CHEMISTRY FOR INDUSTRY, WEALTH AND LIFE

An inaugural lecture delivered
at the University of Ibadan

on Thursday, 28 July, 2011

By

ROTIMI AYODELE ODERINDE
Professor of Industrial Chemistry
Faculty of Science
University of Ibadan
Ibadan, Nigeria.

UNIVERSITY OF IBADAN

Ibadan University Press
Publishing House
University of Ibadan
Ibadan, Nigeria.

First Published 2011

ISBN: 978 – 978 – 8414 – 58 – 2

Printed by: Ibadan University Printery

The Vice-Chancellor, Deputy Vice-Chancellor (Administration), Deputy Vice-Chancellor (Academic), Registrar, Librarian, Provost of the College of Medicine, Dean of the Faculty of Science, Dean of the Postgraduate School, Deans of other Faculties, and of Students, Distinguished Ladies and Gentlemen.

Introduction

I feel particularly honoured to stand before this great audience to deliver the 13th inaugural lecture in the 2010/2011 series on behalf of the Faculty of Science. It is a rare privilege which I humbly accept with all sense of responsibility. I give adoration to God Almighty who appointed today for the honour and privilege in this great iconic symbol of academia, the Trenchard Hall. Kindly permit me to thank the Dean of Science, Professor K.O. Adebowale who incidentally was my first PhD graduate, for his support in making this lecture a reality. As you might have guessed or inferred from the kind and generous citation given of me by the Vice-Chancellor, today's lecture is a significant one, not only because it is the first inaugural lecture from Industrial Chemistry Unit, but also that it is to be delivered by the first Professor of Industrial Chemistry from the Department of Chemistry of this great University. The two "first" attached to this occasion make it a unique one. The other unique aspect of today's lecture is the fact that among the distinguished audience attending this lecture are some of my former research students in Industrial Chemistry, who today are occupying Professorial Chairs in various universities in the country.

Mr. Vice-Chancellor, Sir, in this and other universities, it is traditional of many inaugural lectures to carry titles which have disguised meanings, at least to readers who are not specialists in the particular discipline. The purpose of this, according to Jibowo (1989) is to win the hearts of readers who could then be encouraged to attend the lecture, so as to arouse the level of curiosity and expectancy with which inaugural lectures have come to be identified. Thus, we have come across titles such as,

“In search of the original Jesus”
“A peep into the Garden of Eden’
“A gentle invitation to chaos”
“A place for everything”

After due and painstaking consideration, I have therefore chosen for this inaugural lecture, the title “Chemistry for Industry, Wealth, and Life”. This title is a pointer to my research endeavours since joining the University of Ibadan, and to the contributions I have made through chemistry, to industry, wealth and life.

There is certainly no doubt that a lot of people seem not to realize the relevance and, more importantly, the place of chemistry in a nation’s economy. Frankly speaking, chemistry is indispensable to industrial growth and national development. At this point, I would like to pay tribute to all the preceding inaugural lecturers from the great Department of Chemistry for their unique presentations of various views from chemistry.

Chemistry

Chemistry is the science of matter and the changes it undergoes. The science of matter is also addressed by physics, but while physics takes a more general and fundamental approach, chemistry is more specialized, being concerned with the composition, behaviour (or reaction), structure and properties of matter, as well as the changes matter undergoes during chemical reactions. Chemistry is a physical science and is sometimes called "the central science" because it connects the other natural sciences such as astronomy, physics, material science, biology and geology. The structure of objects we commonly use and the properties of the matter we commonly interact with are a consequence of the properties of chemical substances and their interactions. For example, steel is harder than iron because its atoms are bound together in a more rigid crystalline lattice; wood burns or undergoes rapid oxidation because it can react spontaneously with oxygen in a chemical reaction above a certain temperature; sugar and salt dissolve in water because their molecular/ionic properties are such that dissolution is preferred under the ambient conditions. The transformations that are studied in chemistry are as a result of interactions either between different chemical substances or between matter and energy. Disciplines within chemistry are traditionally grouped by the type of matter being studied or the kind of study. These include inorganic chemistry, organic chemistry, physical chemistry, analytical/environmental chemistry, industrial chemistry and biochemistry. Many more specialized disciplines have emerged in recent years, e.g. neurochemistry, nanochemistry, computational chemistry, combinatorial chemistry, green chemistry, etc.

How I Started

I came to University of Ibadan from University of Manchester after my PhD in October 1976. My first major assignment was to start Industrial Chemistry Unit under the headship of Professor J. G. Beetlestone. The first five years of this pioneering responsibility could best be described as a teething period. With the assistance of Professor T. O. Bamkole, we paid visits to some industries in Lagos to discuss the idea of establishing Industrial Chemistry Unit in the Department and their expectations of our graduates. This interaction assisted us in producing a robust curriculum for the programme which we commenced in 1983 with six students. The first set of lecturers in Industrial Chemistry included Professor T. O. Bamkole, my humble self, Dr. F. A. Dawodu, Dr. G. B. Oguntimehin and Dr. Mopelola A. Omotoso. The first set of students graduated four years after in 1987. Research work was slow initially, because there were no research facilities in the Unit to work with. In the circumstance, I was advised to move into other viable areas like Physical Organic Chemistry and Spectroscopy where I collaborated and had my first set of publications with the following senior colleagues—Professor J. Hirst, Professor T. O. Bamkole, Professor J. A. Faniran, Professor B. B. Adeleke, Professor I. Iweibo and Professor A. O. Adeyemo. I returned to active research in industrial chemistry when research facilities became available, with my first set of research students engaged in research relating to fermentation, seed oils and fats, crude oil, solid minerals, environmental chemistry, etc.

Fig. 1. Industrial Chemistry Laboratory

This lecture will reflect on six aspects of my research activities which are fermentation, seed oils and fats for edible and industrial uses, crude oil and pyrogenic hydrocarbons, solid minerals, skincare chemistry and the environment. As expected, it will end with acknowledgements.

