Professor F.O. Bamiro
Professor of Analytical Chemistry.

UNDERSTANDING CHEMISTRY WITH A VIEW TO IMPROVING SERVICE TO MANKIND: AN ABYSMAL ADVENTURE OR A REALISTIC IDEAL?

By

Francis Olukayode Bamiro

B.Sc. (Special Honours Chemistry) (UNILAG)
M.Sc. (Petroleum Chemistry) UMIST, Britain
PhD (Analytical Chemistry) Strathclyde, Glasgow
Professor of Analytical Chemistry
Department of Chemistry
College of Natural Sciences
University of Agriculture, Abeokuta, Nigeria.

An Inaugural Lecture delivered at the
University of Agriculture, Abeokuta, Nigeria
May 4, 2005

The Vice-Chancellor,
Deputy Vice-Chancellor,
The Principal Officers of the University
Deans and Directors of Centres
Heads of Departments
Distinguished Guests and Friends of the University
My Academic Colleagues
Members of my immediate and extended family
Gentlemen of the Print and Electronic Media
Great UNAABITES.

I have been given the honour and privilege of presenting the 18th inaugural lecture of this University which incidentally is the 4th from the College of Natural Sciences. In addition, it is the second to be presented in Chemistry Department.

What is an inaugural lecture? In an attempt to give accurate and comprehensive definition, I refer to the first inaugural lecturer at UNAAB, Prof. Julius A. Okojie[1] where he defined it as "an occasion to survey one's field, to explain what someone does, to demonstrate its relevance and to place one's own contributions into their general perspective." Another definition was given by the 8th inaugural lecturer[2] at UNAAB, Prof. B.A. Ola Adams, who defined it as "contributions to knowledge in your area of specialisation to the development of the society". It is in the light of this understanding that I have chosen to speak on the topic, UNDERSTANDING CHEMISTRY WITH A VIEW TO IMPROVING SERVICE TO MANKIND: AN ABYSMAL ADVENTURE OR A REALISTIC IDEAL?

1.0. INTRODUCTION

Tertiary education chemistry has been taught in Nigeria for a little over sixty years right from the days of the Higher College Yaba into the time of founding the University College Ibadan (in 1948) and ever since. The first Nigerian to obtain a University degree in Chemistry is the late Professor Stephen Oluwole AWOKOYA, who obtained his bachelor's degree at the University College London in 1946. Prior to that, he attended the Higher College, Yaba. The first single-honours graduate produced in Nigeria is Professor E.V. Emovon, former Federal Minister of Science and Technology. He obtained his bachelor's degree from the University College Ibadan in 1956 (under the special relations programme with the University College, London). As at present, Nigeria has produced a large army of chemistry graduates. Unfortunately, however the impact of these chemistry graduates on our economy has been minimal despite our knowledge of the role of chemistry in the industrialised nations. Chemistry graduates in Nigeria, either as a result of the quality of their training or some other inexplicable reasons, behave like the proverbial chicken which refuses to fly even when all the other birds fly high into the heavens. Today it is not uncommon to see geologists and biologists suddenly becoming experts in environmental chemistry and chemical technology. It is said that nature abhors vacuum, so they have only moved in to prevent the continued existence of the vacuum so unwittingly created by the chemistry graduates.

ROLE AND IMPORTANCE OF CHEMISTRY

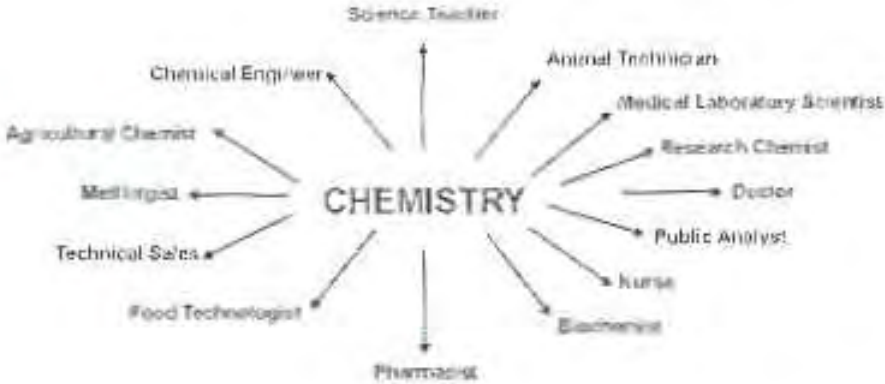
Many people regard chemistry as an abstract, theoretical subject, far removed from everyday life. Indeed, it often taught as such infact, chemistry is a subject of immense social and economic importance.

Man has been concerned with chemistry during all his history, passively at first, since his very existence depends on chemical and biochemical processes and to an increasing extent actively as he has sought to control his environment for his own convenience. The first chemical reaction purposefully brought about by man may be assumed to be combustion, fire having been known since about 30,000 BC and the use of fire for cooking, that is, for chemical modification of food, must have followed fairly closely on its discovery. The production of alcoholic beverages by fermentation also appears to be of great antiquity. More sophisticated applications of chemical transformations, for example the smelting of ores to produce metals, the manufacture of glass, the tanning of leather, were developed in very early times, and a steady but very slow progress in chemical technology occurred up to the 18th century. The emergence of industrialised societies, and the development of chemistry as a science, resulted in rapidly increasing rate of application of chemistry in the society. Applications of chemistry and chemical products now have a profound importance in practically all aspects of our lives.

2.0. PROSPECTING INTO CHEMISTRY

Chemistry is the science of material world. It is concerned with the structure and interactions of all the matters in the universe-whether animal, plant or minerals. It offers, therefore unlimited scope to people who want to understand and contribute to further development in the use and conservation of the materials around us. Chemistry occupies the central position among the basic sciences. On the other hand, it is linked with physics through physical chemistry and on the other with biology through biochemistry. Life depends basically on chemical reactions. Chemistry is therefore fundamental to physiology and to medicine. It plays an important part in the development of such sciences and geology and it underlines many branches of technology such as atomic energy, fuel technology and more importantly chemical engineering.

If you choose to study chemistry as one of your option subjects, then, the chart below shows some of the jobs for which you will be qualified. Some can be started at age 16, for others you will need to continue your studies to a higher level. Of course the list is not complete; you will agree that application of chemistry has no bounds.



As at today, over six million compounds are now well known and characterised (Heaton C.A, 1987). Yet this number is meagre when compared to the number of chemical compounds that can theoretically be synthesised from the various elements and even from carbon atom alone which has the gift of catenation.

It now becomes imperative and worthwhile to study chemistry into details. Now, this leads me to the topic of today which is "understanding chemistry with a view to improving service to mankind: an abysmal adventure or a realistic ideal?" Answering the subsequent question in the title of the present paper may provide more difficulties. However, giving a definitive answer is not the purpose of this address. The aim is to make the audience (reader) conscious of a problem: the existence of an abyss, a gap between fundamental academic research on one hand, and development and application on the other.

Perhaps I am harping herewith on the same string as WALTER SLAVIN did as recipient of the Analytical Chemistry Award in 1989, but I shall look at the problem from a somewhat different angle of incidence. My concerns may be expressed by expanding the title into a few further questions:-

- Do we not waste previous resources on fundamental research by only sterilising the results in the ebony towers of academic theses and scientific journals?
- Is it possible to bring the fruits of fundamental research closer to the public that could directly profit from them?
- Do we want to understand chemistry for the mere sake of understanding certain aspects of science or do we want to understand and let it be exploited by others to improve chemical analytical methods?
- Is the fundamental route not too long for the rational solution to still be of use for the hurried analytical chemists who are often compelled to find an irrational and awkward ways of finding solutions to practical problems when implementing new methods?
- How do we want to define fundamental, understanding chemistry, abysmal adventure or realistic ideal?

I shall deal with these questions by considering examples rather than by presenting a vigorous and dry philosophy. I have taken the examples chiefly from my own research experience and contribution towards knowledge in the field of analytical chemistry. using modern and acceptable equipment or else someone runs the risk of being described by the audience or reader that "He is growing old".

Mr Vice-Chancellor sir, it will be very necessary to define first who is an analytical chemist? This definition will throw light on the state of confusion where every chemist regards his/her self as an analytical chemist. There are three major branches of chemistry – Physical, Organic and Inorganic. Researchers in chemistry try to fall into any of these branches with and without overlapping depending on each group. It is a known fact that each group tries to carry-out analysis and collect data to establish their research findings. This does not make such groups to be analytical chemists. An analytical chemist must be well versed in all the three aspects of chemistry i.e is the father of all. In that wise, an Analytical Chemist must be able to:-

- examine facts or materials in order to give an opinion on them.
- use logical methods of thinking in order to understand it by looking at all the parts (equipment) separately.
- establish generally usable rules for optionization of various types.
- establish optimum and compromise conditions for any analytical tools.
- devise universally applicable approaches for the detailed development of practical methods.
- design equipment so as to improve on the one on grounds bearing cost and time in mind.
- evaluate the methodology/equipment presently used.
- ease comparison of data obtained with different equipment/methods
- facilitate the exchange and transfer of methods and data between equipment and laboratories.

3. CONTRIBUTION OF THE AUTHOR TO ANALYTICAL CHEMISTRY

Mr. Vice-Chancellor sir, I am delighted to submit with all honour and humility to be in the midst of analytical chemist with qualities stated earlier. I have made my contribution majorly in the field of atomic spectroscopy (i.e. analysis of elements) then followed by medicine, food science and petroleum.

