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Inaugural Lecture Series, No 12

IGWE NA NDU: THE ROLE OF METALS IN LIFE

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Date: 22nd January, 2015

OPENING REMARKS

The Chairman, Professor Michael Umale Adikwu, the Deputy Vice-Chancellor (Academic) Professor S.E Kakulu, the Deputy Vice-Chancellor (Administration) Professor G. Tahir, Deans and Directors here present, the Chairman, Inaugural Lecture Committee, Professor B.M. Barkindo and other members of the Committee, distinguished members of the University Senate, other Staff and Students, Ladies and Gentlemen.

Every Inaugural lecture has its peculiarities and this one is not an exception. It is the 12th in the Inaugural lecture series in this university; there can never be another 12th in the series. It is titled in Igbo language, subtitled in English language which is also the language of its delivery. It is the 4th in the Faculty of Science and the 2nd in the Department of Chemistry. It is the first by a Professor of Inorganic Chemistry in this University. It is being delivered by a Professor of thirteen years in rank.

I am very grateful to the Almighty God for making it possible for us to be alive and witness this occasion. Many people will take credit for what is happening today. Sometimes in the mid-50's, two people finished enjoying themselves and that led to my being conceived. Here I am today. They are my parents the late, Ogbuefi Nwabueze Okolo and Mrs. Ocho Nwabueze.

I am grateful to them, for that productive encounter. On a certain Afor market day, my mother was on her way to the market when she went into labour. She was taken to the house of a certain teacher at Methodist Primary School, Amurri where she gave birth to me. I

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(iii) Member, Constitution Drafting Committee, Unibuja Staff Club.

(iv) Member, Investigation Panel (EUSS 1 – 7) into the 1994 University of Abuja crisis.

(v) Chairman, Campus Maintenance Committee, University of Abuja.

(vi) Chairman, Committee on FCDA Houses, University of Abuja.

(vii) Member, Investigation Panel, Staff Involvement in Examination Malpractice.

(viii) Member, Certificate Screening Committee.

(ix) Member/Chemist Expert, EIA Review Panel: Associated Obigbo Node Gas Gathering project (FEPA TEAM), May, 1999.

(x) Member, Technical Comittee forThe Review of Standard for Tobacco and Tobacco Products-Specification for Cigarette, Standard Organization of Nigeria, 2013.

(xi) Chairman/Member of many Ad-Hoc Committees.

(48) MEMBERSHIP OF PROFESSIONAL ASSOCIATIONS

(i) Fellow, Chemical Society of Nigeria.

(ii) Member, Science Association of Nigeria.

(iii) Fellow, Institute of Chartered Chemists of Nigeria (ICCON).

(46) ADMINISTRATIVE/EDITORIAL RESPONSIBILITIES

(i) Department Examination Officer, 1991 – 1993.

(ii) Coordinator, Departmental Postgraduate Programme, 1994 – 1999.

(iii) Member/Secretary, Editorial Board, Zuma Journal of Pure and Applied Sciences, 1995 – date.

(iv) Head of Department, University of Abuja: October 1998 – 2003.

(v) Deputy Dean, Faculty of Science, University of Abuja: 2002 – 2003.

(vi) Director, Academic Planning and Development Unit, University of Abuja, 2003 – 2007.

(vii) Acting Vice-Chancellor, University of Abuja 1st – 30th June, 2009.

(viii) Deputy Vice-Chancellor (Academic), University of Abuja, 2007 – 2009.

(ix) Review Assessor: Z. Journal of Pure and Applied Sciences, Abuja.

(x) Review Assessor: Journal of the Chemical society of Nigeria.

(xi) Review Assessor: Academy Journal of Science and Engineering, NDA, Kaduna.

(xii) Review Assessor: Nig. Journal of Technical Education, Kaduna.

(47) COMMUNITY SERVICES

(i) Member, Constitution and Bye-Law Drafting Committee, UNIBUJA Cooperative Society.

never knew that teacher, but I am grateful to him for that assistance. That was why I was named Nwafor (i.e. child born on Afor market day). Perhaps in appreciation of the gesture by this "unknown teacher", I am popularly called Nwafor Teacher. Prophetically, I ended up a teacher. I am most grateful to my senior brother, Chief Bonny Nwabueze (KSM) and his late wife Cordelia. It was in their care that, I started my early education up to the secondary school level. I want to appreciate the contributions of my other senior brothers and sisters towards my education and general upbringing. They are the Late Charles Nwabueze, Late Christopher Nwabueze the late David Nwabueze, Adol Nwabueze, Mike Nwabueze, Mrs. Rose Oko and the Late Vicky Nwabueze.

I want to especially appreciate my wife, Mrs. Maria Nwabueze. My prayer warrior, you have been a pillar of support. I will remain eternally grateful to you for tolerating my occasional excesses.

My wonderful children, Tochukwu, Ijeoma and Uwaoma, I thank you all for being level-headed.

Mr. Chairman, I have just acknowledged the contributions of my biological family. At the concluding part of this lecture, I will appreciate my academic family including my very wonderful Chemistry family.

IGWE NA NDU: THE ROLE OF METALS IN LIFE

Igwe has at least three meanings in Igbo language depending on how it is intoned. Igwe means crowd, Igwe, literally means the sky, including human sky, i.e paramount ruler, in the context of this lecture, Igwe, (i.e. metals) are the focus. While iron is the most visible, copper, tin, zinc and aluminum are also commonly encountered. Metals play diverse roles in our lives; these include their roles in various aspects of Civil engineering construction and other aspects of engineering that help us get by in life. The aspect that is of interest in this lecture is the role of metals in what I will call 'BIOLOGICAL LIFE'.

The description of a field of Chemistry as BIO-INOGRANIC involves a contradiction in terms which reflect a misconception going back to the origin of modern science. In the early nineteenth century, Chemistry was still divided into 'organic' which included only substances isolated from living organisms and 'inorganic' (i.e Chemistry of dead matter). This distinction became meaningless when a supposedly 'organic urea' was synthesized from inorganic ammonium cyanide in 1821[1]. Nowadays organic chemistry is defined as the chemistry of carbon compounds, especially hydrocarbons and their derivatives with the possible inclusion of heteroatoms such as nitrogen, oxygen or sulphur, regardless of the origin of the material (living or non-living matter). The need for a collective designation of the chemistry of living organisms then led to a new term biochemistry. For a long time, biochemistry was concerned mainly with organic compounds, but the two areas are not identical.

A new term bio-organic chemistry is increasingly being used for studies of organic compounds that are directly relevant for biochemistry. Improved trace analytical techniques have demonstrated the importance of a number of inorganic elements (mainly meta,l in biochemical processes, thus revealing a multitude

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19. Dr. M.I. Mohammed Assessed for Reader, Bayero University Kano.