Production and Optimization of Ethanol and Citric Acid from Fermentation Media

Mr. Vice-Chancellor, Sir, one of my foremost areas of research is the production and optimization of ethanol and citric acid from fermentation media. As we know, there has been a growing need over the years for increased production of ethanol and citric acid due to their tremendous importance to food, pharmaceutical and other allied chemical industries. In recent times, ethanol has become useful as alternative energy source to petroleum for obvious reasons. This explains why we ventured into this area of research.

Ethanol and Citric Acid

The production of ethanol by fermentation routes is inherently associated with low yields, among other problems. The sensitivity of the microbial strains to fermentation conditions like pH, substrate concentration, temperature, nutrients supplementation as well as the possibility of accumulation of toxic products are some of the problems responsible for the low yields obtained via the fermentation routes. In order to address these problems, Oderinde and Esuoso (1988) considered the effect of pH, sugar concentration and temperature on the alcoholic fermentation of sugarcane molasses. Since the presence of trace metals in sugarcane molasses presents a major problem during fermentation, we also considered various ways of controlling the concentration of these metals to satisfactory levels in the substrate. It is generally believed that this can be achieved by passing the crude substrate through ion exchange resins and thereafter adding known concentrations of metal ions. According to Choudhary and Pirt (1966), and Noguchi and Johnson (1963), the method is laborious and subject to failure because the metal requirements by microorganism is only known qualitatively. Slight changes in the environmental conditions like temperature can change the optimal metal ion requirements by microorganisms.

We therefore considered the use of metal chelating agents for the medium (Oderinde, Ngoka, and Adesogan 1986; Oderinde, Esuoso, and Okogun 1990). The metal complexing agents used are ferrocyanide, ethylene-diamminetetraacetic acid (EDTA), cyclohexane-diamminepentaacetic acid (CDTA) diethylene-triamminepentaacetic acid (DPTA) and nitrilotriacetic acid (NTA). These agents were introduced under pilot plant conditions during the three-stage process of inoculation (acclimatization phase), propagation (active growth phase) and fermentation, with the hope of finding an appropriate agent which will improve the yield optimally. Our results indicated that the metal complexing agents acted as metal buffers in the medium producing metal complexes which are in a dynamic equilibrium with the solution and can reversibly dissociate, releasing metal ions at a concentration that is commensurate with the need and growth of the micro-organism. The ethanol concentration increased by over 5% v/v in the fermentation media and CDTA exerted an all-round stimulating effect on the yield of ethanol.

Oderinde, Esuoso and Adesogan (1990) also considered the effect of lipids on the alcoholic fermentation of molasses using *Saccharomyces cerevisiae*. Fatty acids are known to act as growth depressing and stimulating agents. The growth depressing ability has been explained in terms of the acidity of the medium and the disruption of biochemical activities of the cell. The mechanism of growth stimulation was explained either in terms of uncoupling of oxidative phosphorylation or acting as alternative hydrogen acceptors. Our results showed that lipids with high concentration of unsaturated fatty acids considerably increased the concentration of ethanol by over 7% more than control cultures while lipids high in saturated fatty acids inhibited the concentration of ethanol by over 2% compared to control cultures. In our studies, we observed that typical uncoupler, 2, 4-Dinitrophenol did not affect the yield of ethanol. We therefore concluded that the mechanism of stimulation was due to the fact that unsaturated fatty acids were acting as alternative hydrogen acceptors to oxygen during fermentation thereby improving the rate of production of ethanol

Our quest for the production of ethanol from cheap and inexpensive fermentation substrates has led us to explore other cheap substrates. Oderinde and Esuoso (1989) and Esuoso *et al.* (1993) considered the hydrolysis and alcoholic fermentation of the tubers of *Cyperus esculentus*, one of the five worst weeds in the world. The hydrolysis was carried out both in 1M HCl and 1M H_2SO_4 at various time intervals in order to determine the level of sugars produced. In addition, the level of the toxic by-product of hydrolysis, 5-(Hydroxymethyl)-2-furaldehyde, was monitored during the hydrolysis period. It was observed that the level of this toxic by-product was below the tolerance level for yeasts (*Saccharomyces cerevisiae*). Our results also indicated that 252 kg ethanol was produced from 507 kg of reducing sugars per ton of *Cyperus esculentus* tubers. This yield was within 92% of the theoretical possible alcohol yield from hexoses.

In view of the availability and cheapness of *Cyperus esculentus*, citric acid was also produced from the substrate using *Aspergilus niger* Ws 72 strain obtained from the Department of Botany and Microbiology (Esuoso, Oderinde and Okogun 1991). Fermentation was carried out on the orbital rotator shaker, under non-agitated condition and under occasional manual agitation. Our results indicated that the highest concentration of citric acid was accumulated in the un-agitated cultures. This was the first ever report with aerobic microorganism like *Aspergillus niger*.

Chemistry and Technology of Fats and Oils

Oils and fats are mixtures of lipids. They are mainly triacylglycerols accompanied by diacylglycerols, monoacylglycerols and free fatty acids. They may also contain phospholipids, free sterols and sterol esters, tocols (tocopherols and tocotrienols), triterpene alcohols, hydrocarbons and fat-soluble vitamins. Seed oils are used in various industrial applications such as emulsifiers, lubricants, plasticizers, surfactants, plastics, solvents and resins. Research and development approaches took advantage of the natural properties and excellent environmental credentials of these oils which make them outstanding for the numerous possible applications.

In my search for the positive contribution of Chemistry to life, I noticed that there was paucity of information on the composition and utilization of most of the seed oils indigenous to the tropics, which was more of a problem than the real shortage of the oils (Oderinde and Tairu 1989; Oderinde *et al*. 1989). Though we found abundant data in literature on the proximate composition, mineral content and other characteristics of the more conventional seed oils, there was no adequate information on non-conventional, lesser known underutilized seeds and their oils (Oderinde *et al.* 1992). A large amount of these lesser known seeds are discarded as wastes yearly (Oderinde 1988; Oderinde and Tairu 1988). This attitude not only negates their use as potentially valuable resources but also aggravates an already serious disposal problem (Oboh and Oderinde 1989; Oderinde 1990). The wasted seeds and their oils can be quite useful and economically viable, if their properties and compositions are evaluated (Oderinde *et al.* 1994; Ajayi and Oderinde 2002; Ajayi *et al.* 2004).