3.1 Atomic Spectroscopy

There are four major problems facing analytical chemists in the field of atomic spectroscopy all over the world. They are:-

(i) Energy source
(ii) Sample introduction
(iii) Interferences
(iv) Detection Limits.

The problems III & IV (interference and detection limits) are hinged on energy availability. In most cases high energy is required to atomise the elements. In terms of development, acceptance, commercialisation and wide-spread everyday usage, the

inductively coupled plasma (ICP) has proven to be a highly successful new technique, best energy source for multi-element analysis[5]. The ICP systems offer high sensitivity, freedom from chemical interference. The marked success of this new technique can be attributed to the fact that its development came at a time when there was increasing demand for multi-element analysis and for the determination of a wide concentration range, varying from major to minor to trace levels, of the different elements to be

determined in the same sample. The simultaneous or rapid sequential multi-element analysis capability of the ICP is perhaps its most significant advantage over competing commercial flame and furnace-based techniques, although there are indications in the literature of promising new developments in this area for these alternative atomisation devices[6,7]. Traditional excitation sources have included combustion flames, arc and sparks. Flames are limited by relatively low temperature so that it is difficult, if not impossible, to analyse refractory elements or elements with high excitation energies, especially at low concentration levels. Also, combustion products and flame gases give rise to both chemical and spectral interferences.

What is Inductively Coupled Plasma (ICP)?

It is a gas (e.g. argon) having reasonable fraction (1%) of its atoms or molecules in ionised form.

Generation of the Plasma

The plasma consists of a torch (made of 3 concentric tubes). This is placed in the load coil of a radio frequency generator. Application of a radio frequency energy by means of 2-3 turn coil encircling the torch will create an oscillating magnetic field around the argon stream (Fig. 1) Through the help of tesla (spark), the argon gas is made conductive by ionising; the electrons and ions produced will be induced to flow in an annular path. The ionised argon will be accelerated by the oscillating magnetic field and will collide with argon atoms producing a great deal of heat and promoting the formation of new ions. The magnetic field causes the ions and electrons to flow in closed horizontal paths.

These eddy currents heat the neutral argon and collisional energy exchange and a white hot discharge is produced.

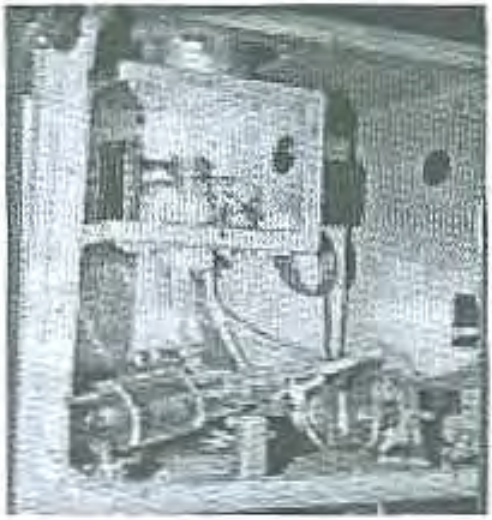


Fig. 1: ICP Set with Sample Introduction System

Optimisation of the ICP

A Philips PV8490 source has been coupled with spectra metrics Inc. echelle monochromator for ICP emission studies. The conditions were varied from power, carrier gas flow, coolant gas, observation Height and plasma gas flow and optimum condition established for Mn, Fe, Cu, Mg and B. It has been shown that the carrier gas flow and power are the most influential factors which determine analyte intensity.

It was observed, however, that the plasma conditions which give optimum net analyte intensity are not necessarily the best conditions in terms of signal to background ratio (SBR), and hence

detection limit, due to the influence of the plasma backgrou intensity.

The detection limit achieved for the elements at optimum (SE conditions were found to be in agreement with those determir by Boumans *et.al.*,[2] and Fernando *et.al.*,[1] (Table 1).

Further optimisation with wider elements (Table 2) gave resu which showed that significantly different conditions of power a carrier gas flow rate apply to the determination of vario elements. It was then possible to classify the elements into Ha and Soft lines i.e. elements requiring high and low ionisatic potentials, respectively. The Hard-lines require high power ar low carrier gas flow, while the soft line requires low power ar high carrier gas flow. It is clear that different conditions of pow and carrier gas flow rate apply to different elements.
The question now arises, do we optimise for the plasm parameters for every element to be measured? This leads to th establishment of compromise conditions generally for a

Table 1: Detection limit At Optimum SBR Conditions. (µg L^{-1})

Element	Wavelength (nm)	This work	Fernando[1]	Boumans[2]
Mn II	257.61	0.35	2	0.93
Fe II	259.94	17.6	5	4.10
Mg II	279.55	0.12	0.06	0.10
B I	249.47	4.30	5.0	3.20
Cd I	214.75	0.53	5.0	3.60

Table 2: Plasma parameter for Optimum SBR for Hard and Soft lines.

Element		Wave length nm	Power (kW)	Carrier gas flow rate L/min	Plasma flow rate L min^{-1}
Hard	Mn II	257.61	1.05	0.65	14.5
	Mg II	279.55	1.27	0.65	14.5
	Fe II	259.94	1.05	0.65	13.5
	Cu II	226.50	1.05	0.75	14.5
	Zn II	213.86	1.05	0.65	14.5
Soft	Cu I	324.75	0.9	0.9	14.0
	Fe I	373.49	0.9	0.9	14.5
	Ca I	357.49	0.9	1.10	14.5

Observation Height = 10mm

elements. The approach is to ascertain which conditions are most advantageous for the removal of interference effects in all analyses whilst maintaining high sensitivity (DL). For multi element analysis, the best compromise conditions were resolved in favour of Hardline. Hard lines were found to be significantly less affected by chemical interferences than soft lines. This is related to the fact that the optimum SBR conditions of Hard lines are those of high power and low carrier gas flow rate. The high power required will result in an increase in energy transfer into the plasma, while the lower carrier gas flow rate will provide an increase in the residence time of the sample. Both factors will promote an increase in molecular dissociation and hence, serve to reduce interference effects and give good detection limit (Table 3). The compromised condition establishes has proved very useful for the analysis of up to 60 elements at time using polychromator (Bamiro *et al.*,1983)[10].

Table 3: Comparison of detection limits under compromise conditions with published values at optimum SBR conditions.

Element	Wavelength	This work	Fernando[2]	Bouman[3]
	nm	μgL^{-1}	μgL^{-1}	μgL^{-1}
As I	197.20	540	-	51
Mo II	202.03	5.5	-	53
Zn I	213.6	3.1	5	1.2
Mn II	257.61	0.5	2	0.9
Fe II	259.94	20.3	8	4.1
Cr I	264.72	3.3	-	4.7
Cu I	324.75	2.1	3	3.6
Cr I	357.49	5.0	-	15.0
Fe I	373.49	27.7	-	32.0
Mo I	379.83	18.7	20	5.3

Direct Current Plasma (DCP)

Similar optimisation was carried out in D.C. plasma. The D.C. Plasma is a high intensity excitation source similar in some ways to ICP. The DCP is a high temperature plasma which is stabilised by the continuous flow of argon around the electrodes. The plasma is generated by arranging the current carrying electrodes at right angles and firing a strong gas flow at the centre. This flow contained the sample aerosol and produced an inverted Y shaped plasma, which is stabilised by the presence of the third electrode. The excitation temperature is about 5500K.

OPTIMIZATION

The parameters were optimised in the order of observation height in the plasma, nebuliser gas flow pressure and electrode sleeve gas flow pressure. It was observed that the background intensity is always greatest for both Cu and Mn (soft and Hard lines) in the hot core of the plasma and decreases rapidly as it is viewed further from the core apex (1.5mm above) (See fig. 2). The optimal nebulizer gas pressure and sleeve gas pressure were established at 20 psig and 50 psig, respectively. It was found that the plasma conditions which give net analyte intensity are not necessarily the best condition in terms of SBR. Despite the high energy available in the DCP, the optimum viewing height was outside the plasma. This is due to the instability of the aerosol to penetrate the plasma because of the large thermal gradient[11]. Another contributing factor was the high background from the argon recombination continuum and tungsten electrode in the plasma. It has been shown that the DCP parameters have no effect on removal of interference. Hence, no compromise conditions could be achieved[12] as in ICP for multi-element analysis. This is due to maximum working point in DCP which is 1.5mm above the hot core of the plasma, and it is outside the plasma where energy is required for removal of interference. However, the background intensity is high.

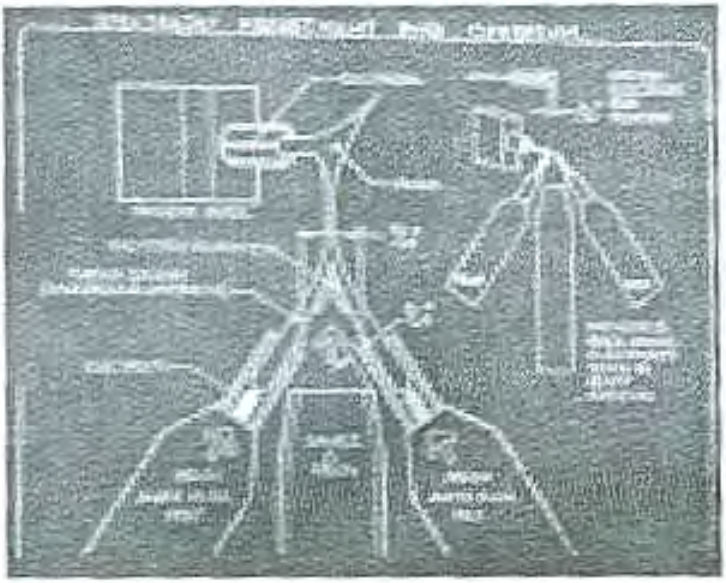


Fig.2:Spectrajet Adjustment and Operation in DCP.