20. Dr. M.A.Kurawa Assessed for Reader, Bayero University Kano.

21. Dr. S.M. Gumel Assessed for Reader, Bayero University Kano.

22. Dr Suleiman Ola Idris Assessed for Associate Professor, Ahmadu Bello University, Zaria.

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(45) FELLOWSHIPS AND AWARDS

(i) UNESCO Fellow: Fifth Postgraduate course in Techniques in Advanced Inorganic Chemistry, Sept., - Nov., 1989. Department of Chemistry, University College, Dublin, Ireland.

(ii) COMMONWEALTH Fellow; 1994 Commonwealth Academic Staff Fellowship, Department of Chemistry, University of Wales, College of Cardiff, UK. Oct., 1994 – July, 1995.

2. Dr. P.C. Njoku, Assessed for Reader, Federal University of Technology, Owerri.

3. Dr. O. O. Offiong, Assessed for Professor, University of Calabar, Calabar.

4. J.O. Onah, Assessed for Reader, University of Jos, Jos.

5. Dr. Adeoye, Idowu Olatunbosun. Assessed for Reader, Ladoke Akintola University of Technology, Ogbomoso, Nigeria

6. Dr. Basil Eke Assessed for Reader, University of Ilorin, Ilorin.

7. Dr. Adamu Uzairu, Assessed for Reader, Ahmadu Bello University, Zaria.

8. Dr. M.O. Aremu Assessed for Reader, Nassarawa State University, Keffi.

9. Dr H.N. Aliyu Assessed for Reader, Bayero University, Kano.

10. Dr. Basil Eke Assessed for professor, University of Ilorin, Ilorin.

11. Dr. M.O.Aremu Assessed for Reader, Nassarawa State University.

12. Dr. M.O.Aremu Assessed for Professor, Federal University Dutsin-ma Katisina State.

13. Dr. A.A.Ayuk Assessed for Professor, Federal University of Technology, Owerri.

14. Dr. N.H.Aliyu Assessed for Professor, Bayero University Kano.

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of inorganic natural products, infact, some of today's 'inorganic' elements had been established quite early as essential components of living systems. Notable among them are the extraction of potash (K_2CO_3) from plants and the iron containing hexacyano ferrate (III) ($K_3[Fe(CN)_6]$) and potassium hexacyno ferrate (II) $K_{4[}Fe(CN)_6)]$ from animal blood in the 18th century. Others include the discovery of phosphorus (as P4) by dry distillation of urine residues and elemental iodine from the ashes of marine algae in the 17th and 19th centuries respectively. In the middle of the 19th century, studies on the metabolism of inorganic nutrients especially nitrogen, phosphorous and potassium salts, significantly improved agriculture making it gain enormous practical importance. However, the theoretical background and the analytical methods at that time were not sufficient to obtain detailed information on the mechanism of action of such essential elements several of which occur in trace amounts. Some very conspicuous compounds that include metallic elements like iron containing haemoglobin and myoglobin, magnesium containing chlorophyll (the pigment of life) were analysed and characterized later within a subfield of organic chemistry – NATURAL PRODUCTS.

Another important distinction between organic chemistry and the chemistry of living organisms is that the former is carried out almost entirely in non-aqueous media, whereas the latter occurs essentially in aqueous media. It is recognized that the human body is made up of 99.9% of just eleven (11) elements, four of which are; hydrogen, oxygen, carbon and nitrogen,these account for 99% of the total. Non-negligible doses of phosphorus, as well as some sulphur, are also needed.

But these element alone do not enable life, as we know it to exist, in its multiple and varied forms. We need components of inorganic chemistry (Mineral chemistry in French). In the aforementioned definition of inorganic chemistry, we are confronted neither with a world that is not organic nor of animal or vegetable origin. Most inorganic compounds do not contain carbon and are derived from

mineral sources. Yet this inanimate chemistry apparently with nothing to do with living systems has crucial role to play in our understanding of the biological world. Nature has selected constituents not only from the organic world but also from the inorganic world to construct living organisms.

In the course of this lecture, the role the inorganic elements (especially the metals) will be examined but one thing is clear; these elements have been selected on the basis of their suitability for the functions that they are called up on to perform in what is predominantly an aqueous environment.

It is generally acknowledged that interdisciplinary research has become increasingly important for scientific progress. This commonplace statement is particularly true of bio-inorganic chemistry which already includes in its name two classical fields of chemistry (biochemistry and inorganic chemistry). In addition, the recent rapid progress in bio-inorganic chemistry[2] has been made possible through contributions from:

i. Physics (development of techniques for detection and characterization)

ii. Biology (supply of material and recently specific modification based on site-directed mutagenesis)

iii. Agriculture (effect of inorganic elements and their mutual interdependence)

iv. Pharmacology (interaction between drugs and endogenous or exogenous inorganic substances)

v. Medicine (diagnostic aids, tumor theraphy)

vi. Toxicology and environmental sciences (potential toxicity of inorganic compounds)

(xv) Sule I. and Nwabueze J.N, (2008) Synthesis, magneto-spectral characterization and in vitro biological evaluation of some oxovanadium (iv) complexes of hydrazones of nicotinic and isonicotinic acid hydrazides, Proceedings of International Conference of science and Technology, University of Abuja, Abuja 2008.

(xvi) J.N Nwabueze, O.Adedirin, SA Emmanuel and RA Alebiosu, (2012), Complexes of Some M(II) Sulphates with some hydrazine derivatives, A paper presented at the 35th Annual International Conference of the Chemical Society of Nigeria, Owerri, September, 2012.

(43) EXTERNAL EXAMINATIONS:

a. External Examiner, Chemistry Department, Nigerian Defence Academy, Kaduna, 1999 – 2001.

b. External Examiner, Chemistry Department, Kogi State University, 2002/3 – 2003/4.

c. External Examiner (Ph.D.) Chemistry Department, A.B.U., Zaria, 29th July, 2003.

d. External Examiner, Department of Chemistry, Federal University of Technology, Owerri, 2003.

e. External Examiner, University of Agriculture, Makurdi, 2005 – date.

(44) EXTERNAL ASSESSMENT

1. Dr. G.N. Onuoha, Assessed for Reader, Federal University of Technology, Owerri.

(x) J.N. Nwabueze, Drug Development: The Role of Chemistry. A paper presented at the 2000 Students Chemical Society Week. Chemist, 1, 33.

(xi) J.N. Nwabueze and H.D. Aliyu (2001), Studies on complexes of isovalero acid hydrazide with Co^{2+} and CU^{2+}. A paper presented at the 24th Annual Conference of the Chemical Society of Nigeria. Abuja, Sept., 2001.

(xii) Hassan Y, Umar M.A. and Nwabueze J.N. (2001), Fixation of Cd^{2+} and Pb^{2+} from waster using simple and reinforced lime/fly ash composites. A paper presented at the 24th Annual Conference of the Chemical Society of Nigeria, Abuja, September, 2001.