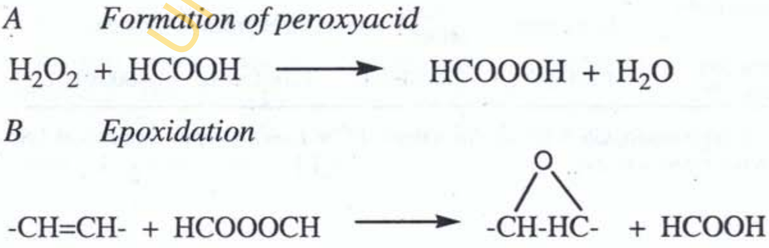
In our laboratory, we have investigated the properties of most non-conventional seeds and seed oils sold in our major markets and the lesser known underutilized ones that are not available in the market (Oderinde and Oladimeji 1990; Oderinde and Tairu 1992). The results of our evaluations were very useful in giving specific classification and unique applications to the seeds and their oils (Oboh and Oderinde 1988; Oderinde and Tairu 1988). As a side attraction, we also examined the properties and the uses of flours of these underutilized lesser known seeds with the ultimate goal of using them in the compounding of animal feed (Oderinde *et al.* 1990; Oderinde *et al.* 1994).

Mr. Vice-Chancellor, Sir, it will interest you to know that our University of Ibadan is rich in economically viable seeds from plants which have been considered to be classified as solid wastes. The seed-bearing plants belong to the *Leguminaceae* family. Over the years, my group has examined these 'solid wastes' (underutilized seeds) and the oils from them (Oderinde *et al.* 2008; Adewuyi and Oderinde 2002; Adewuyi *et al.* 2010). The *Leguminaceae* family has three sub-family members which are: *Caesalpinaceae*, *Mimosaceae* and *Papilionaceae* (Oderinde *et al.* 1989; Oderinde *et al.* 1990). Of the three, the *Papilionaceae* sub-family has the highest yield of oil. We have extracted oils from members of this sub-family, characterized them and used them in various applications (table 1) (Adewuyi and Oderinde 2011).

Production of Surfactant

Surfactants are substances whose molecules contain a hydrophilic group at one end and a hydrophobic group at the other. They are applicable to both edible and industrial products. Edible applications of surfactants include use as emulsifiers or thickening agents. The monostearate and oleate glycerides are used mainly in the food industry where they act as viscosity modifiers and stabilizers that provide texture to processed foods. Industrial applications of surfactants are numerous and they are important components in formulations of agrochemicals, corrosion inhibitors, cosmetics, detergents, lubricants, metal works and oil drilling fluids, polymers, and textile finishes.

Surfactants possess characteristics which can be altered by chemical modifications along the hydrocarbon chain of the fatty acid containing hydroxyl or epoxy functionalities. Fatty acids or their methyl esters react with primary and secondary amines such as monoethanolamines and diethanolamines to produce the corresponding alkanolamides. The alkanolamides are usually used as non-ionic surfactants in the household and cosmetic industries. Industrial applications of surfactants owe a lot to chemical modifications. In our efforts, and on the basis of the *Papilonaceae* family, we have developed reaction mechanisms for the modification of non-ionic alkanolamide surfactants. The Proposed modification reaction steps are given in figures 2 and 3.



A *Formation of peroxyacid*

$$H_2O_2 + HCOOH \longrightarrow HCOOOH + H_2O$$

B *Epoxidation*

$$\text{-CH=CH-} + \text{HCOOOCH} \longrightarrow \overset{\text{O}}{\text{-CH-HC-}} + \text{HCOOH}$$

Fig. 2: Reaction scheme for the synthesis of epoxidised oil.

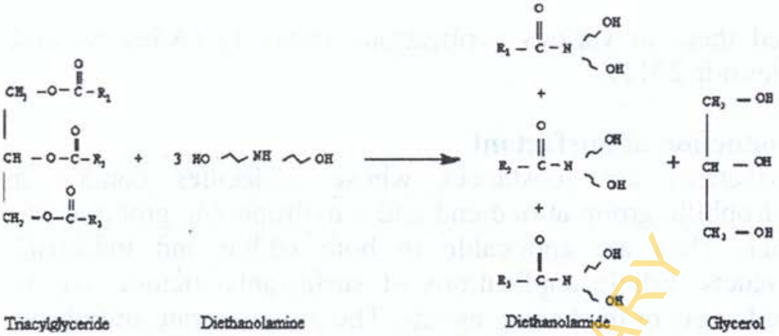


Fig. 3. Reaction scheme for the synthesis of diethanolamide. R_1, R_2 and R_3 are alkyl chains without epoxide(s) functional group.

Table 1: Physicochemical Properties of the *Papilonaceae* Family

Parameter	LS	LC	BN	GS
Free fatty acid (%)	**1.61±0.10**	**1.41±0.50**	**1.23±0.01**	**0.70±0.40**
Acid value (mgKOH/g)	3.20±0.10	2.80±0.50	2.24±0.01	1.40±0.40
Saponification value (mgKOH/g)	195.20±0.50	198.35±0.30	184.80±0.60	197.90±0.70
Iodine value (gIodine/100g)	**166.88±0.80**	**170.46±1.00**	**138.38±0.50**	**128.60±0.40**
Peroxide value ($mgO_2/gOil$)	1.20±0.40	0.80±0.20	1.10±0.40	0.40±0.30
Unsaponifiable matter (%)	1.70±0.50	1.90±0.50	2.48±0.06	1.00±0.20
Mean molecular mass (g)	292.87±1.20	286.11±1.00	299.82±0.10	281.26±1.00
Specific gravity (25°)	0.9720±0.10	0.9600±0.10	0.9215±0.02	0.8760±0.05
Colour (25°)	Light green	Golden brown	Light green	Orange
Refractive index (25°)	1.3900±0.30	1.4500±0.10	1.4810±0.05	1.4000±0.01

BN = *Baphia nitida*, GS = *Gliricidia sepium*, LC = *Lonchocarpus cyanescens* LS = *Lonchocarpus sericeus*

All the members of this family (table 1) have high iodine values which indicate that modification could be carried out on these oils. The high iodine values showed that these oils are highly unsaturated. The unsaturation points are also the points at which different functional groups could be introduced into the oils for different industrial applications. Based on this high unsaturation, we proposed the introduction of the epoxy functional group to the alkanolamide surfactants in order to improve on its properties. The fatty acid composition of these oils also confirmed the unsaturation reflected by the iodine values that were obtained. The oils are rich in linolenic (C18:3) and linoleic (C18:2) fatty acids (table 2). The modification carried out on the oil gave an epoxyalkanolamide with good surface-activities. Aside that these surfactants exhibited good properties, we also found them to show good antimicrobial activities which present them as promising antimicrobial agents (Adewuyi *et al.* 2011).