APPLICATION OF THE ESTABLISHED COMPROMISE CONDITIONS IN ICP AND DCP

The established conditions were applied to analysis of copper in blood serum (Wilson's disease) without any pre-treatment of the blood sample. There is marked decrease in interference effect at ICP compromised conditions. Analysis using DCP gave interference for every interferent element. The interferent effect of every element was found to be additive in DCP (Fig.3).

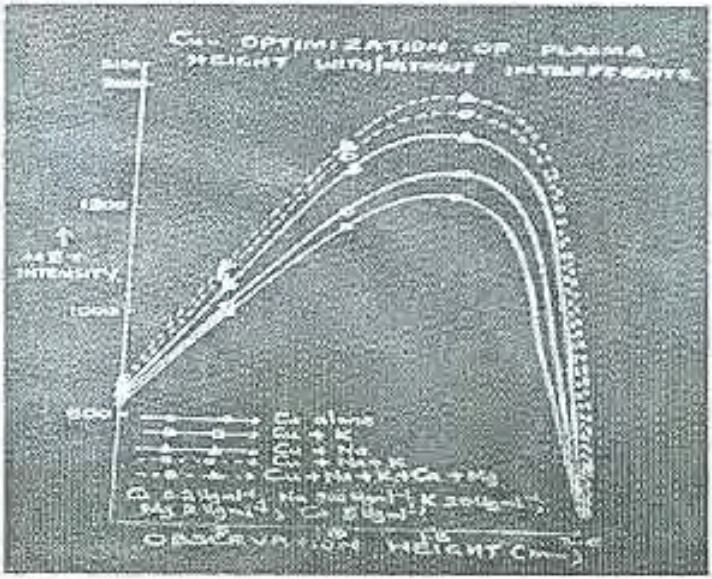


Fig.3:Cu-Optimization of Plasma height with/without interferents.

Direct analysis of copper in blood serum could not be carried out, hence the standards were matrix matched. For ICP, analysis of ten samples of blood serum collected from Glasgow Royal Infirmary (GRI) as part of the National Quality Control scheme, gave accurate results and compared favourably well with the results of National Quality Standard (See Table 4) Bamiro *et al.*, 1988) [13].

Table 4: Concentration of copper in blood serum determined by ICP at compromise conditions.

Blood Sample	This work $\mu g\ ml^{-1}$	Hospital (GRI) National quality values $\mu g\ ml^{-1}$
1	1.16	1.17
2	1.57	1.56
3	1.83	1.87
4	1.27	1.27
5	1.06	1.05
6	1.29	1.30
7	1.13	1.11
8	0.96	0.92
9	1.10	1.02
10	0.76	0.79

INSTRUMENTAL DEVELOPMENT

Sample Introduction System:- Nebulizer Problems encountered in the introduction of complex sample solutions into a plasma are recognised as a major limiting factor in the application of ICP-AES in spectrochemical analysis.

Samples may be introduced directly to the ICP as solids, as solutions or as vapours. Of the alternative approaches, solution sample introduction is the overwhelming choice for the most routine analysis, because of its simplicity, versatility and well characterised nature. A good sample introduction system based on nebulisation must meet the following requirements: - First, the

nebulizer must reproducibly generate an aerosol spray droplet with as small a diameter (<10μm) as possible. This assists the rapid transportation of the liquid sample into the plasma and ensures volatilization of the sample. Second, the nebuliser must be able to work at argon flow rates in the order of $lLmin^{-1}$ to be compatible with most of the commercially available ICP system.

One difficulty has been the absence of a totally satisfactory nebulisation device, especially for solutions, that have a high salt content. The limitations of conventional nebulisers have promoted the investigations of alternative approaches to nebulisation such as ultrasonic nebulisation[14], sample introduction by vapourization from a carbon rod[15], and hydride generation[16]. Pneumatic nebulisation remains, however the most popular form of sample introduction as it is simple and inexpensive, without being particularly prone to memory effects.

Two of the most popular types of nebulizer used are the cross-flow nebulizer[17,18] and concentric glass nebuliser[19]. Although, these nebulisers are capable of efficient aerosol generation, capillary tubes sometimes become partially or completely blocked, especially in the analysis of samples with high salt content. If the nebuliser partially clogs, substantial alteration of droplet formation can occur without the operator's knowledge. This in turn will affect the accuracy of determinations performed on subsequent samples. Such nebulisers therefore require frequent cleaning to maintain the original rate of aerosol generation. Scott[20] has described with clarity, the construction of a nebuliser to solve such problem. Bamiro F.O. and other workers [22,23] improved on this and reduced the problem of salt blockages and reduce droplet size by constructing a nebuliser based on the Babington principle.

The nebulisers are based on the "V" groove concept [24]. A Quick-Fit glass stopper was modified to allow the positioning of a horizontal glass-line in a similar orientation to the conventional Philips Cross. Flow nebuliser A "V" groove was cut in the end of the glass tube, and the surface of the groove polished to give a "ground glass" finish. A vertical sample delivery line was above the apex of the groove, such that the tip of sample tubing almost touched the top edge of the "V" (Figure 4).

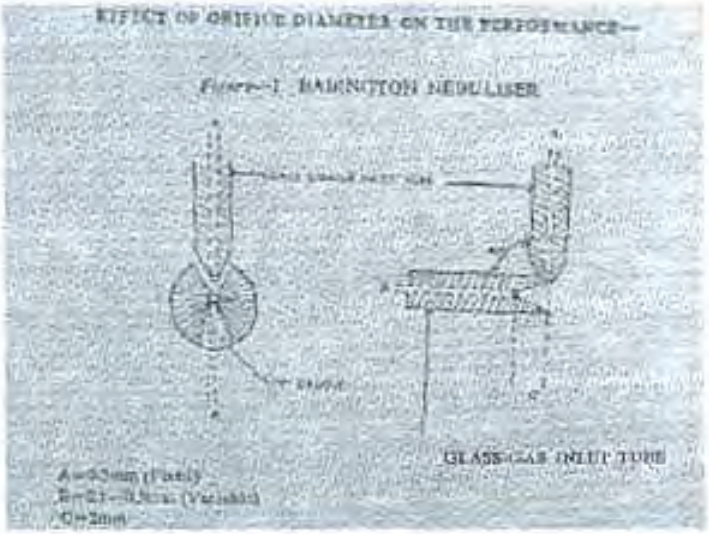


Fig.4: BABINTON NEBULIZER

The internal diameter of the sample delivery tube was set at 0.5mm, and fixed in place with quick setting epoxy resin. When a sample solution was pumped through the delivery tube, the flow of liquid down the groove was blasted by the argon carrier gas

flow passing through the "V" groove tube. Four nebulisers of the "V" groove type with different gas capillaries (0.1, 0.2, 0.3, 0.5mm) were constructed. On optimisation for different parameters, the highest net Mn intensity was obtained with 0.2mm diameter gas capillary.

The 0.3mm and 0.5mm Babington nebuliser gave slightly lower analyte signal intensities, but more increasingly, the H_2O background signal for these nebulisers tended to increase with increased capillary diameter. The 0.2mm orifice permitted an argon flow rate of up to 0.9 to 1.0 $Lmin^{-1}$. The flow rate is consistent with the requirements of a conventionally operating inductively coupled argon plasma [35,36]. The nebuliser of 0.3 and 0.5mm orifice diameter permitted argon flow rates up to 2$Lmin^{-1}$. At the higher flow rates, significant plasma instability was observed, which was found to be directly correlated with imprecision in net analyte intensity measurements. Satisfactory aerosol formation could not be achieved with the 0.1mm capillary. There appeared to be a back pressure building in the line, which probably reduced the velocity of the gas at the orifice and adversely affected the performance of the nebuliser.

Optimisation of the nebulisers revealed that increase in power is required with increasing orifice diameter. This is due to the change in aerosol density and droplet size distribution, which significantly alters the excitation energy characteristics. On the basis of SBR, the 0.2mm Babington clearly gave the best performance and free from blockage, when sample with high salt content was introduced (See Table 5) (Bamiro, 1991)[71].

Table 5: Influence of Babington Nebuliser Capillary Diameter on Mn Emission and Background Intensities.

Capillary diameter (cm)	Net Mn Signal (0.5µg ml⁻¹	Mean background Signal (H_2O)	SBR
0.1	1734	385	4.5
0.2	7974	220	36.2
0.3	7542	527	14.3
0.5	7405	636	11.6
Standard Philips nebuliser	9052	241	37.5

SPRAY CHAMBER

In the previous work by the author (Bamiro, 1991)[27] it was shown that the design of a nebuliser makes an important contribution towards achieving good analytical measurement. However, it is the total sample introduction system (nebuliser and spray chamber) that dictates signal to background ratio (SBR) values and ability to nebulise complex sample solution (Brown et al., 1981, Bamiro, F.O. 1991)[21,27]. As part of nebuliser evaluation, it was considered worthwhile to compare the performance of constructed different spray chambers in conjunction with the two nebulisers (Standard Philips cross flow and Babington) to establish possible improvement of neblisation for ICP-AES. The performance of a laboratory constructed Babington nebuliser/spray chamber with a flow spoiler has been compared with Philips Standard nebuliser/spray chamber combination. The results indicate the importance of a spray chamber with reduced – length

and a flow spoiler to improve analytical performance. The advantages exhibited include: low background intensity, improved SBR values (sensitivity), improved RSD of analysis and background, and the detection limits obtained were approximately a factor of 2 better than those obtained with standard Philips system, Bamiro, 1995 [26].

