** (2003). INHIBITION OF THE CORROSION OF MILD STEEL IN HYDROCHLORIC ACID BY (4-AMINO-2-METHYL-5-PYRIMIDINY METHYLTHIO) ACETIC ACID AND ITS PRECUSOR, THE JOURN. OF CORROSION SCIENC AND ENGINEERING, VOLUME 3 PAPERS 21. 1-10 http:/www/umist.ac.uk/corrosion/JCSE.
22. ABIOLA, O.K. AND **OFORKA, N.C.** (2003). CORROSION INHIBITION EFFECT OF COCO-NUCIFERA JUICE ON MILD STEEL IN 5% HYDROCHLORIC AND SOLUTION, SCIENTIA AFRICANA, VOL. 1(2) 1-10.

23. ABIOLA, O.K. AND **OFORKA, N.C.** (2003). ADSORPTION OF (40 AMINO-2-METHYL-5-PYRIMIDINYL METHYLATHIO) ACETIC AND ON MILD STEEL FROM HYDROCHLORIC ACID SOLUTION (HCL) – PART 1 MATERIALS CHEMISTRY AND PHYSICS.
24. ORUBITE, K.O. AND **OFORKA, N.C.** (2004). INHIBITION OF THE CORROSION OF MILD STEEL IN HYDROCHLORIC ACID SOLUTIONS BY THE EXTRACT OF LEAVES OF NYPA FRUITICANS WURMB, MATERIALS LETTERS 58, 1768-1772.
25. OLUSEGUN, K., ABIOLA, O.K., **N.C. OFORKA** AND S.S. ANGAYE (2004). CORROSION BEHAVIOUR OF ALUMINIUM IN HYDROCHLORIC ACID (HCL) SOLUTION CONTAINING MERCAPTOACETIC ACID, MATERIALS LETTERS 58, 3461-3466.
26. BRUCE R. GREGG, WILLIAM K. DALTON., JOHN, E. NEELY AND RICHARD, R.KIBBE (2004). MODERN MATERIALS AND MANUFACTURING PROCESSES, THIRD ED. PERSON PRENTICE HALL.
27. E.E. EBENSON; U.J. IBOK; U.J. EKPE; S. UMOREN, EKERETE JACKSON, O.K. ABIOLA, **N.C. OFORKA** AND S.MARTINEZ (2004). CORROSION INHIBITION STUDIES OF SOME PLANT EXTRACTS ON ALUMINIUM IN ACIDIC MEDIUM, TRANSACTIONS OF THE SAEST 39, 117-123.
28. A.O. JAMES, **N.C. OFORKA,** AND O.K. ABIOLA (JAN. 2005). INHIBITION OF ALUMINIUM IN HYDROCHLORIC ACID SOLUTIONS BY PYRIDOXAL HYDROCHLORIDE JSCE, VOL. 7 PREPRINT 21-31.
29. KAMMA, C.M., (2006). INAUGURAL LECTURE SERIES, UNIVERSITY OF LAGOS.

30. O.K. ABIOLA, **N.C. OFORKA,** E.E. EBENSON AND N.M. NWINUKA (2007). THE INHIBITIVE ACTION OF *DELONIX REGIA* EXTRACT FOR THE CORROSION OF ALUMINIUM IN ACIDIC MEDIA, ANTI-CORROSION METHODS AND MATERIALS, VOL. 54, NO. 4, 219-224.
31. A.O. JAMES, **N.C. OFORKA** AND O.K. ABIOLA; B.I. ITA (2005). A STUDY ON THE INHIBITION OF MILD STEEL CORROSION IN HYDROCHLORIDE ACID BY PYRIDOXOL HYDROCHLORIDE ECLETICA QUIMICA, VOL. 32, NUMERO 3, 2007, PP31-38.
32. A.O. JAMES, **N.C. OFORKA** AND O.K. ABIOLA (2006). INHIBITION OF ALUMINIUM (3RS) CORROSION IN HYDROCHLORIC ACID BY PYRIDOXOL HYDROCHLORIDE. BULLETIN OF ELECTRO CHEMISTRY, VOL. 22, PP. 111-116.
33. A.O. JAMES, **N.C. OFORKA** AND O.K. ABIOLA (2007). INHIBITION OF ACID CORROSION OF MILD STEEL BY PYRIDOXOL AND PYRIDOXOL HYDROCHLORIDE. INTERNATIONAL JOURN. OF ELECTROCHEMICAL SCIENCE 2, 278-284.
34. LAUTERWASSER, C. (18TH JULY 2007) OECD.org.http//www.oecd/dataoecd/37/19/37770473.pdf.
35. ABIOLA, O.K., **OFORKA, N.C.,** EBENSON E.E., AND NWINUKA N.M. (2007). ECO-FRIENDLY CORROSION INHIBITORS: THE INHIBITIVE ACTION OF *DELONIX REGIA* EXTRACT FOR THE CORROSION OF ALUMINIUM IN ACIDIC MEDIA, ANTI-CORROSION METHODS AND MATERIALS, VOL. 54, NO. 4, 219-224.