Production of Biodiesel

A report of the United States Energy Information Administration estimated Nigeria's oil reserves to range from 16 billion to 22 billion barrels (USEIA 1997). This oil is found in fields in the coastal areas of the Niger Delta. According to the Ministry of Petroleum Resources, there are 159 oil fields, producing from 1,481 wells (Emoyan 2008). These figures are in agreement with the recent position of the Energy Commission of Nigeria (ECN), that in the short term (2005-2007), crude oil will continue to play a dominant role in the economic development of the country, while in the medium term (2008-2015), Nigeria envisages an energy transition from crude oil to a less carbon-intensive economy. However, the Energy Commission of Nigeria's long-term (2016-2025) plan on the nation's energy requirements is completely non-fossil (FEPA 1991).

Table 2: Fatty Acid Composition (wt %) and Distribution in Different Lipid Classes of Oils

Sample	C14:0	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3	C20:0	C20:1	C22:0	C22:1	C24:0	Unsat.	Sat.
LS	ND	7.50	ND	4.3	**27.8**	11.3	**26.3**	1.6	2.3	13.9	0.4	4.6	**68.1**	31.9
NL	ND	12.3	ND	3.3	**23.7**	18.0	**29.0**	1.4	1.0	8.0	0.2	3.1	**71.9**	28.1
GL	ND	20.0	ND	4.4	**24.2**	16.1	**20.8**	1.6	0.4	6.5	3.5	2.5	**65.0**	35.0
PL	ND	32.1	ND	8.4	**13.2**	11.0	**27.0**	2.7	0.9	3.5	ND	1.2	**52.1**	47.9
LC	ND	11.9	0.2	3.4	**24.0**	18.0	**28.2**	1.4	1.0	8.2	0.2	3.5	**71.6**	28.4
NL	ND	8.2	ND	4.3	**27.9**	12.2	**29.7**	1.5	2.4	10.3	0.4	3.1	**72.6**	27.4
GL	ND	20.0	0.3	4.4	**24.0**	16.0	**20.6**	1.6	0.8	6.4	3.5	2.4	**65.2**	34.8
PL	ND	28.6	0.8	7.2	**23.3**	9.3	**23.5**	2.3	0.8	3.0	ND	1.2	**57.7**	42.3
BN	ND	1.6	ND	1.8	15.9	**50.0**	0.7	0.8	2.8	17.0	1.3	8.1	**70.7**	29.3
NL	ND	1.6	ND	1.4	13.7	**49.0**	0.7	0.6	2.2	18.2	1.0	11.6	**66.6**	33.4
GL	ND	8.8	ND	4.0	13.2	**35.6**	1.0	1.1	2.0	18.0	0.7	15.6	**52.5**	47.5
PL	ND	22.7	ND	8.2	12.6	**17.6**	1.0	2.7	1.1	19.6	ND	14.5	**32.3**	67.7
GS	ND	16.0	0.2	19.2	**23.8**	**32.2**	1.2	3.5	0.2	1.8	ND	1.9	**57.6**	42.4
NL	ND	17.0	0.3	17.6	**25.8**	**32.1**	1.1	3.1	0.2	1.5	ND	1.3	**59.5**	40.5
GL	ND	30.9	ND	17.9	**22.8**	**22.8**	2.1	2.4	ND	ND	ND	1.1	**47.7**	52.3
PL	ND	32.5	ND	16.2	**25.1**	**17.5**	ND	3.4	1.7	3.6	ND	ND	**44.3**	55.7

C12:0 = Lauric, C14:0 = Myristic, C16:0 = Palmitic, C16:1 = Palmitoleic, C18:0 = Stearic, C18:1 = Oleic, C18:2 = Linoleic, C18:3 = Linolenic, C20:0 = Arachidic, C20:1 = Eicosenic C22:0 = Behinic, C22:1 = Erucic. C24:0 = Lignoceric C24:1 = Nervonic acid **BN = *Baphia nitida*, GS = *Gliricidia sepium*, LC = *Lonchocarpus cyanescens* LS = *Lonchocarpus sericeus* NL = Neutral lipid, GL = Glycolipid, PL = Phospholipid Unsat. =Unsaturation, Sat. = Saturation**

Mr. Vice-Chancellor, Sir, combustion of fossil fuels and petroleum products is known to contribute to the levels of gaseous pollutants, such as SO_x, CO, CO_2 and NO_x, and particulate matters in the atmosphere. The ill effects of these pollutants include acid rain, global warming, and health hazards to man and lower animals. Now more than in the past, greater recognition of the environmental consequences of fossil fuels has drawn more researchers' interest to biofuels. To deal with these serious problems, such as the deteriorated situation of the whole world energy supply, energy environment and energy security, our group decided to evaluate the use of alternative renewable biofuels in propounding a solution to the steering problems.

Modern biofuels have been reported as a promising long-term renewable energy source which has the potential to address both environmental impacts and security concerns posed by current dependence on fossil fuels (Batidzirai *et al.* 2006; Alamu *et al.* 2007). Besides, the oil shocks of 1973 and 1979, the rising oil prices since 2000, greenhouse gas emissions (leading to global warming) and the instability in the Middle East, which were widely acclaimed justifications to seek alternatives to conventional petroleum-based fuel (Singh 2006; Girard and Fallot 2006), available data on the global depletion of petroleum resources is a pointer to an approaching sunset on crude oil production which is also a confirmation of the universal admission that fossil fuels are not only finite but will run out in a foreseeable future (Sambo 1981; Fluck 1992; Jekayinfa and Bamigboye 2005).