CONSTRUCTION OF A DEMOUNTABLE TORCH AND EXTENSION OF THE LIFE SPAN OF THE EXISTING STANDARD ICP TORCH FOR ICP-AES

One of the main impediments to the acceptance of ICP-AES system has been the high operational cost and complexity with the ICP source itself. Many workers have sought to overcome the limitations by alteration of the design and operating conditions of the ICP, in the hope that power and argon requirements could be reduced, whilst retaining the analytical advantages of the source. The methods considered in pursuit of this aim include: (i) replacement of the argon outer gas flow by a cheaper gas e.g. nitrogen, (ii) the use of special torch design, (iii) the application of external cooling of the wall of outer tube by either water or pressurised air, and (iv) miniaturisation of the torch and increase in the radio frequency of the generator.

As part of the move to reduce the running cost of the argon ICP, some workers considered the use of N_2 gas as a substitute for the argon outer gas flow. Boumans *et al.*, [29] and Montaser *et al.*, [30], compared the use of N_2 as substitute for argon and reported increase in RF power level to maintain analytical performance coupled with poor detection limits.

As an alternative to the foregoing approaches, reduction in power and gas consumption can be achieved by miniaturisation of the torch. Hence, a number of research groups worked on this and observed that with a fixed frequency of RF generator, miniaturisation of torch was limited to a certain extent by (i) the skin depth of the plasma, which is the distance from the plasma boundary to that where energy coupling has fallen to 37% of its maximum value and (ii) the channel diameter, roughly defined as the diameter of the carrier gas nozzle.

For efficient heating of any cylindrical body in an induction coil, the radius R of the cylinder must be much greater than the skin depth (d). Bourmans[8] showed that for efficient heating, the value R should be greater than 2.3d.

As a contribution to the foregoing approach, an attempt was made by the author to construct a miniature demountable torch (9mm) coupled with a radio frequency generator of 80MHZ (Fig.5). The demountable torch consisted of three quartz tubes of specific dimensions which were fixed in a brass holder using epicote 1009 adhesive. This substance melts at 150°c but at room temperature is a strongly bonded fixing agent. The tubes were heated gently in a bursen burner flame and the contact ends were coated with a film of epicote 1009. The tubes were rapidly pushed into the brass holder which was heated in an oven to 200°C. To ensure the correct spacing of the tubes relative to one another, a stainless steel positioning mould was fitted around the free ends of the tubes. In case of any damage of any of the tubes before or after usage, repairs could be carried out by heating the assembly to a temperature of 160°C in an oven to remove the damaged tubes. This has an advantage over the permanently standard fixed Philips macro one piece torch.

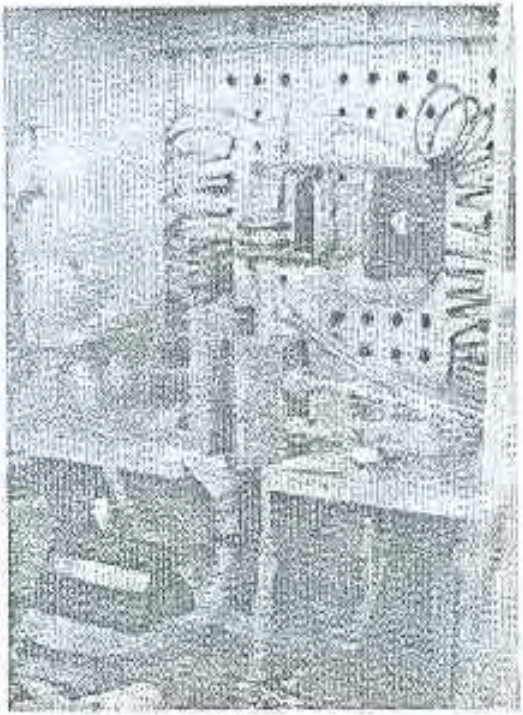


Fig. 5: An 80MHz ICP System with a Demountable Torch.

The performance of this set was compared with the traditional standard ICP of 18mm torch and 50MHZ. The 80MHZ demountable micro-ICP system gave analytical performance approaching that of the conventional ICP at a reduced power level but at only slightly lower gas consumption. A stable micro inductively coupled plasma was formed which readily accepted sample solutions and exhibited many of the same analytical characteristics associated with the conventional ICP sources.

The results obtained in this work have shown that micro – ICP can be operated at compromised conditions for the determination of a variety of elements with low limits of detection. Interferent effects have been shown to be minimal in the micro – ICP system. Bamiro and Marshall (1995).

EXTENSION OF TORCH LIFE SPAN IN ICP-AES

As an alternative to the foregoing approach, an attempt had been made by the author to extent the life span of the normal Philips ICP torch which is continuously faced with the problem of melting at a very high temperature of the plasma (6,000 – 10,000K). The torch is expensive (₦25,000) and requires constant change due to melting. The authors observed that the part melted is about 2.0mm above the coil, without affecting the coolant, plasma and carrier gas flow pipes. A modified head (a cap) was constructed to replace the damage part of the torch. Evaluation of the repaired torch was carried out and compared with the normal standard Philips torch. (Bamiro F.O., Littlejohn D., and Marshall J. Patent 34 to Pye Unicam. 1984).

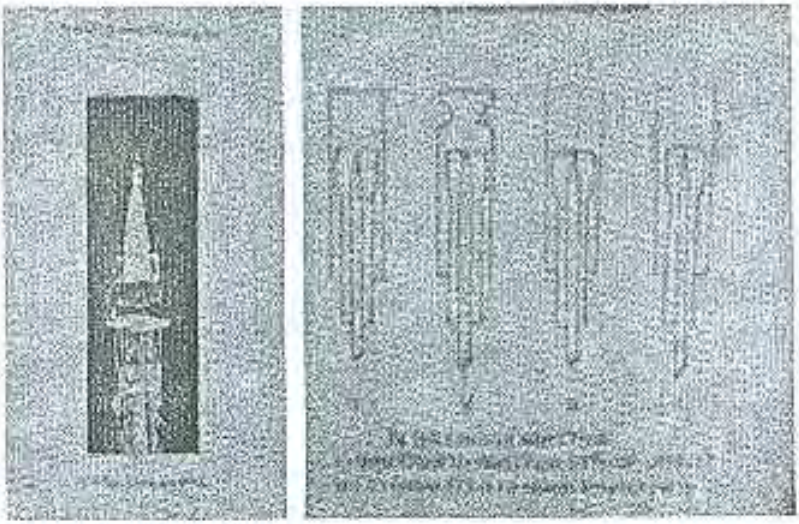


Fig. 6: Correction of Melted ICP Torch.

The modified torch compared favourably well with the standard Philips torch. The study indicated that its is possible to amend a melted standard Philips torch by simple device and at the same time give analytical results comparable to the new standard Philips torch. The work really prolonged the life span of ICP torch without any loss in sensitivity. It also gives sanity to the user of the instrument who is always faced with constant loss of torch and constant delay in analytical work. A ready-made modified demountable glass cap really solved this problem of continous analysis. Bamiro F.O. and Little John David (1994) [32].

A CRITICAL EXAMINATION OF THE ANALYTICAL SIGNIFICANCE OF BACKROUND INTENSITIES AND RSD ON DETECTION LIMITS AT DIFFERENT WAVELENGTHS.

Most spectrochemical analysts wish to optimise their equipment for best analytical performance. Different methods used successfully for optimisation include alternating variable research methods, simplex method, modified simplex methods and univariate method. All these methods tried to achieve the goal of establishing the best working conditions in terms of interferent free zones and also good detection limits(DL). In determining this factor (DL), background and relative standard deviation of both the analyte and free solution determine this factor. Boumans[33] described two possible methods of determination of detection limits as:-

$$DL_1 = \frac{2 \times SD_0}{SLOPE}$$

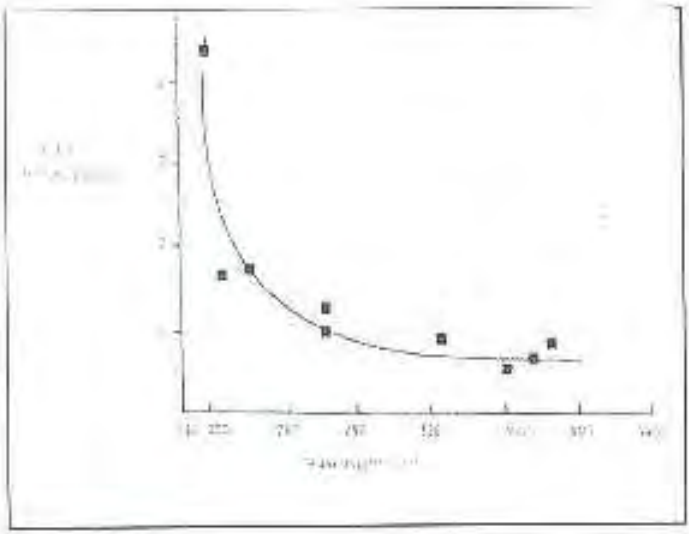
$$DL_2 = \frac{.02 \times X_B}{SLOPE}$$

Where SD_B = Standard deviation of the background (X_B). The SLOPE = slope of a linear calibration graph of net signal (X_{NET}) intensity against concentration. Boumans also indicated that the RSD of background is approximately = 0.01.