(xiii) J.N. Nwabueze (2006), Sample collection Handling and Quality Assurance in Isotope Tracers' Hydrology Investigation: A paper presented at the Preliminary Training of Would-be Operators of the Isotope Hydrology Laboratory on Isotope Techniques, Basic Hydrochemistry and Laboratory Procedure held at the Centre for energy Research and Training (Cert), A.B.U. Zaria, 13th – 17th March, 2006.

(xiv) J.N. Nwabueze (2006), Solubilizing Minerals for Analysis. A paper presented at the Preliminary Training of Would-be Operators of the Isotope Hydrology Laboratory on Isotope Techniques, Basic Hydrochemistry and Laboratory Procedures held at the Centre for Energy Research and Training (CERT), A.B.U. Zaria, 13th – 17th March, 2006.

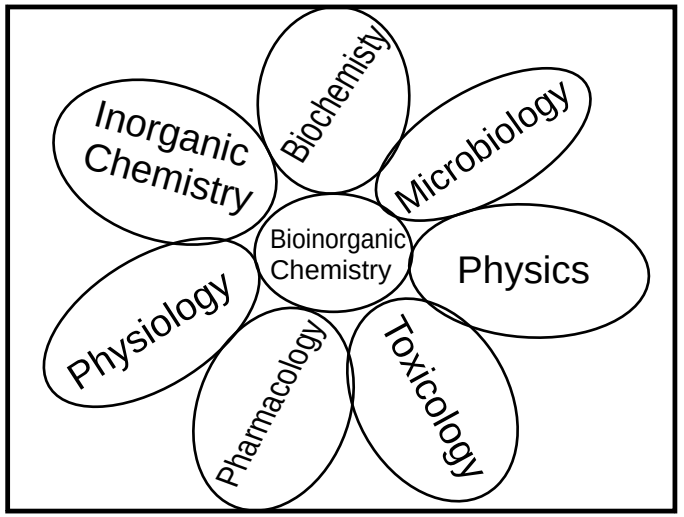

Fig 1. Bioinorganic chemistry as a highly interdisciplinary research field.

Life is a process which for an adult organism, can be characterized as controlled stationary flow equilibrium, maintained by energy consuming chemical reactions. Input and output are essential requirements for such an open system which differ from the more familiar thermodynamic equilibria. In addition to the energy flux, life requires a continuous exchange of materials which in principle includes all chemical elements.

The Occurrence and Availability of Inorganic Elements in Organisms

The occurence of the elements depends on external and endogenous conditions. Elements can be biovailable to various extents but can also be bioaccumulated by organisms using energy consuming processes involving a local reduction of entropy. Some trends are, however obvious from the composition of chemical elements in an adult human being.

Table 1. shows the abridged version of this composition.

Table 1. Average elemental composition of a human body (adult, 70kg)

Element	Symbol	Mass(g)
Oxygen	O	45,500
Carbon	C	12,600
Hydrogen	H	7,000
Nitrogen	N	2,100
Calcium	Ca	1050
Phosphorus	P	700
Sulphur	S	175
Chlorine	Cl	105
Sodium	Na	105
Magnesium	Mg	35
Iron	Fe	4.2
Zinc	Zn	2.3
Silicon	Si	1.4

The values for oxygen and hydrogen reflect the high content of (inorganic) water, though these elements also occur in other molecules. The organic element, carbon, only comes third. The most abundant metallic element in the body, calcium, ranks fifth, its main quantitative use being the stabilization of the endoskeletion. The table also shows relatively large quantities of potassium, chlorine, sodium and magnesium, these are known variously as mass elements, bulk elements or macro nutrients.They are followed by iron and zinc, two less abundant inorganic elements. According to one definition, trace elements with regards to the human body involve a daily requirement of less than 25mg.

Conference of the Chemical Society of Nigeria, Zaria, September, 1990.

(iv) Nwabueze, J.N., Chelates of acetone benzoyl and acetone salicyloyl hydrazones with some transition M(II) chlorides; 16th Annual National Conference of the Chemical Society of Nigeria, Owerri, Sept., 1991.

(v) Nwabueze, J.N. and O.T. Ogunmoroti, Oxovanadium (IV) complexes of some cyclocarboxylic acid hydrazides: 17th Annual National Conference of the Chemical Society of Nigeria, Lagos, Sept., 1992.

(vi) J.N. Nwabueze, Inorganic Chemistry – A life science. A paper presented at the students' Chemical Society Week, University of Abuja. 18th July, 1996.

(vii) J.N. Nwabueze, Iron chelation therapy: Hydroxamic acids derived from cyclocarboxylic acids. A seminar paper presented at the College of Science and Agriculture, University of Abuja, 9th January, 1997.

(viii) J.N. Nwabueze and M.T. Yusuf: Ternary complexes of Iron (III) with 8 – hydroxyquinoline and some hydrazine derivatives 22nd Annual Conference of the Chemical Society of Nigeria, Kaduna, Sept., 1997.

(ix) J.N. Nwabueze (2000). Interaction of Aluminium with Biological Molecules: A paper presented at the 2000 Students' Chemical Society Week. Chemist, 1, 4.

of acetone succinyldihydrazone and fufuraldehyde succinyldihydrszone with Ni(II)Sulphate and acetate. International Journal of Inorganic and Bioinorganic Chemistry 4, 1.

(41) A.E Alamuoye and J.N. Nwabueze., (2014), Synthesis and characterization of the complexes of acetone succinyldihydrazone and fufuraldehyde succinyldihydrszone with Cu(II)Sulphate and acetate. International Journal of Inorganic and Bioinorganic Chemistry 4, 5.

(42) H.D. Aliyu, J.N. Nwabueze, and M.O. Obadare, (2014) Complexes of M(II)Sulphate with 4-Cyanobenzaldehyde and 4-Ethylbenzaldehyde-cyclopropanecarboxylicacid Hydrazones. Journal of Natural Science Research 4(21), 8-11

a. Research Reports and Monographs:
None

b. Conferences Attended and Papers Presented:

(i) Nwabueze J.N., K.S. Patel and P.O. Ikekwere, Some transition metal complexes of some cyclocarboxylic acid hydrazides: 11th Annual Conference of the Chemical Society of Nigeria, Lagos, Sept. 1986.

(ii) Nwabueze J.N., K.S. Patel and P.O. Ikekwere, Magnetic and spectral studies of some transition metal complexes of some cyclocarboxylic acid hydrazides; 28th Annual Conference of the Science Association of Nigeria, Owerri, May, 1987.