Biodiesel refers to a vegetable oil- or animal fat-based diesel fuel consisting of long-chain alkyl (methyl, propyl or ethyl) esters. Biodiesel is typically made by chemically reacting lipids (e.g., vegetable oil, animal fat (tallow)) with an alcohol. Biodiesel is commonly produced by the transesterification of the vegetable oil or animal fat feedstock. Chemically, transesterified biodiesel comprises a mixture of mono-alkyl esters of long-chain fatty acids. Biodiesel is meant to be used in standard diesel engines; it can be used alone, or blended with petro-diesel. Biodiesel can also be used as a low carbon alternative to heating oil. Its application also includes use as a heating fuel in domestic and commercial boilers, and a mix of heating oil and biofuel which is standardized and taxed slightly differently from diesel fuel used for transportation. Biodiesel has better lubricating properties and much higher octane ratings than today's lower sulfur diesel fuels. Biodiesel additionally reduces fuel system wear, and in low levels in high pressure systems increases the life of the fuel injection equipment that relies on the fuel for its lubrication. Depending on the engine, this might include high pressure injection pumps, pump injectors (also called unit injectors) and fuel injectors.

Oderinde *et al.* (2006) have produced biodiesel from underutilized lesser known seed oils using a two-step reaction system which involved esterification reaction followed by transesterification reaction in the presence of a catalyst (fig. 4). The essence of the esterification is to reduce the problem of soap formation normally encountered during the production of biodiesel from feedstock with high free fatty acid content.

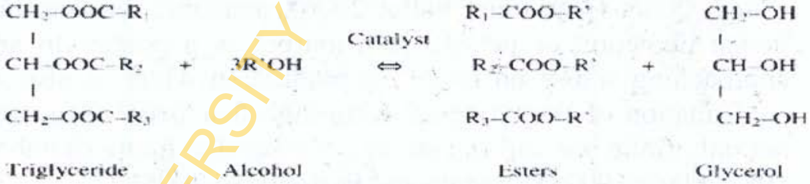


Fig. 4. Transesterification Reaction

Our very recent attempt by my group to tackle this problem of soap formation showed that the free fatty acid can be reduced in a one-step pre-treatment of esterification using H_2SO_4 as catalyst. This one-step pre-treatment reduced the problem of soap formation normally encountered when using oil with high free fatty acid for the production of biodiesel, thus reducing the production cost of biodiesel (Adewuyi *et al.* 2011). The fuel properties of the methyl esters (biodiesel) from these underutilized lesser known seed oils compared favourably with the ASTM and European recommendation (EN14214).

Toxicity/Edibility of Oils

Conventional edible oils are becoming very scarce and there is a need to establish alternative oil-bearing seeds as their substitutes (Agbaji *et al.* 1993). The continued increase in world population and the ever-increasing demands for both oils and oil-meal have resulted in increase in the prices of edible oils. This increase in prices necessitates the need to investigate new sources of edible oils, especially among the non-conventional and under-exploited oil seeds (Omode *et al.* 1995). The search for alternative oil sources, especially for developing countries, is therefore of utmost importance.

In Nigeria, there is little or no information on most of the underutilized lesser known seed oils and most of the seeds have no specific industrial purposes. Our findings from *in vitro* and *in vivo* studies on rats showed that most of the seed oils were toxic (Ajayi *et al.* 2004; Ajayi *et al.* 2007; Oderinde *et al.* 2008; Ajayi *et al.* 2008) (see figs. 5-8). We do hope that refining these seed oils will serve as a way of removing the extraneous materials present in them, which might be responsible for their toxic nature.

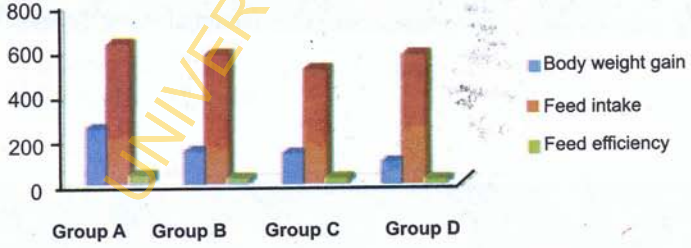
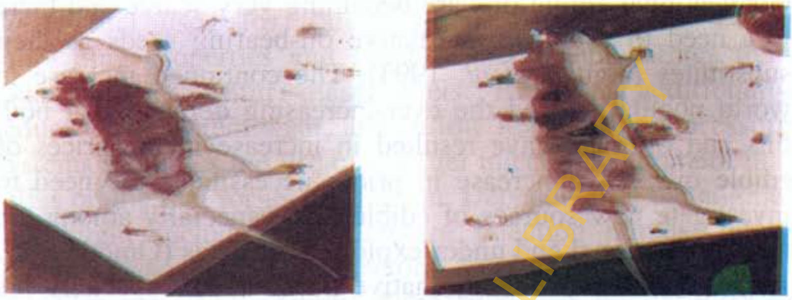


Fig. 5. Graphical representation of feed intake, body weight gain and feed efficiency of rats



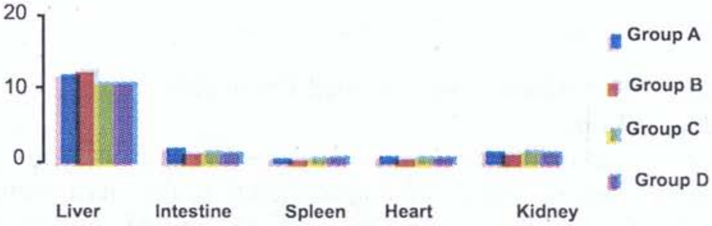
Group A fed with test oil

Group B fed with test oil

Group C fed with ground nut oil

Group D fed with no oil

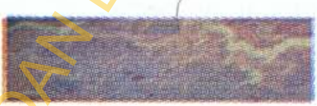
Fig. 6. Photographs of slaughtered rats after feeding for twelve weeks