A study was carried out to establish the correlation between the standard deviation and background intensity at a very wide range of wavelengths of different elements. Also to establish the effect

of these parameters on detection limits as established in analytical measurements by Bourmans.

It was established for most elements that the RSD decreases as the wavelength increases and remain almost constant ~ 1% RSD for a very wide range of wavelength, (see Fig. 7). A range of 4% to 1.6% RSD was observed for element with wavelength lower than 250nm. However, a systematic departure of the background RSD from the approximately 1% level showed marked effect on detection limit. The higher values gave poor detection limits. It was also established that detection limit (DL_2) based on approximation of 1% of RSD for all elements are not always correct when it is above 1% RSD value, but reasonable since most lines fall within this range, (Bamiro,1993).



Plot of %RSD versus Wavelength
(Fig. 7)

MINERAL ACID EFFECTS ON THE TRACE ELEMENT DETERMINATION IN ATOMIC SPECTROSCOPY USING LICHEN AND ALGAE CERTIFIED REFERENCE MATERIAL.

Lichen and algae are among materials used as biomonitors in pollution studies. Lichens accumulate our pollutants over long period of time and their use in the highly polluted zones usually furnish data to understand the fluctuations in atmospheric pollution for relatively short periods of time and for small volumes of air. Many investigations have been carried out around smelters, power plants and urban centres using Lichens as biomonitors.

A study has been made of mineral acid matrix interferences in trace element determinations and methods are described for the multi-element analysis of lichen and algae using ICP-AES. Several calibration strategies were compared employing aqueous standards with and without acid using modified ICP instrumental parameters. There was marked depression in analyte signal intensity in all the measurements. It has been shown that signal depressions up to 32% can be observed under normal operating conditions (see Table 6). The depression in the line intensities has been attributed to: (i) changes in the rate of sample uptake due to different physical properties of the solution (ii) variation in the aerosol transport efficiency and (iii) changes in plasma excitation conditions due to increased energy consumption for acid atomization. It has been shown that the acid effect depends on the type of acid and the depression effect increases in the following order $HCl < HNO_3 < HClO_4 < H_3PO_4 < H_2SO_4$

The use of acid matrix-matches standards and internal standard for calibrations substantially reduced signal depression problem in this work. The methods gave elemental recovery from 97.7 to 98.8%. Accurate results were obtained with improved precision when analysis was carried out on certified lichen material from the International Atomic Energy Agency (IAEA), (Bamiro, 2000).[35]

TABLE 6: Effect of ICP parameters on SBR values and % signal depression of 0.5 μg ml⁻¹ of each element in solution with and without acids.

Plasma Parameters	Zn % SBR	Dep	Mn % SBR	Dep	Fe % SBR	Dep	Cr % SBR	Dep	Mg % SBR	Dep	Ca % SBR	Dep	Al % SBR	Dep
Carrier gas flow rate (l min⁻¹)														
0.55	57	32	09	28	135	22	88	27	31	16	21	12	74	8
0.65	77	32	406	33	177	17	81	30	38	13	24	13	87	10
0.75	54	36	231	24	172	18	78	32	36	13	27	15	57	13
0.90	99	26	254	31	185	23	86	32	123	26	28	17	51	17
1.0	31	25	150	42	121	31	16	48	100	47	15	19	53	17
Power/kW														
1.10	77	28	312	33	169	19	40	22	93	16	33	10	51	11
1.20	75	32	370	24	172	15	72	21	89	12	27	10	52	9
1.30	79	30	430	23	178	17	81	29	119	13	27	13	88	10
1.40	72	29	430	28	163	27	86	26	127	16	25	10	92	6
1.50	69	29	434	26	149	21	96	26	101	13	25	11	82	7
Plasma gas flow rate (l min⁻¹)														
12	75	30	412	21	174	19	79	19	116	14	26	11	82	5
13	75	27	407	24	170	21	81	22	115	18	29	10	87	11
14	70	31	431	25	167	22	77	18	103	16	23	14	79	14
15	70	26	392	25	169	24	74	24	114	20	21	15	77	13
Observation height/mm														
8	62	29	191	31	75	22	54	28	87	19	26	11	75	5
10	62	28	267	29	75	16	78	26	92	17	33	14	70	5
12	79	30	288	29	107	22	95	27	110	17	22	9	81	7
14	82	31	354	27	109	19	87	21	113	14	30	6	80	8
16	99	22	419	25	205	15	69	25	129	17	34	10	57	8

Dep: Depression; Zn (λ=213.856nm); Mn (λ=257.610nm); Fe (λ=259.9nm); Cr (λ=267.716nm); Mg (λ=280.270nm)

FOOD ANALYSIS

FORTIFICATION OF CORN-FLOUR FEED AS INFANT FORMULATE SUBSTITUTE

Infant formulae have become culturally acceptable as part of the diet[26]. In some developing countries of the World, however, most low income workers who cannot afford the high cost of commercial infant formulae resorted to the use of corn flour varieties as substitute. This is because the corn flour varieties are cheaper and readily available. The inadequacy of food for infants and children during the weaning period continues to be a major problem on developing countries. If growing children do not have sufficient protein in addition to sufficient energy intake, they may suffer growth restriction, protein energy malnutrition and mental retardation in severe cases [35].

In Nigeria, all mothers breast feed their babies at least for the first 3 months of life, unless there are circumstances which prevent this[27]. Some infants sustain excellent growth over the first 9-12 months of life despite breast milk being their source of nutrition[28,29]. Most infants however, fail to show satisfactory growth after 4-6 months unless flour intake is supplemented with other foods. The infant formulae (milk) substitutes are very expensive, and women from low income group in Nigeria tend to reduce the level of intake or neglect totally by shifting to very cheap alternatives.

Eight different brands of popular infant formulae and two corn-flour, infant feed varieties commonly consumed in Nigeria were

analysed for K, Na, Ca, and Mg. Results obtained showed that high amounts of sodium, potassium and calcium (Na, 1.8-3.5, K, 4.1 -7.5; and Ca, 1.2-6.0mg g^{-1} formular, respectively and low amounts of magnesium (Mg, 0.5 - 0.9 mg. g^{-1} formula) are present in the infant formulae. The corn-flour types have considerably lower amounts of these mineral elements (Na, 0.3 – 0.4; K, 0.3 - 0.5, Ca, 0.2 and Mg, 0.2-0.3 mg.g^{-1} flour, respectively) (see Tables 7 and 8). (Bamiro, and Fatoki, 1990). [41]

Table 7: Na, K, Ca and Mg Contents in Infant Formulae: Comparison of survey Results with Manufacturers' Levels (mg constituent/g formula)

Brand	Survey result				Manufacturers' level			
	Na	K	Ca	Mg	Na	K	Ca	Mg
Ismil	2.9	5.7	5.7	0.7	2.5	5.4	5.3	0.4
Cow & Gate	3.6	7.5	6.0	0.7	2.0	7.4	5.3	0.5
Nan	2.5	4.2	4.1	0.9	1.3	5.7	4.0	0.4
My Boy	3.1	4.1	4.5	0.6	2.4	7.7	7.5	0.6
SMA	3.2	5.8	1.2	0.6	2.0	7.4	5.6	0.4
Similac	3.0	7.2	4.0	0.5	1.6	5.1	4.2	0.3
Friedlac	1.8	4.3	3.0	0.7	1.9	5.2	6.0	0.5
Dielac	2.3	6.2	6.0	0.7	1.9	5.2	6.0	0.5
Overal mean	2.8	5.8	4.4	0.7	1.8	5.3	5.2	0.4
Standard deviation	0.6	1.5	1.7	0.1	0.4	1.2	1.3	0.1

Table 8: Na, K, Ca and Mg Contents of Corn-Flour Infant Feeds (mg constituent/g flour)

Brand	Na	K	Ca	Mg
Millet flour	0.4	0.5	0.2	0.3
Corn flour	0.3	0.3	0.2	0.2
Overall mean	0.4	0.4	0.2	0.2

Further work was carried out on the corn—flour feed varieties commonly consumed in Nigeria and were fortified with dry white crayfish (*Pinnens notialis*), red crayfish (*Macrobrachium macrobium*) and Tilapia. Eight different brands of popular infant formulae and the fortified corn meals were analysed for fats, protein, carbohydrate and nutritionally valuable minerals.

The results on fat, protein and carbohydrate contents in the formulae determined in the laboratory and the level given by the manufacturers are presented in Table 9 while those for the mineral elements are shown in Table 10. The laboratory results were in reasonable agreement with the levels given by the manufacturers for all the infant formulae. The results indicate that the formulae are good sources of sodium, potassium and calcium (Na, 1.1 – 3.6; K, 4.1 – 7.2 and Ca, 1.2 – 6.0mg. g^{-1}). The magnesium content is, however, low (0.5 – 0.7 mg. g^{-1}).