(iii) Nwabueze, J.N. Some M(II) sulphate complexes of acetone benzoyl hydrazone and acetone salicyloyl hydrazone: 15th Annual

Fluorine and silicon, two structurally important nonmetallic elements, fall within the range of iron and zinc. The relative amount of genuine trace element is smaller by at least one order of magnitude and some of them have not been well defined with regard to amount, essential character and function[3].

Elements are essential if their total absence in the organism results in severe irreversible damage. When the optimal functioning of the organism is impaired, the element is better referred to as beneficial.

It is remarkable that elements such as silicon, aluminum and titanium which are prominent components of minerals in the earth's crust, play only a marginal role in the biosphere. The major reason for this is that, in general, the physiological conditions for life processes include pH values of about 7 in aqueous solutions. Under these conditions, the aforementioned elements in their usual high oxidation states, exist as nearly insoluble oxides or hydroxides and are therefore not bioavailable. On the other hand, molybdenum, a rare element with low crustal abundance is quite soluble at pH 7 as molydbdate (VI) (MoO_4^{2-}) and therefore quite abundant in sea water. It has, therefore, been found to be an essential element in many organisms. In general, metallic elements are soluble in natural aqueous media and thus bioavailable either in lower oxidation states (+1,+2) as hydrated cations or in very high oxidation states (+5, +6, +7) as hydrated oxo-anions. Despite the forgoing, living organisms have developed complicated mechanisms to actively acquire inorganic substances. For example, efficient biological mechanism exists to accumulate silicate or trivalent iron both of which are practically insoluble at pH 7 and thus make them bioavalable for structural or other purposes.

Not surprisingly, elemental compositions are highly variable for different species and even different parts of higher organisms depending on the kind of metabolism and biotype.

The issues of which elements are essential, which are beneficial and which are toxic, are continuously being discussed under various areas of popular science, particularly for humans. Quantitatively, this is a matter of the physiological state (i.e. ability to function properly) or even the individual disposition of the organism depending on the presence of dose or concentration of an element. Fig 1 shows the ambivalent effects of many substances and illustrates the principles of paracelcus (i.e. the dose makes the poison)

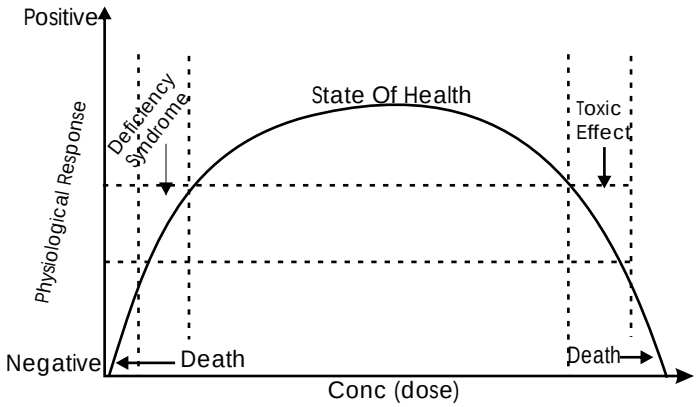

Fig. 2. Dose response diagram for an essential element.

An important term here is that of 'therapeutic width' which characterizes the concentration range causing advantageous physiological effects.

The effects of metal overload and metal deficiency will be discussed later in this lecture.

Metals in Biological Systems

Mr. Chairman, for over thirty (30) years, I have been working on and with metals, notably the transition metals. The metals of interest here are shown in Table 2 which is a very abridged version

(35) J.N.Nwabueze and O.W.Salawu., (2012), Complexes of Mn (II) and Co (II) Sulphates with Keto annd Enol Forms of Isobutryl Acetic Acid, 4 – Amino Benzoic Acid and 4 – Cyano Bennzoic Acid Hydrazides. The International Journal's Research journal of Science and IT management. Vol.

(36) Nwabueze J.N and Salami H.A., (2013), Complexes of 4-cyanobenzaldehydeisonicotinic acid hydrazone with some transition M(II) sulphates, International Journal of Research in Inorganic Chemistry, 2(1):1-3

(37) H.A Salami and J.N Nwabueze., (2013), Studies on Uranyl(VI) complexes of schiff base ligands deried from 1,3-diethylpropanediote and 1,4-diethylbutanediote with hydrazine hydrate, International journal of Inorganic and Bioinorganic Chemistry, 3(1): 16-19

(38) J.N Nwabueze, O. Adedirin, S.A Emmanuel and R.A. Alebiosu., (2013), Complexes of some M(II)sulphate with some hydrazine derivatives, International of Chemistry and Pharmacitical Science. 1, 406-

(39) Idi Sule and J.N. Nwabueze., (2013), Complexes of copper(II) with some hydrazones derived from nicotinic and isonicotinic acid hydrazides, International journal of Inorganic and Bioinorganic Chemistry, 3, 52

(40) A.E Alamuoye and J.N. Nwabueze., (2014), Synthesis and characterization of the complexes

(30) Tenimu A. Abubakar and J.N Nwabueze, (2011), Complexes of Nicotinic and isonicotinic Acids Hydrazides and their Acetone Hydrazones with Uranyl Nitrate and Acetate, Zuma Journal of Pure and Applied Sciences. 9.41

(31) Salami, H.A and Nwabueze.J.N, (2011), Studies on complexes of malonyl and succinyl dihydrazides wit copper(II) nitrate and acetate, Zuma Journal of Pure and Applied Sciences. 9.13

(32) H.D Aliyu and J.N Nwabueze (2011) Studies of Fe(III) and Mn(II) Complexes of Valerohydroxamic Acid and Isovalerohydroxamic Acid Asian Journal of Chemistry, Vol 23, No 1, 34-36.

(33) J.N.Nwabueze and O.W.Salawu., (2012), Complexes of Zn (II) and VO (IV) Sulphates with Keto annd Enol Forms of Isobutryl Acetic Acid, 4 – Amino Benzoic Acid and 4 – Cyano Bennzoic Acid Hydrazides. Advances in Pure and Applied Chemistry. Vol. 1, No 2, pp 20-30 .

(34) J.N.Nwabueze and O.W.Salawu., (2012), Complexes of Cu (II) and Ni (II) Sulphates with Keto annd Enol Forms of Isobutryl Acetic Acid, 4 Amino Benzoic Acid and 4 – Cyano Bennzoic Acid Hydrazides. Advances in Pure and Applied Chemistry. Vol. 1, No 2, pp 40-48 .

Table 2. Some important metals in biology;

H																	
Na	Mg														B		
															Al		
K	Ca			V	Cr	Mn	Fe	Co	Ni	Cu	Zn						
					Mo												

The first element, hydrogen is extremely important in biology. It can be incorporated into bonds with non-metals such as carbon and nitrogen notably by the action of light. It can be transferred in important number of biological redox reactions involving one or two electron transfers and it can participate in the generation of the proton gradients across biological membranes which are universally used for ATP synthesis.