Liver of A (Marked central venous congestion) H & E x 400

Kidney of A (Diffuse congestion of the parenchyma) H & E x 400

Heart of A (mild haemorrhage) H&E x 400



Spleen of A (Mild congestion) H&E x 400

Fig. 7: Photomicrographs of the organs of group A rats

Spleen of B (Very severe congestion) (More red blood cells in the sinusoids than lymphoid cells) H&E x 400

Heart of B (Moderate myofibre haemorrhage) H & E x 100

Fig. 8. Photomicrographs of the organs of group B rat

Crude Oil, Refined Products and Pyrogenic Hydrocarbons

Crude oil, refined products and pyrogenic hydrocarbons are the most frequent causes of contaminants in the environment. To effectively determine the fate of spilled oil in the environment and to successfully identify source(s) of spilled oil and petroleum products, development of oil hydrocarbon fingerprinting and identification techniques is extremely important in many oil-related environmental studies and liability cases. Crude oil and petroleum products possess high social and economic significance. The characterization and determination of the chemical composition and physico-chemical properties of these products are major analytical challenges. The extremely high complexity of these products calls for the use of various analytical techniques, including chromatography (GC, HPLC), spectroscopy (IR, UV, NMR, MS), other specific tests and empirical measurements of physical and chemical properties of interest.

Mr. Vice-Chancellor, Sir, one of my research interests in the past twenty five years has been geared towards detailed characterization and compositional analysis of Nigerian crude oils and their products using various spectroscopic analytical techniques, for planning the most effective utilization of these fractions as feedstock in the petrochemical industry (Oderinde 1985 & 1988). Impact assessment of organic and inorganic polluting substances in environmental samples (soil, water, sediments, etc) was also investigated. Accordingly, our research activities and programmes are organized around two interrelated topics, with the following specific areas:

(a) Structural characterization of Nigerian crude oils and their products together with coal-porphyrins, using a combination of spectroscopic analytical techniques,

(b) Analysis of organic and inorganic pollutants in environmental samples.

We have applied the infrared spectrophotometric technique to structural characterization of crude petroleum, middle distillate and heavy residual (> 387 °C) oils from various locations in Nigeria (Olajire and Oderinde 1992). Our results showed that infrared absorbance ratio serves as a good criterion for distinguishing crude petroleum and their products from different locations. We also carried out the first study on the effects of weathering on the infrared characteristics of Nigerian crude petroleum (Olajire and Oderinde 1993). The large difference in the spectra of naturally weathered oil and the fresh crude petroleum showed that infrared analysis of the whole crude cannot give enough information necessary for fingerprinting the source of oil spill. This can be accomplished with infrared spectrophotometry by subjecting the fresh and weathered oils to be compared to distillation or to some other vapourization procedure, which induces comparable volatility losses in the oils, and the spectral fingerprint of the nonvolatible components can then be compared.

The present trend in catalytic cracking is in the direction of utilizing heavier oils as feedstock; hence the concentrations of metal contaminants in the heavy residual oil call for great attention. Energy dispersive X-ray fluorescence spectroscopy was used by Olajire and Oderinde (1993) for multielemental analysis of crude petroleum and their heavy residual oil boiling above 387 °C (729 °F) from different oil producing companies in Nigeria. The distribution pattern of the two major contaminants, i.e. vanadium and nickel, in the crude petroleum and heavy residual oils was established by making a plot of the V/Ni ratio of the crude petroleum against that of the residual oils. The equation generated around the common line predicted the V/Ni ratio of the residue to be three-quarters that of the crude petroleum. The results showed unequivocally that vanadium and nickel present in the crude petroleum were concentrated in the residue. The utilization of such residue as feedstock would therefore pose a lot of industrial problems, as these elements, together with including sulphur, poison the catalyst used in the refinery, resulting in poor product yield and corrosion of processing units. Refiners are therefore advised to find a means of keeping such contaminants under control.

Olajire and Oderinde (1994) further investigated the effects of weathering on the trace metal contents of Nigerian crude oils, with a view to assessing the applicability of some elemental ratios for fingerprinting the source of oil spill. The main conclusion of the work was that the ratios of concentrations of vanadium to nickel, iron, cadmium and manganese, respectively, in an oil sample were unaffected by weathering to any significant extent, thus allowing their use in fingerprinting the source of an oil spill. Detailed compositional characterization of petroleum aliphatic and aromatic fractions is of fundamental interest and it is instrumental in the development of widely used techniques in industry.

In a related study to that of Sazonova *et al.* (1986), we measured fingerprints of the major oil components such as individual resolved n-alkanes and major isoprenoids, by detailed analysis of the Nigerian crude oil saturated hydrocarbon biomarkers using liquid chromatographic technique followed by computerized gas chromatographic analysis of the n-hexane soluble fraction (Olajire and Oderinde 1996). The ratios of Pr/Ph, C17/Pr, C17/C18 and CPI were greater than unity, providing evidence in support of a strong predominance of odd-numbered carbon atoms over the even-numbered carbon atoms, which is indicative of petroleum-free plants. The method used in this study is particularly suited to the identification and differentiation of crude oils, distillate fuel oils, and other petroleum fractions which contain significant concentrations of n-alkanes fractions of moderately low boiling point. It is much less suitable for the identification and differentiation of heavy residual oils because they contain mainly the high boiling constituents.

In our efforts to provide a detailed analysis of the chemical composition of Nigerian heavy residual oils boiling above 387 ^{0}C, we adopted the separation scheme of Jewell *et al.* (1972), using coordination chromatography, ion-exchange chromatography and a single dual-packed adsorption column chromatography containing silica gel and alumina, followed by infrared and ultraviolet studies of the neutral aromatic fractions of the oil (Olajire and Oderinde 1998). The ultra-violet portion analysed the polynuclear aromatic types and determined their specific absorptivities at each matrix wavelength, while the infrared characterized the aromatic compounds. The UV-IR technique used in the study enabled the determination of the high boiling aromatic hydrocarbons present in heavy fractions for oil pollution awareness.

In contrast to the gas chromatographic technique, the approach described in our study is only applicable to oils that contain significant concentrations of aromatic hydrocarbon compounds that are highly absorbing. However, there is an abundance of such structures in the heavier oils and particularly in the residual oil. A further advantage of the UV-IR technique used in this study is that it helped in the determination of the degree of separation achieved and the validity of the four compound-type concentrates obtained in the silica-alumina adsorption procedure. The variations in the values of the specific absorptivity ratios of the aromatic fractions of the heavy oils also served as a basis for the applicability of the ultraviolet technique for fingerprinting of heavy oil types.