CITATION ON

PROFESSOR NICHOLAS CHARLES OFORKA

Introduction

Mr. Vice-Chancellor, Sir, our 89th inaugural Lecturer is none other than Professor Nicholas Charles Oforka, a seasoned and well-bred chemist. Professor Oforka was born on 15th August, 1947 at Jimeta, Yola in the present Adamawa State to late Mr. Nwokoye Oforka and late Mrs. Veronica Oforka, of Ebeteghete Ukpor, Nnewi South Local Government Area of Anambra State.

Educational Career

Professor Oforka started his early education at St. John's Primary school, Odoakpu, Onitsha in 1953. He then proceeded to the famous Christ the King College (CKC) Onitsha in 1961 for his secondary education. At CKC, Nicholas excelled in both sports and academics. At various times at CKC, he served as a Senior Prefect, Sports Prefect, Food Prefect, Football and Athletics Captains.

With his West African School Certificate in the kitty, coupled with his soccer prowess, Professor Oforka's Irish teachers at CKC encouraged him to enroll into the Higher School Certificate programme in 1966. This journey was interrupted mid-way by the Nigerian Civil war. At the end of the crisis, he went back to CKC and finally completed the programme in 1970.

For his University education, Professor Oforka went to the only University of Nigeria, Nsukka, where he studied Chemistry. In fact, after his first year at UNN, he did so well that he was awarded a German scholarship. He completed the programme in 1976 with a First Class Hons degree, carting away both the Faculty and the Departmental prizes as the best Graduating student in these Units.

In order to equip himself fully for his chosen career, he went to University of Sheffield, England in 1979, under the University of Port Harcourt staff development programme, where he obtained a Post-Graduate Diploma (with distinction) in Metallurgy in 1980 and subsequently a Ph D degree in the same field in October 1983.

Academic Career

Professor Oforka started his academic career at Alvan Ikoku College of Education, Owerri in 1977, where he taught Chemistry for a year. He joined the services of University of Port Harcourt in August 1978 as an Assistant Lecturer. On his return from University of Sheffield in1983, he was promoted to Lecturer II and in 2005 he rose to the peak of his academic career as a Professor of Material Chemistry in the Department of Pure and Industrial Chemistry.

Administrative and Professional Experiences

Professor Oforka has served the University in many capacities. He was Acting Head of Department of Pure and Industrial Chemistry from 1992 to 1994. From 1995 - 1997, he served as Coordinator of Science Laboratory Technology programme, the forebear of the now School of Science Laboratory Technology. He was Chairman, Departmental Graduate Committee (1991-1994), Chairman, Faculty of Science Examination Committee (1990-1992), Member, University Appointment and Promotion Committee (Academic) (1994-1996); Member, University Senate (1991-1997; 2001-Date).

Professor Oforka is a Life Member and Fellow of the Chemical Society of Nigeria (CSN); Member, Metallurgy Society of Nigeria; Member, Nigeria Corrosion Association and Fellow, Institute of Chartered Chemists of Nigeria (ICCON). In the Chemical Society, he has played very active role both at the local Rivers Chapter and at the National level. He was once the Publicity Secretary (1988-1990); Secretary, (1990-1992), and Vice-Chairman (1994-1996) in the Rivers Chapter and Membership Secretary at the National level.

In the Department of Pure and Industrial Chemistry, Professor Oforka has, no doubt demonstrated special teaching qualities in many ways. His students describe him as a born-teacher of chemistry. Because of his special area which is multi-disciplinary, he fits into many areas of chemistry. He has been teaching inorganic, physical and general chemistry courses, besides courses in his special area of metallurgy (material chemistry). He has supervised several postgraduate students both at the Master and PhD levels as well as the regular undergraduate students. He is indeed a good academic mentor to the younger colleagues in the Department.

Professor Oforka is External Examiner at the following institutions: Alvan Ikoku College of Education, Owerri, University of Calabar and Rivers State University of Science and Technology, Federal University of Technology Owerri and Delta State University, Abraka.

Professor Oforka has published widely both in national and international journals. He has acted as Soil/Water Chemistry Consultant to a number of Environmental Companies since 1989 and has taken part in and coordinated a number of Environmental Impact Assessment (EIA) studies.

Professor Oforka is a philanthropist of the old mould, where the left hand is not supposed to know what the right hand is doing. He is an ardent Christian of the Roman Catholic Faith. He is a proud father of three lovely children and a doting grand-father.

Conclusion

Mr. Vice-Chancellor, Sir, distinguished ladies and gentlemen, it is with great honour and privilege that I present to you a Renowned Chemist, a Meticulous Metallurgist, a Fellow of the Chemical Society of Nigeria, a Chartered Chemist, an Erudite Academic, a German Scholar, the Man With Measured Steps, **Professor Nicholas Charles Oforka**, as he delivers the 89th Inaugural Lecture of the University of Port Harcourt.

Thank you

Professor Regina E. Ogali