Some of these metallic elements such as sodium, potassium, calcium and magnesium are present in large quantities and as earlier sated are referred to as bulk elements. Sodium and potassium ions are ideally suited in generating ionic gradients across membrane and for the maintenance of osmotic balance. Magnesium and calcium ions play important structural roles, in the particular case of calcium serve as a change carrier and a trigger for signal transmission. The role of magnesium is intimately intertwined with phosphate in many phosphoryl transfer reactions, as Mg – ATP in muscle contraction, in the stabilization of nucleic acid structure and in the catalytic activity of ribozymes (catalytic RNA molecules). It is also found as the metal centre in chlorophylls which absorb light energy in photosynthesis. Aluminum, while extremely abundant in the earth's crust is not used by living organisms. In fact, it is a notorious neurotoxin. Acid rain, due to sulphur and nitrogen oxides, increases its solubility and hence it's bioavailability. Another effect of acid rain is that it changes the usual association of aluminum with silicate (predominant above pH

6.5) for phosphate, thus rendering aluminum more toxic. This may well be the reason while silicon is essential, namely it keeps aluminum in a non-toxic form as aluminum silicate.

Vanadium is known to be essential and is a constituent of some haloperoxidases as well as nitrogenases in some nitrogen fixing organisms. It is particularly abundant in tunicates (a species of marine organisms)

Chromium appears to be essential to man yet it's mode of action is unclear. In fact hexavalent chromium is carcinogenic but the trivalent form is required for carbohydrate and lipid metabolism in mammals. It is a component of glucose tolerance factor (GTF) [4]. Chromium has become very popular as a nutritional supplement, weight loss and muscle development agent, second only to calcium containing products among mineral supplements.

Molybdenum is the only heavy transition metal that has biological relevance. Together with iron, it is involved in nitrogen fixation.

Let me comment more on the importance of nitrogen-fixation. Nitrogen fixation is of considerable interest for a variety of reasons. It is a very important step in the nitrogen cycle providing available nitrogen for plant and, hence animal nutrition especially proteins. It is an intriguing process since it occurs readily in various bacteria, blue-green algae, yeasts and in symbiotic bacteria –legume associations under mild conditions.

Molecular nitrogen is so unresponsive to ordinary chemical reactions that it has been characterized as inert.
The strong triple bond can only be broken by;

(i) Thunderstorm

(ii) (ii) Haber process which requires high temperature, high pressure and a catalyst and,

(23) J.N. Nwabueze and H.D. Aliyu (2007), Synthesis and characterization of Valero and isovalero hydroxamic acids and their complexes with Zn(II) and Al(III), Int. J. Chem. Sci., 5(2) –

(24) A.O. Aliyu and J.N. Nwabueze (2007), Complexation of nicotinohydroxamic acid with nickel(II), European Jourenal of Scientific Research, 18(3) 354..

(25) Nwabueze, J.N. and Aliyu A.O. (2007), Complexation of vanadium(IV) with some hydroxamic acids, European Jounal of Scientific Research, 18(3), 417.

(26) Nwabueze J.N. and Aliyu A.O. (2008), Complexes of Copper (II) with some Hydroxamic Acids, International Journal of Bioscience, 3 (4).

(27) H.D. Aliyu and J.N. Nwabueze (2009), Synthesis and Characterization of Valero and Isovalerohydroxamic acids and their complexes with Zn(II) and Al(III). Pakistan J. of Scientific & Industrial Research 52(5) 239.

(28) A.O. Aliyu and J.N. Nwabueze (2009), Complex Formation Between Iron l(III) and Isonicotinohydroxamic Acid and its Microbial Studies, Nig. Jornal of Basic and Applied Science, 17 181.

(29) M.C Enedoh and J.N Nwabueze (2011), Complexes of 4-Cyanobenzaldehydecyclo-hexylacetic acid Hydrazone with some M(II) Sulphates (M=Ni, Cu, Co. Zn) , Zuma Journal of pure and applied sciences. 9, 1.

(15) J.N. Nwabueze (2000). Interaction of Aluminium with Biological Molecules: Chemist, 1, 4.

(16) J.N. Nwabueze (2000). Drug Development: The Role of Chemistry. Chemist, 1, 33.

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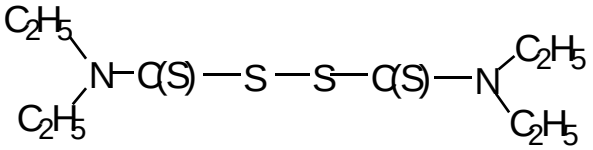
(iii)(iii) Nitrogen fixation by micro-organisms which take place in the root of legumes at ambient temperature and pressure.

Molybdenum is also involved in the metabolism of alcohol in the liver. Ethanol is metabolized in two stages.

$$\text{Ethanol} \xrightarrow[\text{Fast}]{\text{ADH}} \text{Acetaldehyde} \xrightarrow[\text{Slow}]{\text{ALDH}} \text{Acetic acid}$$

In the first stage, alcohol dehydrogenase (ADH) oxidizes ethanol to acetaldehyde while in the much slower second stage catalysed by aldehyde dehydrgenase (ALDH), acetaldehyde is oxidized to acetic acid.

The buildup of acetaldehyde causes unpleasant physiological effect known as 'hang over. This has been exploited in alcohol abuse therapy. ADH is a zinc containing enzyme while ALDH contains zinc and molybdenum. The drug of choice is tetraethylthiuram disulfide.



It is also known as disulfiram or more commonly, as antabuse[5]. Manganese is essential to man although possibly it's most significant contribution to biology is its incredible chemistry as a tetra-manganese centre in the splitting of water by photosystem II in plants. Mr. Chairman, in my opinion, photosynthesis is unarguably the most important chemical reaction on earth.

This chemical process, often summarized by the equation;

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6$$

is fundamental to the existence of higher forms of life on earth. The production of reduced carbon compounds (food) including fossil fuels on one hand and the production of oxygen on the other hand are based on this energy consuming process. This reaction generates oxygen which changed the pattern of life on earth moving from an essentially reducing atmosphere to the oxidative world we now know. The appearance of oxygen was, perhaps the greatest pollution event in history as all organisms which could not withstand its oxidative power perished. Another consequence of the appearance of dioxygen was that divalent copper became more bioavailable, whereas trivalent iron became more difficult to extract.[6]

The remaining five metals in Table 2, iron, cobalt, nickel, copper and zinc are of immense importance in the living world. Iron is essential for all living organisms. It is truly ubiquitous in living systems. Its versatility is unique. It is at the active centre of molecules responsible for oxygen transport (haemoglubin and myoglolin) and electron transport. Not only is iron involves in an enormous range of functions, it is also found in the whole gamut of life from bacteria to man. It is extremely abundant in the earth's crust; in fact, it is the fourth most abundant element (after O, Si, Al) and second most abundant metal (after Ca). It has two readily interconvertible oxidative states, a property that propably led to its evolutionary selection for use in many life processes. Sixty –five percent (65%) of iron in the human body is found in haemoglobin.