Solid Minerals and the Chemical Industry

Solid minerals are naturally occurring substances used in the production of various industrial products. They represent the very foundation of the chemical industry and are among the most important elements of a production process. To a large extent, they determine the economics of the process, the production method, and the quality of the product. Raw materials employed in the chemical industry are classified according to their origin as mineral, plant or animal materials. The most common are the mineral materials, i.e, substances mined from the earth.

Upgrading of Solid Minerals

In the chemical industry, it is beneficial to use materials of high concentrations, since their use results in intensified production processes and high quality products at minimal cost. Often, the levels of the useful constituents in solid minerals are rather too low for it to be utilized economically and effectively in chemical processes; hence the materials have to be subjected to preliminary enrichment, otherwise known as upgrading, ore dressing, beneficiation or mineral dressing. The upgrading process is designed to separate, by physical, mechanical, thermal or chemical means, as much of the valuable mineral as possible, from the ore.

Mr. Vice-Chancellor, Sir, God has endowed Nigeria with abundant mineral resources to place her among the foremost economic nation giants of the world. It is sad to note that many of these minerals are yet to be exploited or explored, least to talk of making financial gains from them. Unlike the hydrocarbons industry, the solid minerals sector in Nigeria has suffered terrible and devastating investment neglect. A particular worrisome threat to industrialization in the solid minerals sector is epileptic supply of electricity which inadvertently caused some of our industries to fold up.

In Nigeria today, there is a growing demand for various industrial products and construction materials such as fertilizers, ceramics, pigments, refractories, etc. It is pertinent to note that the raw materials required to manufacture these and other products could be sourced locally. I like to mention here that commercial exploitation of our solid minerals for local sourcing of raw materials should be encouraged. This will not only reduce substantially the huge foreign exchange that presently goes into importation of some raw materials for our ailing industries, but also reduce production and products costs, as well as provide many more employment opportunities for many of our youths. The youths have been taught the required principles and processes needed for various productions, as a form of human capacity building. Unfortunately, industry and entrepreneurship cultivated in our graduates by the ivory tower are grossly under-utilized and/or are wasting away in the midst of our rich endowment of raw materials which hitherto are largely unexploited for industrial and economic revolution. No wonder that industrial chemistry for industry in Nigeria is at its infancy!

Over the years, my research group has also focused primarily on generating basic chemical data that are essential for the industrial processing of six indigenous solid minerals into useful and consumable products. These minerals are bitumen, galena, ilmenite, laterite, phosphorite and sphalerite. Our specific areas of active investigation include:

(a) kinetics and mechanism of heterogeneous dissolution (leaching) reactions of solid minerals,
(b) chemical characterization, beneficiation and industrial processing of solid minerals,
(c) The kinetic studies constitute the major area of research due to the fundamental nature of the expected results; other meaningful studies are practically impossible without these basic data.

Bitumen

Bitumen, also referred to as asphalt, is composed of high molecular weight hydrocarbons. It is either natural or artificial. Natural bitumen is an outcrop resulting from the loss of the light end of crude oil due to seepages or biodegradation, while artificial bitumen is a residuum of petroleum refining. Bitumen consists of three major components, namely asphaltenes, resins and oils. Asphaltenes are solid at room temperature and show some crystallinity, resins are amorphous solid, while oil is a liquid and may contain solid aromatic hydrocarbons and paraffin waxes (Kirk and Othmer 1978).

Various methods, including soxhlet extraction (Streiter 1941), solvent deasphaltening (Corbett 1969) and successive coagulation (Lysikhina 1947) have been employed in isolating the three major components. In our contribution, we employed a combined procedure of soxhlet extraction and elution-adsorption chromatography to isolate the three components of bitumen (Oderinde and Olanipekun 1990). Our results revealed that the bitumen consisted of 25% asphaltenes, 38% resins, and 36% oil on a weight to weight basis. Structurally, bitumen consists of two distinct components, asphaltenes and malthene. The latter is more variable in character relative to asphaltenes and has greater influence on the overall properties of bitumen. Although both components are necessary for the make-up of bitumen, the characterization of the malthene contributes a great deal more towards characterizing the whole bitumen (Griffin *et al.* 1959).

The composition of bitumen has been a subject of much study in the past because compositional data will assist in the handling of problems relating to its transportation and usage. Generally, three major techniques have been employed in the composition analysis of bitumen; they include spectroscopic (Kotlyar *et a.l* 1989), chromatographic (Majid *et al.* 1989) and densimetric (Corbett 1969) methods. The densimetric technique has been used by Oderinde and Olanipekun (1990, 1991) to define the average chemical structures present in the components of the bitumen. Our results indicated that asphaltenes have the largest molecular size, followed by the resins, while oil had the smallest. For the resin fractions, we observed that molecular size increased with increasing polarity of fraction. As for the oil fractions, the paraffins had the smallest molecular sizes compared to the aromatic. The three major components of the bitumen and their associated fractions were found to have positive values of condensation index, implying that the rings in the molecules were polycyclic in nature, with the asphaltenes having the highest number of rings and the saturates (oil fraction) having the lowest.

Generally, it was evident from our studies (Oderinde and Olanipekun 1990, 1991), that the bitumen was actually made up of a complex structural framework, comprising varying proportions of paraffins, naphthenes, aromatics, and heteroaromatic-containing compounds. The asphaltene, resin and oil components of the bitumen, however, exhibited some similarity in their chemical compositions but differed in terms of the average chemical structures present. The physico-chemical properties and semi-empirical measurements obtained showed that the isolated oil was of the heavy type; hence it will be a good raw material for industrial production of petrochemicals.

Galena and Sphalerite

Galena and sphalerite are both sulphide minerals that often occur commonly together in limestones, dolomites and other sedimentary rocks, in hydrothermal ore veins in contact with metamorphic deposits but rarely in pigmatites (Kirk and Othmer 1981). Atmospheric pollution by sulphur dioxide from pyrometallurgy is the main reason for studying the hydrometallurgical treatment of sulphide minerals. Most of the hydrometallurgical processes offer the possibility of obtaining suphur in the elemental form (Neou-Singourna and Fourlaris 1990).