Table 9: FAT, PROTEIN AND CARBOHYDRATE CONTENTS IN INFANT FORMULAE COMPARISON OF SURVEY RESULTS AND MANUFACTURER'S LEVEL (% BY WEIGHT)

	Laboratory results			Manufacturer's Level		
Brand	Fat	Protein	Carbo-hydrate	Fat	Protein	Carbohydrate
SMA	22.0	10.23	61.1	27.70	11.9	55.4
S-Milac	22.5	10.20	52.4	27.40	11.4	55.8
Friolac	17.5	9.26	62.1	–	10.6	-
My-boy	25.6	10.06	70.0	29.0	11.70	54.2
Babena	5.51	2.86	60.1	5.5	17.0	66.0
Nutrend	5.51	4.22	66.0	5.0	15.0	64.0
Cerelac	5.51	3.74	69.0	5.0	15.5	67.4
Frisa Cream	14.5	12.67	70.0		15.5	64.0
Overall	16.3	7.10	61.3	1.5	13.7	60.1

Table 10: Na, K, Ca, Mg CONTENTS IN INFANT FORMULAE COMPARISON OF SURVEY RESULTS AND MANUFACTURER'S LEVELS (mg CONSTITUENTS/g FORMULAE)

	Laboratory results				Manufacturer's Level			
Brand	Na	K	Ca	Mg	Na	K	Ca	Mg
SMA	3.2	5.8	1.2	0.6	2.0	7.4	5.6	0.4
Similac	3.0	7.2	4.0	0.5	1.8	6.1	4.2	0.3
Frisolac	1.8	4.3	3.0	0.7	1.1	4.2	3.5	0.4
My-boy	3.1	4.1	4.6	0.6	2.4	7.7	7.5	0.4
Babena	3.6	7.2	5.0	0.6	-	-	-	
Nutrient	1.6	6.8	5.2	0.5	1.5	5.8	3.1	-
Cerelac	1.9	6.7	6.0	0.4	1.7	6.5	5.4	-
Friso Cream	1.1	3.2	2.8	0.5	-	-	-	-
Overall	2.4	5.7	4.1	0.5	1.8	6.3	4.8	0.4

Similar elements are also present in the corn flour infant feed which is presented in Table 11 except that the values are much lower. (Na, 0.3-0.4; K, 0.3-0.5, Ca, 0.2 and Mg, 0.2-0.3 mg. g^{-1}). The fat content of corn-flour feed ranged from 4.0 – 5.6% while protein accounted for 7.5 – 8.28%. These values are also lower than that for the commercial infant feeds. The carbohydrate content is however higher (82.0 – 84.6%). The analytical data of Tilapia and crayfish is presented in Table 12. The result indicate moderate levels of fat (7.5 – 1.5%), low carbohydrate (21.9-30.0%) and high protein (50.75-53.64%) compared with either infant formulae or corn flour. Similarly, elements were also higher (Na, 13.0 – 18.4, K, 12.5-16.; Ca 27.8 – 44.0, Mg 1.12-2.0mg.g^{-1}.

Table 11: FAT, PROTEIN, CARBOHYDRATES AND MINERAL CONTENTS OF CORN FLOURS (DRY WEIGHT)

	Percentage by weight			mg Constituents/g flour			
Flour	Fat	Protein	Carbohydrate	Na	K	Ca	Mg
Millet	4.5	7.5	82.0	0.4	0.5	0.2	0.3
Corn	6.5	8.28	84.0	0.3	0.3	0.2	0.2
Overall Mean	6.0	8.0	83.0	0.4	0.4	0.2	0.2

Table 12: FAT, PROTEIN, CARBOHYDRATES AND MINERAL CONTENTS OF DRIED TILAPIA, WHITE RED CRAYFISH (DRY WEIGHT)

	Percentage by weight			mg Constituents/g flour			
Fish samples	Fat	Protein	Carbohydrate	Na	K	Ca	Mg
Tilapia	7.5	59.6	30.0	12.0	16.0	27.8	1.1
White crayfish	10.5	52.4	22.0	14.5	15.0	37.0	1.6
Red crayfish	6.0	53.6	21.9	188.4	12.5	44.0	2.0
Overall Mean	9.0	52.0	25.0	15.0	14.0	30.0	1.5

The results for the analysis of fortified corn-flour are presented in Table 13. All the commercial samples compared well with the sueveyed samples. The sample with ratio 4:1 (Corn-flour: white crayfish) gave the closest and most acceptable results compared with infant formulae. There was marked improvement in the protein value (17.1%) compared to corn flour (8.0%) and average infant formulae (11.6%). The fat content in the mixture was lower than the average value for infant formulae. However, a higher carbohydrate value of 70.82% was obtained in the mixture compared with the average infant formulae with 61.3%. The calcium level for the 4:1 mixture (7.6 mg.g^{-1}) was higher, compared

to infant formulae (4.1 $mg.g^{-1}$). This may serve as advantage in bone building. The recommended dietary allowance (RDA) in USA for calcium is 360mg for infant while magnesium is 50mg.

Table 13: FAT, PROTEIN, CARBOHYDRATES AND MINERAL CONTENTS OF FORTIFIED CORN FLOUR
(a) CORN FLOUR AND CRAYFISH (DRY WEIGHT)

	Percentage by weight			mg Constituents/g flour			
Corn flour crayfish	Fat	Protein	Carbohydrate	Na	K	Ca	Mg
1:1	8.0	30.1	54.0	7.2	7.1	18.2	0.7
2:1	7.5	22.6	59.7	5.4	5.4	13.4	0.5
3:1	7.3	18.9	57.5	4.1	4.3	10.1	0.4
4:1	7.0	17.1	70.8	3.2	3.1	7.6	0.3

Table 14: FAT, PROTEIN, CARBOHYDRATES AND MINERAL CONTENTS OF FORTIFIED CORN FLOUR
(b) CORN FLOUR AND TILAPIA (DRY WEIGHT)

	Percentage by weight			mg Constituents/g flour			
Corn flour Tilapia	Fat	Protein	Carbohydrate	Na	K	Ca	Mg
1:1	4.1	32.4	50.9	6.5	7.0	13.6	0.5
2:1	3.8	24.5	60.2	7.4	6.6	10.4	0.4
3:1	3.4	20.4	66.6	4.8	5.2	8.6	0.4
4:1	3.1	18.7	71.2	4.2	5.0	5.8	0.2

There are no RDAs established for sodium and potassium, but authorities have recommended that potassium intake should equal sodium intake to counteract the effect of sodium in raising blood pressure. Also, the National Research Council has suggested a daily intake of 1.8 – 5.6g as safe and adequate[41]. This is within the fortified corn-flour feed. In addition, the fortified corn-flour has

an advantage of balanced Na: K ratio (3.2: 3.1) over the averaged infant formulae (2.4: 5.7 $mg.g^{-1}$). The low cost of the corn-flour-crayfish blend (25-30%) over the cost of infant formulae has a great advantage for low income mothers to feed their infants on equally good quality food at much cheaper price.

CONCLUSION AND RECOMMENDATIONS

My research endeavours over the years encompassed the development and evaluation of instrumentation and improvement of detection limits of elements. These novel techniques have enhanced various analytical procedures which solve the day to day problems encountered in often routine analyses of samples. I extended the frontiers of knowledge in ICP by establishing the optimum and compromise conditions needed for the best detection limits for most elements and made it possible for the multi-element analyses of 55-60 elements at once and free from interferences.

My research work led to the development of mini – ICP instrumentation system with demountable torch which costs much less than the often used Philip System. I also extended the life span of the existing Philips torch which is faced with the problem of melting at high operating energy (temp.) of ICP (Ù 10,000K). The newly developed torch gives sanity and confidence to the ICP analyst.

I have on a continuous basis applied singly or jointly my analytical skills generally in the areas of atomic absorption, emission

spectroscopy, chromatography and instrumentation to direct analyses of numerous samples from Nigeria and abroad. These research efforts have contributed extensively to knowledge in the fields of medicine, Agriculture and Food Industries.

Lastly, I authored a book (Basic Intermediate Practical Chemistry) which educates extensively both the students and the Instructors.

Recommendations

Mr. Vice Chancellor, sir, ladies and gentlemen, undaunted in the strong belief that we have a government that just fairly listens to the people and is an improvement over the past government, I bravely affirm that by the grace of God, the best for Nigerian education and Nigerians as a whole is soon to be; because: "It matters not how strait the gate, how charged with punishment the scroll, we are the masters of our fate" I will not be indulged in enumerating what education generally or science can do to a nation. A lot of reports have been released to the Government without receiving proper attention.

The country, Nigeria is endowed with abundant resources; and has no excuse for not being one of the leading nations of the world. But what do we have? Our standard of living is one of the lowest in the World. Nigeria is contending with inadequate shelter, clothing, food shortage, non-functioning of essential services, huge foreign debts and dwindling foreign exchange. As though all these were not enough, there is graduate unemployment, political instability and dwindling economy. Definitely, this is bound to affect our educational system.

We are at a cross-road and we have a choice – throw in the towel and accept defeat, or decide to fight a war of survival which is now imminent and the cause of uproar in our Higher Institution today. The government is still paying lip-service to the funding of education in this country. This is seriously affecting our educational system, and making higher Institutions difficult for Institutions' leaders to operate effectively.

I would like us to realise that the human race has gone through two revolutions; the agricultural revolution and industrial revolution. The advanced nations have again initiated the third revolution which is the information revolution. As a result of the benevolence of these, advanced nations, developing nations which care, are assisted to go through the two previous revolutions (agriculture and industrial) faster than they (the advance nations) did; and every nation must go through these two revolutions. They form an unavoidable portion of the inevitable wall of circumstance. Thus at a CHEMRAWN (Chemical Research Applied to World Needs) meeting in Tokyo, Japan, Mr. Tadahiro Sekimoto, confidently declared, "Today, Japan has finally drawn abreast of the West". I predict however, that any under developed nation which through act of planlessness, or by commission or omition fails to take prompt advantage of the benevolence mentioned above, and allows herself to be caught midstream in the information revolution, such a nation will have committed herself to everlasting servitude and remain in perpetual darkness. With the information revolution, the advanced nations will close the door of science and technology behind them and against us, and henceforth dominate technology in total monopoly because it is clear to all mankind that whoever controls technology dominates the human race.