Cobalt is the active metal in Vitamin B12; like cobalt, nickel appears to be much more extensively utilized by anaerobic bacteria in reactions involving chemicals such as methane, carbon monoxide

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(b) Book Chapters: None

(c) Journal Articles

(1) Ikekwere P.O., K.S. Patel and J.N. Nwabueze (1990): Complexes of copper (II) sulphate with some cyclocarboxylic acid hydrazides. Synth. React. Inorganic Met-Org Chem., 19(6), 599.

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and hydrogen, the metabolism of which was importance before the appearance of dioxygen, Copper, like iron, is frequently encountered in reactions involving dioxygen. The copper protein haemocyanin is involved in oxygen transport in some invertebrates notably molluscs.

Zinc in addition to its use as a Lewis acid in enzyme catalysis, plays a structural role in stabilizing protein molecules.

Mr. Chairman, it is established from the foregoing that these metals are essential for the human organism. The recommended daily allowances (RDA) for these metals are shown in Table 2.

Table 2. Recommended daily allowances for some essential metals (mg) [7,8]

Metal	**RDA**	
	Adult	**Infant**
K	200-5500	530
Na	1100-3300	260
Ca	800-1200	420
Mg	300-400	60
Zn	15	5.0
Fe	10-20	7.0
Mn	2.0-5.0	1.3
Cu	1.5-3	1.0
Mo	0.075-0.250	0.06
Cr	0.05-0.2	0.04
Co	ca 0.2	0.001

Table 3. Shows typical deficiency symptoms associated with the elements.

Table 3. Deficiency symptoms [9]

Deficient element	Symptoms
Ca	retarded skeletal growth
Mg	muscle cramps
Fe	anemia, disorders of the immune system
Zn	skin damage, stunted growth, retarded sexual maturation
Cu	artery weakness, liver disorders, secondary anemia
Mn	infertility, impaired skeletal growth
Co	permcious anemia
Mo	retardation of cellular growth
Ni	growth depression, dermatitis
Cr	diabetes symptoms

A corollary of this situation is that uncontrolled mobilization may lead to the presence of excess, free metal ion, with subsequent health problems. Excess metal can be as a result of insufficient excretion or by excessive uptake, such poisoning can be treated using bioinorganic measures like application of antagonists or a chelate therapy [10,11]

TOXIC METALS

So far, it has been shown that many metals are essential for life. As stated earlier even such substances will be poisonous if the dosage is high enough. With regards to toxicity two groups of non-bio essential groups of metals can be distinguished.

The first group consists of metals that have not been recognized as relevant for life due to low abundance or bioavailability. The second

(b) **Doctoral**

(i) Studies on complexation of biotransition metal ions with some hydroxamic acids. Aliyu Adetutu Oluwakemi (Ph.D., 2005).

(ii) Studies on complexes of Valero and isovaleric dyroxamic acids with some transition metal ions. ALIYU, Haruna Dede (Ph.D. 2004)

(iii) Studies on Complexes of Some M(II) Sulphates and Chlorides with Hydrazones derived from Nicotinic and Isonicotinic Acids. Idi, Sule (PhD, 2009)

(iv) Complexes of VO(IV), Mn(II), Co(II), Cu(II) and Zn(II) sulphates with keto and enol forms of Isobutryl acetic acid , 4-aminobenzoic acid and 4-cyanobenzoic acid hydrazides. Salawu Olalekan Wasiu (Ph.D, 2013).

(v) Complexes of 2-amino-4-thiazoleacetic acid hydrazide (keto and enol forms), salicylaldehyde-2-amino-4-thiazoleacetic acid hydrazone and acetone-2-amino-4-thiazoleacetic acid hydrazone, with M(II) sulphates and acetates [M= Ni, Cu, Zn, Mn]. Enedoh, Margaret Chinyelu. (PhD, 2014)

9. **PUBLICATIONS**

(a) Books

J.N. Nwabueze and K.S. Patel (2001) “Essentials of Coordination Chemistry”. (7 Chapters of 153 pages), Eezee Media Publishing, Abuja.

(ii) Fixation of some heavy metals using fibre-reinforced lime/fly-ash composites. (M.Sc. 1997/98). Hassan Yakubu.

(iii) Complexes of Nickel(II) sulphates with hydrazones derived from nicotinic and isonicotinic acids – SALAWU Olalekan (2005).

(iv) Complexes of nickel(II), copper(II), cobalt(II), and manganese(II) sulphates with 2 bromovaleric acid hydrazide and its acetone hydrazone. Oyewale Stella (2006).

(v) Synthesis of the complexes of 4-cyanobenzaldehydecyclohexylacetic acidhydrazone with M(II) sulphates and acetates, Enedoh, Margaret Chinyelu (2008)

(vi) The Synthesis and Characterization of Complexes of Cobalt(II), nickel(II), copper(II) and zinc(II) acid hydrazide and its acetates with isonicotinic acetone hydrazone. Gotapwa Nahungu Nzokala (2009)

(vii) Complexes of manganese(II), cobalt(II), nickel(II), copper(II) and zinc(II) with cyanobenzaldehydecycloprppanecarboxylicacid and 4-ethylbenzaldehyde cyclopropanecarboxylicacidhydrazones. Obadare, Olabisi Mobolaji (2009)

(viii) Studies on complexes of malonyl and succinyl dihydrazides with copper(II) and Uranyl(VI) with nitrate and acetate. Salami.H.A (2011).

group consists of those for which negative effects, have been found.

Among the latter group are the soft sulphur loving metals lead, cadmium, thallium and mercury. Arsenic (a semi-metal) can also be added. Their toxicity is a result of their ability to block enzymes; there is also the possibility of substitution of natural/native metal centres in metalloenzymes by foreign metals with similar but not identical chemical characteristics.

For example, Zn Cd, Ca Pb, Cd

Even before the additional man-made introduction of toxic substances into the environment, organisms had to cope with such poisonous elements as cadmium or mercury either in the form of continuous stress situation or during suddenly occurring catastrophic events such as volcanic eruption.

Historically, lead is the oldest recognized toxic metal and it is also the one that has been most extensively spread into the environment by mankind[12]. It is not particularly rare in the earth's crust, its relatively easy mining and processing, its apparent resistance against corrosion and the not easily recognized toxicity made it a highly valuable metal in ancient civilizations. Additional demand arose after the industrial revolution when lead was beginning to be used in batteries, bearing alloys, solder, optical glasses, pigments, radiation protection materials and fuel additives.

Chronic lead poisoning is known as saturnism. Saturn is the alchemists name for lead. It is common among young children in socially deprived areas. The attraction of lead for young children is that it has a sweet taste.