The question now arises as to what is the major problem militating against Nigeria in taking off to develop our educational system more than what we have now? Mr. Chairman sir, the answers to this problem are numerous, but I would just mention the few examples that are pungent and that touch us most. They are the syndrome of BLAMING, UNIONISM and FINANCE.

BLAMING: I would like to use this occasion to comment briefly on a negative syndrome in our national polity which has eroded our values, and virtually made us impotent in taking badly needed practical and concrete actions to put the ship of the nation on a steady course. I call this, the syndrome of BLAMING. The civilian blames the past military regimes for our national predicament, while the military faults politicians. The North blames the South for lack of national cohesion while the South accuses the North of monopoly of political power. The East blames the West as the cause of its misfortune, while the West accuses the East for being opportunists ever ready to exploit past electoral setbacks. The follower-ship blames the leadership, workers blame the Unions, while the Unions accuse the Government. Christians blame Muslims and vice-versa. The students blame Government and University authorities for their predicament while those in turn blame the students for indiscipline.

As we develop this syndrome of BLAMING into a national epidemic, the nation turns to a state of paralysis. Nothing works again. Crime is rampant. There is close to a breakdown of law and order. Private interest has totally overtaken public interest. The result is massive corruption and diversion of the resources of the people of Nigeria. The end result, which is most dangerous,

is that in looking for solutions to these problems, we all blame everybody else except ourselves. Which takes us back to square one and extends the vicious cycle.

What role has education got to play in this? It is my considered opinion that we cannot begin to make progress until the leadership everywhere has purged itself of the syndrome of blaming and begins to take decisions that will reflect equity and fairness to all interest groups. We need to start marketing a system of values in our children, and to compliment this with the right educational orientation. We must begin to lay down the fundamentals of good values, sound and qualitative education, honesty, discipline and hard-work right from the kindergarten through primary, secondary, and tertiary levels of education. Unless the collapse in the value system in our schools is redressed the deterioration in our national life will remain irreversible.

UNIONISM: According to the school of thought in political science, politics is born out of the economic concept of insatiable wants in the realm of limited resources not commensurate to the wants. This culminated into the existence of an organisation of the possessing class for protection against the non-possessing class. Unions (Labour, students, non-academic and academic) are formed in Institutions to fight for their rights and make their own quota felt for the development of the nation. In the history of Nigeria, these Unions have rendered valuable contributions to the struggle for liberation and national development. The Higher Institutions Unions are cardinal source of manpower, endowed with leadership potentials; they can acquire knowledge and are impregnated with future promises.

Despite the fact that the contributions of these Unions are conspicuous, the positive contributions remain unidentified and uncherished by unprogressive Nigerians who never see anything good in whatever comes from the handlers of Higher Institutions. Hence, there is constant crisis.

I strongly advise the Unions of Higher Institutions to be aware of the fact that there is tactics of "divide and rule "on ground as at now. No nation standing against itself can survive. I advise the academic Unions to adopt the method of "Sit down and Lock" or withdrawal tactics to redeem its image for the time being. Unions should exercise patience, be brief, objective and rational in their demands, if any as at now. Again, however genuine, fault proof and academically sound our demands are, at Local and National levels, we should try to give room for dialogue. We must try as much as possible to condone, swallow our prestige, shelve our personal gains a times to give room for a good atmosphere conducive for dialogue to work. I strongly advise against strike either short or long in Higher Institutions as at now. Such strikes negate our good intentions and put us in bad light to the detriment of good intention we initially had. Constant and prolonged strikes have eroded our values and portray us as unserious set of people. Not only this, it badly affects our academic output to the detriment of the good role Higher Institution stands for in any nation.

I also use this medium to advise the government that if they are prepared to perpetuate peace in this country, they should learn to handle Unions especially in the higher Institutions with understanding, affection, patience, care, free mind, caution and objectivity. Government should note that higher Institution Unions are not irrational human beings or trouble shooters at all, but have

objective minds and are out to resist any attempt to make their future bleak.

FINANCE: Research is one of the major pre-occupations of any University, apart from teaching and service to the community. The pre-eminence of research among these other responsibilities cannot be over emphasized. Research is an essential component of human activity, not only as a manifestation of the human condition but also as a foundation of the well-being of individuals and society. I would like to highlight further from that of a distinguished Nobel Laureate in Chemistry in 1997, Dr. Michael Smith Killam. Professor, University of British Columbia.

I quote

(a) "Universities have unique roles to play in research and discovery and in the learning of by young minds and bodies of the intellectual skills, vigour, ethics and technology of research; and in the encouragement of young researchers to follow their instincts and intuitions.

(b) Research often has applied societal benefits; the direct achievement of such benefits should not be sole "raison d'etre" of university-based research or even the major reason".

The import of these statements is that Research is a necessary tool for development both human and society at large.

Mr. Vice-Chancellor sir, Ladies and gentlemen, funding of Universities especially in the area of scientific research is capital

intensive and the country must make huge investment so as to yield dividents. Presently, less than 1% of the gross national product (GNP) is spent on research. Nigeria, like most developing countries spends as much as 20% on armament and the armed forces. The research career structures that could attract capable and talented people are lacking in developing countries, especially the ECOWAS region. However, Nigeria is an exception, possessing abundant human resources and talented individuals such as you, the Distinguished academic and audience present here today. Therefore, one may ask the question "why the low ebb of scientific research activity or financing in Nigerian Universities" at the present moment. The reasons are not too far fetched. Firstly, there is poor funding of our Universities. The present government's response is actually an improvement in the university over the past governments in terms of welfare, but very poor in financing research. Many have propounded theories and approaches on ways to promote scientific research in our universities; but we have not achieved the desired goals yet. If care is not taken now, we are gradually working towards TOTAL academic collapse in this country. It is not the buildings that make the University but the stuff of materials (human, equipment).

We can only make progress provided that we establish enabling working environment that will promote efficiency in the three-tiers of functions in the University (research, teaching & extension). Again such environment should be devoid of corruption, nepotism, transparent accountability and honesty. These are societal-evils that have bemoaned the academic communities in Nigeria. A Few of the human traits required in research are intellect, commitment, devotion and humility. These are

indispensable traits for the establishment and nurturing of scientific culture in the University. Thus, the young academics should be encouraged to acquire these traits as early as possible in their academic career pursuits.

Secondly and lastly sir, scientific research can be enhanced by increased academic interactions with academic colleagues in developed countries, for example, USA, Canada, Europe, Germany and Britain through exchange programs of visits and lecturers, using scholarship etc. This will foster better understanding of the local problems facing Nigerians intellectuals; expose the individual researchers to the more sophisticated equipment and technology and also lead to the quick acquisition or improvement of technical skills by the researcher. The government should be fast enough now to resuscitate Federal government scholarship for postgraduate students to train students overseas, where they will make use of sophisticated standard equipment. Special preference should be given to junior lecturers who are already in the Higher Institutions. In support of this gesture, government should finance universities to purchase such sophisticated equipment at the same time to benefit those already on ground and those on scholarship when they return back to Nigeria.

ACKNOWLEDGEMENTS

Mr. Vice-Chancellor Sir, Distinguished Ladies and Gentlemen, I would like to recognize at this juncture some of the notable people who have touched my life and contributed to making me what I am today. If I do not mention your name specifically, please forgive

me, limited time and space given to me has not allowed me to mention every notable person.

First of all, I wish to give honour and glory to God through our Lord Jesus Christ for sparing my life and for giving me good health to witness this wonderful day and for granting me this opportunity to give the Inaugural Lecture which had been postponed several times due to academic and economic reasons.

My foremost thanks go to my parents, Late Mr. Julius Yemitan Bamiro and Madam Abolaji Adumadan Bamiro, nee Joshua Talabi (now 84 yrs) all hale from Ijebu-Igbo. When I reflect on my early days and consider my parents' struggle financially and spiritually to educate me as the first born and also the junior ones. I give thanks to God for their courage and ability to see me through to A level that I was able to fend for myself. My father was a goldsmith and by virtue of his profession, he had just only three wives. My mother who was the first wife had five children and the second had four and the last two. My father was very hard-working and loved to give education to his children, but his large family (polygamous) militated against him. He eventually adopted the method of training every child up to school certificate level. For anyone to go further, you relied on your mother. My father joined his ancestors on the 23rd of May, 1980. Although he is not here today to witness this occasion, his bones will rejoice in the grave because of his flair for education. May his soul continue to rest at the bosom of Jesus Christ. I seize this opportunity to thank my mother, popularly called ***mama elelo***. She is a successful trader in food items (bags of rice, beans, pepper, onion etc). She was able to train us up to University level, despite the fact that, she is

an illiterate. May God continue to give her strength to enjoy the fruit of her labour

I also wish to acknowledge my brothers and sisters for the support. I am particularly grateful to my immediate younger brother, Prof. Femi Bamiro and the wife. I really appreciate your worth, academic support, tolerance and responsible role being played in the family. I also appreciate my sister, Mrs. Moradewun Oworu and also the husband who had kept faith with my sister in their marriage for over 25 years. My late sister, Mrs. Mojoyin Kaka is fondly remembered, may her soul rest in perfect peace. I also appreciate the last born of the family Mr. Mabayoje Bamiro and the wife. I also extend my sincere gratitude to Mr. Wahab Agbatogun (the Tailor) and Mr. M. Adedeji, Works and Services Department UNILAG for their contribution towards my education at UNILAG. I also appreciate, Dr. Soji Vaughan, General Manager, Agro Services. He is a very respectable gentleman and was once my student at Molusi-College and later in life my confidant.

I also cherish my association with Dr. & Mrs Ayodeji Ogunbayo. Similarly, I appreciate my cousin Dr. and Mrs. S.O. Talabi (TALON), and my in – laws, Mr. and Mrs. Gboyega Ogundipe and Mr. & Mrs. Oladewa. May God Almighty continue to bless you all.
I appreciate all my teachers and colleagues at All Saints' Primary School, Ijebu-Igbo, Molusi College, Ijebu-Igbo, especially my set, the independence set of 1960. The Universities of Lagos, Manchester and Glasgow. In particular, I am grateful to several past and present lecturers of the Chemistry Department, University of Lagos and the following personalities.

(i) Chief Victor Sijuade Talabi, who identified my potential as a kid in the primary school and encouraged my mother, who is the immediate sister in seeing me through my academic career. I am grateful to him and the two wives.

(ii) Mr. Olatunde Balogun, my Principal at Molusi-College, Ijebu-Igbo, your words and encouragement were just enough to see me through my academic career. I also seize this opportunity to appreciate the pioneer Principals of Molusi College in the names of Dr. Oluwole Awokoya, Late Dr. Tai Solarin and Late Mr. Olanrewaju

(iii) The Late Mr. O. Onanubosi and Mr. O Ogunnubi who were my dedicated teachers in primary school are highly appreciated.

(iv) The Late Mr. Ayo Alabi, my physics teacher and Late Mr. Ayo Adeyemi also my English teacher at Molusi-College. Both are worthy teachers to remember.

(v) The Late Prof. A. Akisanya, a talented teacher and Professors of Professors. He was the best lecturer, I had contact with throughout my chemistry career. I owed my style of teaching to Prof. Akisanya. I copied him to the last mistake. He joined his ancestor, just in July 2004. May his soul rest in perfect peace.

(vi) Prof. David Littlejohn is the present Head of Pure and Applied Chemistry, University of Strathclyde, Glasgow. I am greatly indebted to Professor D. Littlejohn, my PhD supervisor at Strathclyde. He is the main architect of my

research capability in Analytical Chemistry. He is unavoidably absent here today but he sent his good wishes from Britain where he resides. Thank you sir, in absentia.

The late Prof. John Ottaway and Dr. John Marshall were my co-supervisors too for my PhD work. They are highly appreciated for their brilliant ideas shared during my research work.

I thank God for my colleagues with whom I have exchanged ideas or published papers. I acknowledge Prof. S.O. Awonorin, Dean of COLAMRUCS, Prof. M.T. Adetunji, Dean of COLPLANT and Mr. M. Folarin and other members of the Department of Chemistry, all from UNAAB. I also appreciate Prof. R.A. Oderinde, Prof. Segun Ekundayo, Dr. Kayode Adebowale, Prof. Dele Osibanjo and Prof. B.B. Adeleke, all from University of Ibadan.

I also appreciate my colleagues from FUTA, Prof. Kola Ipinmuroti. He is a true, dependable and real long time friend. Others are , Prof. A. A. Oshodi, Prof. Lajide and other members of the department.

I cherish my association with other researchers overseas. I thank them greatly for inviting me on several occasions to exchange ideas in Advanced analytical programmes.

I appreciate the following:

(i) Dr. (Mrs). Benzo, Department of Chemistry, University of Venezuela, IVIC, Caracas, in South America.

(ii) Prof. David Littlejohn, Department of Applied Technology, Strathclyde, Glasgow, Britain

(iii) Dr. A. Kowkoski, IFW, Dresden, Germany

(iv) Pye Unican, invitation to attend

(a) Royal Society of Chemistry meeting at University of Edinburgh, Britain (1982)

(b) Royal Society of Chemistry meeting at University of Loughborough, Britain (March, 1982).

I salute all the colleagues I have had to work with especially the teaching and non-teaching staff of UNAAB for tolerating me. I thank the University (UNAAB) for creating a conducive academic environment to achieve my aim. I thank all my past and present students especially the Great UNAABITES. Words are inadequate to express my gratitude to you. You have been wonderful and I love you all.

Finally, I wish to give glory to the Almighty God for giving me Bola Amoke Oyefunke nee Olanipekun as a wife, a loving mother, a help-mate, a virtuous woman, very accommodating, trusting and hardworking. To quote the sage of Chief Obafemi Awolowo, she is a 'jewel of inestimable value". She is presently the Director of Oyo State Water and Sanitation (WATSAN) Project. Thank you for coping with my character and for moral support always. I seize this opportunity to thank my parents-in-law, Deacon and Mrs. T.O. Olanipekun. They are just fantastic. They put all my children through simple Arithmetic and English right from Primary School while I was away overseas for further studies. Mama is 84 years old now, while Papa is just 95 years. Special thanks also go to my children.

(i) Dr. Olujide Bamiro who is presently studying at Colombia University, New York, USA. He is pursuing Postgraduate studies in Internal Medicine with speciality in Cardiology.

(ii) Engineer Oluyinka Bamiro who is presently pursuing Postgraduate Studies in Mechanical Engineering at University of Toledo, Ohio, USA

(iii) Miss Olusola Bamiro, the baby of the family, who is a pharmacist and has just finished her NYSC service at ILORIN.

Those children are a source of joy to me. They all listened to instructions and were very obedient. They did not give me much problems as I did to my parents. I love you all, and May the Almighty God care for you always. Amen.

Now unto the King Eternal, immortal, invisible, the only wise God, be honour and glory forever and ever. Amen (I Tim. 1[17]).

Mr. Vice-Chancellor, Sir, Distinguished audience, Ladies and Gentlemen, thank you all for your attention and God bless. Kindly join me to sing this song before closing.

E se ibi te ti bere

E se ibi te ti bere
E se ibi te ba de
Adupe o JESU

Ibi te ba wa lo (2ce)

REFERENCES

1. First Inaugural Lecture delivered by Prof. Julius Okojie at UNAAB (1995)

2. Eight Inaugural Lecture delivered by Prof. Ola Adams at UNAAB (1998)

3. Heaton, C.A. (1987) (ed); An Introduction to Industrial Chemistry, Leonard Hill.

4. P.W.J.M. Boumans, Proface of "Slavin Issue" Spectrochim. Acta. 44B, No 12, P.1205 (1989).

5. Greenfield, S., Jones. I.L. and Berry, C.T., Analytst, 89, (1964), 713.

6. Vondt, R. and Fassel, V.A.: Analytical Chem. 37, (1964), 920.

7. Broekaevt, J.A.C.; Spectrochim Acta, 36B (1981), 563.

8. Boumans, P.W.J.M. Spectrochim. Acta, Part B, 1981, 36, 16.9

9. Fernando, L.A., Spectrochim Acta, Part B, 1982, 37, 859.

10. Bamiro, F.O. Littlejohn, D., Marshall, J. and Ottaway J.M. Anal. Proc., vol 2, 602, (1983).

11. Chapman, G.F., Dale, L.S and Whittom, R.N., Analyst, (London) 98, 529 (1973).

12. Bamiro, F.O. International Journal of Chemistry (1995).

13. Bamiro, F.O. Littlejohn, D. Marshall J. Journ. Of Anal. Atomic, Spectrosc. Vol. 3, (1988) 279.

14. Wendt, R.H. and Fassel, V.A.: Anal Chem 41, (1969), 1021.

15. Gunn, A.M., Millard, D.L. and Kirk bright, G.F.: Analyst, 103 (1978), 1066.

16. Thompson, M., Pahlavanpour, B., Walton, S.J. and Kirkbright, G.F.: 103, (1987) 568.

17. Kniseley, R.N., Amenson, H., Butler, C.C. and Fassel, V.A.: Appl. Spectrosc., 28, (1974), 288.

18. Meinhard, J.E.: ICP Information Newslett., 2, (1976), 163.

19. Valente, S.E. and Schrenk, W.G: Appl. Spectrosc., 32, (1978), 1.

20. Scott., R.H.: ICP Inf. Newslett., 3, (1978), 425.

21. Bamiro, F.O.: International Journal of Chemistry, Vol 2, No 1 (1991), 7.

22. Bogdain, B.: ICP Inf. Newslett., 3, (1978) 491.

23. McQuaker, N.R., Kluckner, P.D. and Change, G.N.: Anal. Chem., 51, (1978) 888.

24. Donohue, D.L. and Carter, J.A., Anal. Chem., 50, (1978), 686.

25. Winge, R.K., Fassel, V.A., Kniseley R.N., Dekalb, E. and Haas, W.J., Spectrochim Acta, 32B, (1977), 327.

26. Garabarino, J.R. and Tailor, H.E., Appl. Spectrosc. 33, (1979), 220.

27. Brown, R.J. (1981), Development in Atomic Plasma Spectrochemical Analysis, Ld: Barnes, R.M., P485, Heyden, London.

28. Bamiro, F.O.: Discovery and Innovation (1995) 109.

29. Boumans, P.W.J.M.: Spectrochim Acta 37B, 75 (1982).

30. Montaser, A., Fassel, V.A., and Zalewiski, J., Appl. Spectrosc., 35, 292 (1981).

31. Boumans, P.W.J.M. and De Boen F.J., ICP Inf. Newslett. 3, 228 (1977)

32. Bamiro, F.O. and Littlejohn D.,: Journal of Industrial Research vol 37, 1994., Pg 392.

33. Boumans, P.W.J.M.: Spectrochim, Acta. 36B, (1981), 169.

34. Bamiro, F.O. and Littlejohn D.,: International Journ. Of Chem. Vol 4, No.4, (1993), 129.