METAL IONS AND CHELATING AGENTS IN MEDICINE[10]

The concentrations of naturally occurring metal ions in living systems are carefully controlled within fine limits. This control is normally exercised by proteins and hormones. Disorders will naturally set in if this balance is upset. The interrelationships between metal ions and binding substances in the body are so complex that diseases involving the metal binding substances may result in the presence of high or low concentrations of a metal ion compared with that normally present. Therefore, analysis of body fluids and tissues for trace metal ions is important in diagnosis. A number of major diseases are associated with changes in concentration of the trace metal ions in certain tissues and body fluids.

As already stated in the Paracelsus principle, a trace metal ion that is essential for the activity of enzymes systems will become toxic if the concentration is raised above certain limits. The level beyond which a metal ion becomes toxic depends on its location. For example, a doubling of the concentration of potassium in extra cellular space leads to heart disorder and possibly death, but this concentration is still well below the normal concentration of intracellular potassium. A deficiency of any metal ion, for example, any of the essential transition elements will result in reduced enzyme activity with a break down of normal metabolic processes.

The heavy metals as already noted have toxic effects. These often result from environmental and industrial problems. It is often necessary to design chelating agents to remove metals or excess of essential elements from the system. Furthermore, the toxic effect of certain metal complexes has been exploited in the design of anti-cancer drugs while certain other diseased conditions are treated by Metal chemotherapy. Certain drugs are good ligands and there is the inescapable conclusion that they function by binding to metal ions.

(c) Lecturer II, Department of Chemical Sciences, Ogun State University, Ago-Iwoye, Nigeria - 1985 – 1989

(d) Lecturer I, Department of Chemical Sciences, Ogun State University, Ago-Iwoye - 1989 – 1990

(e) Lecturer I, Department of Chemistry, University of Abuja, Nigeria - 1990 – 1993

(f) Senior Lecturer, Department of Chemistry, University of Abuja, Nigeria - 1993 – 1997

(g) Associate Professor of Chemistry - 1997 – 2001

(h) Professor of Chemistry - 2001

5. **PRESENT POSITION AND SALARY**
Professor CONUASS 7/10

6. **DATE OF LAST PROMOTION**
October 2001 - Professor

7. **THESIS WITH DATES**
   (a) Adducts of some M(II) 4, 4, 4, trifluorothenoy1 acetonates with urea and thiourea. (1982) M.Sc. Thesis, University of Ibadan Library.

   (b) Physicochemical Studies of Co-(II) and Cu(II) complexes of some cyclocarboxylic acid hydrazides. (1986), Ph.D. Thesis, University of Ibadan Library.

8. **RESEARCHES SUPERVISED**
   (a) Undergraduate Projects

   (b) Masters
   (i) Studies of Aluminium binding to some biological model ligands. (M.Sc.) 1996/97. Effiong Esther Bassey.

Curriculum Vitae

1. **BIO-DATA**

Name:	Joseph Nwafor Nwabueze (Prof.)
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Place of Birth:	Amurri, Enugu State, NIGERIA
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2. **EDUCATIONAL INSTITUTIONS ATTENDED WITH DATES**
   (a) Government College, Afikpo - January – July, 1967
   (b) University of Ibadan - 1976 – 1986

3. **ACADEMIC QUALIFICATIONS WITH DATES**

(a)	GCE O'Level	-	Jan., 1974
(b)	GCE A'Level	-	Nov., 1975
(c)	B.Sc. (Hons) 2nd Class (Upper)	-	July, 1979
(d)	M.Sc. Chemistry (Inorganic)	-	Sept., 1982
(e)	Ph.D. Chemistry (Inorganic)	-	Aug., 1986

4. **WORKING EXPERIENCE**
   (a) NYSC – Chemistry Teacher, Multilateral Grammar School, Okun-Owa, Ogun State - 1979 – 1980

   (b) Graduate Assistant, Department of Chemistry, University of Ibadan, Nigeria - 1980 – 1985

Mr Chairman, in the past three decades my research has been in the area of synthesis and study of chelating agents and their metal complexes which are potentially biologically active (relevant references are in my CV which is attached). In this regard, my research group has synthesized acid hydrazides and their complexes with many of their transition metal complexes. The use of isonicotimic acid hydrazide as a tuberculostatic agent was introduced into medical practice by Fox[13] in 1952. We have, therefore synthesized analogues of isonicotinic acid hydrazide and tested them for antimicrobial activity. Many of them were found to be active against the test organisms. The group have also done a lot of research on hydroxamic acids[14-16]. Hydroxamic acids and other compounds containing the hydroxamate group are uubiquitous in nature and are intimately associated with iron transport in bacteria. They are known to act as antibiotics, antibiotic antagonists, tumor inhibitors and many of them act as drugs [17-23]. The biological activity of hydroxamic acids appears to be related to their iron chelating ability. The different but related problems of iron deficient anaemia and iron overload resulting from the treatment of thalassemia are still serious especially in tropical countries. Thalassemia (Cooley's anaemia) is a genetic disorder of haemoglobin synthesis. Sufferers do not get enough oxygen. The best treatment is to transfuse the patient with blood containing normal haemoglobin. Patients with thalassemia gradually accumulate excess iron in their bodies; this build-up of iron may be due to the disease itself (irregular haemoglobin not properly incorporating adequate iron into its structure) but mainly due to many blood transfusions received by the patient. This condition is known as haemochromatosis or siderosis. It is treated by the administration of a chelating agent desferioxamine(DFO). The major drawback of this drug is that it cannot be administered orally as it is rapidly hydrolysed by enzymes in the gut. It is administered as an injection (intravenously) subcutaneously for 8-12hrs at a time six times a week. The economic and social discomforts discourage patients from continuing treatment. There is, therefore, a continuous search for iron complexes which can act as suitable oral iron sources to counter iron deficiency and suitable ligands with high affinities for iron to relieve overload. Iron deficiency is treated by administration of ferrous

sulphate, possibly with ascorbic acid to aid absorption. Iron complexes are being explored as alternatives with the hope that the iron might be released slowly, thus, avoiding the build-up of free iron ions in the body. My research group is active in this area, having synthesised many hydroxamic acids and their metal complexes. The affinities of some of these ligands for iron compares favourably with that of desferioxamine. Other causes of siderosis include, but not limited to, accidental ingestion of iron by children and Bantu siderosis common among the Bantu tribe in South Africa who brew their local beer using iron puts. Common chelating agents used to treat metal ion overload are listed in table 4

Table 4: Chelating ligands for detoxification after metal poisoning;

Ligand	**Trade/trivial name**	**Metal ions**
2,3dimercapto propanol	BAL	Hg^{2+}, As^{3+}, Sb^{3+}, Ni^{2+}
D- 2- amino -3mercapto -3--methylbutyric acid	D-penicillamine	Cu^{2+}, Hg^{2+}
Ethylenediaminetetracetate	EDTA	Ca^{2+},Pb^{2+}
Deferrioxamine	desferal, DFO,	Fe^{3+}, Al^{3+}

BAL is British Anti Lewisite. Lewisite is an arsenic containing gas used by the Germans on the British during the First World War. The British chemists rose to the challenge and synthesised BAL which contains sulfyhydril groups (SH) that combines with arsenic thus rendering it in effective.

METAL BASED DRUGS

The field of inorganic chemistry in medicine can be divided into two main categories. In the first category are drugs which target metal ions in some form whether free or protein bound, while in the second category are metal based drugs where the central metal ion is usually the key feature of the mechanism of action. Metal based drugs are a commercially important sector of the pharmaceutical business. It is important to distinguish between drugs acting by a pharmacodynamic mechanism and chemotherapeutic drugs. For pharmacodynamic drugs, their action must be rapid and reversible.

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For instance, a patient who submits to an anaesthetic does not expect to be deprived of feeling forever. Chemotherapeutic drugs on the

nor charlatanry. Every scientific finding must be subjected to peer review. Those who lay claim to discoveries that cannot be made public are not practicing science; at best they are native doctors.

TRAINING OF CHEMISTS

Are the chemists we are producing these days same as those produced 20, 25 years ago? My answer is in the negative. I had already pointed out the lack of equipment and consumables arising from poor funding as contributory factors to the growth of science in the country. There is also the problem of population explosion and reluctant students. Reluctant in the sense that Chemistry was not their first choice of course of study but was foisted on them by circumstances beyond their control. Because of these reasons, not many students attend lectures. The situation is further worsened by students being grouped for practicals.

Mr. Chairman, permit me to make the following suggestions which, hopefully, will improve the quality of the graduates of Chemistry.

1. As much as possible, only candidates that made Chemistry their first choice should be admitted; aapplicants for the Remedial programme should indicate their preferred course of study e.g. Remedial Chemistry, etc.

2. The concept of carrying capacity should be strictly adhered to at the departmental level. The carrying capacity of a department should be determined using indices such as number and quality of academic and other support staff, physical facilities e.g. classrooms and laboratory space etc. These should be used to determine the number of students that can reasonably be trained by the department.

3. With the advent of the Institute of Chartered Chemists of Nigeria (ICCON), Chemistry has been professionalized. In addition to

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regulating the practice of Chemistry, the Institute should b involved in the supervision of training of chemists as done by other professional bodies such as COREN, etc.

INAUGURAL LECTURES

Mr Chairman, I wish to very briefly comment on the conduct of Inaugural lectures. It is a solemn academic ceremony and an opportunity for the lecturer to tell the world what he/she has been professing. In the course of such lectures, some weighty /controversial issues might be raised. I, therefore see no reason why questions should not be asked on such occassions. This is a food for thought for the University Senate. I , also, do not think that all Senators should robe. I suggest that only the Vice-Chancellor, Deans and Academic Directors should be in the procession.

ACKNOWLEDGEMENT

Mr. Chairman, I have many academic fathers which in principles include all my lecturers at the University of Ibadan. They all inspired me in one way or the other. I have to especially mention Professor K.S. Patel. We first came in close contact when I was posted to him as my undergraduate project supervisor. He nurtured my interest in Inorganic chemistry and made sure I returned to the Department immediately after my youth service as a graduate assistant; for this, I am most grateful to him and to the University of Ibadan for that appointment.I doubt if I would have been what I am today without that appointment. He subsequently supervised my M.Sc project and together with the late Dr. P. Ikekwere, my Ph.D. On completion of the Ph.D. programme, I got employed at Ogun State University (now Olabisi Onabanjo) University, Ago-Iwoye. That appointment was also facilitated by Professor Patel and Professor T.O. Bankole who became the pioneer deputy vice-chancellor of that university.

At Ibadan, I learnt a lot about both Chemistry and life from Professors J.I Okogun and Ikenna Onyido. To them, I say thank you. I am grateful to all my contemporaries at the post graduate level but particular mention must be made of those closest to me. They include, Professor Sam Kakulu, the incumbent Deputy Vice-Chancellor Academic (University of Abuja), Professors Goddy Onuoha (FUTO), Joe Woods (U.I), Tunde Ogunsanwo (OOU), Kayode Bamgbose (FUNAAB), Hyacinth Aniodoh (ESUT), and Harry Garuba (Cape Town, S.A.).

While at Ago-Iwoye, I got my first ever Research fellowship. It was a 3 month UNESCO Fellowship, which I spent at the University College, Dublin in Ireland. It was while there that I got interested in the chemistry of hydroxamic acids in the research group of Professor David Brown. I also regard him as one of my academic fathers. I joined the University of Abuja, in 1990 as one of the pioneer lecturers. My nomination for a Commonwealth Research Fellowship in 1994 was successful. That took me to University of Wales in Cardiff into the Research Group of Professor Robert Gillard. It was there I met and had the rare opportunity of a handshake with a Nobel Laureate in Inorganic Chemistry, Professor Geoffrey Wilkinson. For my trip and stay in the UK, I thank the University of Abuja, for nominating me, the Commonwealth Scholarship and Fellowship Plan for the award and Professor Gillard for being a wonderful mentor and host. Let me also acknowledge the role played by the pioneer Vice-Chancellor of this University Professor Isah Mohammed, Professor Sam Amdii, Professor S.K. Okwate and Mallam M.B. Modibbo (the immediate past Registrar of this University). I am also grateful to all the staff of this University particularly members of the faculty of Science for all the goodwill I have enjoyed from them.

Mr. Chairman, as the saying goes, all work and no play makes Jack a dull boy. I want to appreciate the Management and staff of Cosy-Rest Guest Inn for providing an informal Staff Club for us. I thank members of the club. These include the late Professor Aliyu Idrees, Professors Toye Olorode, EJC Nwana, I. Ekoja, O.B Oloche, Dr. Peter Adakayi, Dr. Nwadiaro, Dr. George Teke Dr. S.K. Agber, Dr. Adakole Oklobia and a host of others.

Finally, and very importantly, I must appreciate the contributions of my students over the years, especially my research students. The truth is that I do the talk but they walk the talk. I am grateful to the following. Esther Bassey, H.D Aliyu, O.A. Aliyu, Idi Sule Olalekan Salawu, Abubabar Tenimu, Margaret Enedoh, Hammed Salami and others too numerous to mention. I appreciate Oluwatosin, Adaobi and Dr. Adakole Oklobia who did the typing/ editorial of this work.

How can forget my dear undergraduate students? We will continue to do our best for as the cliché goes 'Old chemists never die, they only fail to react.

Thank you all for listening.