Galena is often converted to lead (II) chloride while sphalerite is converted to zinc chloride. These are sufficiently soluble salts from which the corresponding metals can be recovered through electrowinning process. However, these two mineral sulphides (galena and sphalerite) can be directly converted into the respective chloride salts by non-oxidative leaching of the mineral sulphides using hydrochloric acid; this method has been the object of considerable interest in recent times. Although other acids may be employed, they are rather unstable, expensive, or they exhibit poor reaction kinetics (Nunez *et al.* 1990).

The kinetics and mechanism of dissolution of galena and sphalerite in hydrochloric acid-chlorate solutions was investigated by my group (Olanipekun and Oderinde 1999a, 1999b). Our investigation revealed that the leaching rates of lead from galena, and zinc from sphalerite, were in both cases directly related to the temperature and the concentration of the leaching solutions but inversely proportional to the initial diameter of the sulphide mineral particles. The same surface chemical reaction mechanism was in operation for all the leaching processes, thus suggesting that the same set of equipment could be employed for hydrometallurgical processing of the two principal sulphide minerals. We were able to establish that the type of oxidizing agent used may influence the rate-controlling mechanism of the dissolution reaction of this mineral.

Laterite

Laterite is a weathered mineral that is rich in secondary oxides of iron, aluminium or both. It is nearly devoid of bases and primary silicates but may contain abundant quartz and kaolinite (Campbell 1946). The utilization of laterite as a raw material for aluminium production is fast becoming popular mainly as a result of the growing demand for this valuable metal which can no longer be met by bauxite (the principal aluminium ore) supply alone, particularly in countries that have no bauxite. The production of aluminium from laterite, however, is often complicated by the large proportions of impurities usually present in the ore. Among different hydrometallurgical routes for extracting metal from aluminium ore is leaching in mineral acids under atmospheric pressure. This process has some distinct advantages which include;

- low capital costs of equipment,
- less engineering problems,
- avoidance of high temperature operations, therefore direct savings in energy (Canterford 1975).

Thus, in our contribution, we investigated the kinetics and mechanism of leaching of laterite in hydrochloric acid solutions (Oderinde and Olanipekun 1992a). Our findings showed that the rate of dissolution of iron found in the laterite was largely affected by acid concentration, unlike aluminium and silicon, both of which exhibited slow reaction kinetics. Analysis of the rate data with the shrinking-core model for reaction control, indicated that the rates of dissolution of aluminum, iron and silicon were determined by a surface chemical reaction mechanism. In order to enhance the slow reaction kinetics exhibited by aluminum during the leaching of laterite in hydrochloric acid solutions, Oderinde and Olanipekun (1992b) examined the effect of adding sulphuric acid to the leaching reagent, on reaction rate. This procedure showed that the added acid markedly increased the leaching rate as well as the magnitude of the aluminium leached, but did not alter the reaction mechanism observed for leaching experiments conducted in hydrochloric acid solutions only.

Ilmenite

Ilmenite is one of the chief sources of titanium(IV) oxide, and is widely distributed across the globe. Most of the ilmenite mined is consumed to make pigments via the 'sulphate process' (eqn. 1), for the paint, paper, plastic and metallurgical industries.

$$FeO.TiO_2.Fe_2O_3 + 5H_2SO_4 \longrightarrow TiOSO_4 + FeSO_4 + Fe_2(SO_4)_3 + 5H_2O \qquad (1)$$

Also, high purity TiO_2 is often produced from the mineral rutile, via the 'chloride process' (eqns. 2 & 3)

$$TiO_2 + 2C + 2Cl_2 \longrightarrow T_1Cl_4 + 2CO \qquad (2)$$
$$TiCl_4 + O_2 \longrightarrow TiO_2 + 2Cl_2 \qquad (3)$$

Unlike ilmenite which abounds in nature, the world's reserves of rutile are very limited (Mackey 1974). The growing inability of natural rutile resources, now principally derived from Australia and Sierra Leone, to meet the raw material needs of the "chloride" pigment manufacturers, is the main reason for studying the upgrading of ilmenite into "synthetic" rutile.

In our study (Oderinde and Olanipekun 1992c), optimum parameters have been worked out for chemical beneficiation of ilmenite by leaching with hydrochloric acid; a concentrate with more than 80% titanium enrichment was obtained. Also recovered with the concentrate was hydrated iron(III) chloride from the leach liquor. In a separate but related study on the kinetics of ilmenite decomposition with some acid solutions, Oderinde *et al.* (1992) observed that the use of $HCl-H_2SO_4$ mixture resulted in larger dissolution of the two chemical elements (i.e, titanium and iron), than when either HC1 or H_2SO_4 alone was used under the same experimental conditions. Although our findings reported that hydrochloric acid was an effective reagent for chemical upgrading of ilmenite into "synthetic" rutile, the need for high acid concentration and high temperature that promote corrosion is a serious impediment to the beneficiation process.

A related study in circumventing this problem was concluded by Olanipekun (2002b) when he investigated the quantitative dissolution of ilmenite in aqueous and methanol solutions of hydrochloric acid. The magnitude of iron leached was significantly enhanced when the solvent medium was changed from water to methanol, and the reaction conditions for leaching became less severe. Moreover, it was observed that on changing the solvent medium from water to methanol, the apparent activation energy value was almost doubled and the reaction mechanism switched from a diffusion process to a chemical reaction process. X-ray diffraction analysis of some reaction residues confirmed that titanium ions were readily hydrolysed in $HC1-H_2O$ solutions and precipitated as titanium(IV) oxide (eqn.4)

$$TiOCl_2 + H_2O \longrightarrow TiO_2 + 2HC1 \qquad (4)$$

Conversely, the X-ray diffraction spectra of residues obtained from HCl–CH_3OH solution did not indicate any peak corresponding to either rutile on anatase (TiO_2).

Skincare Chemistry

Mr. Vice-Chancellor, Sir, our society is such that most people, women in particular, young as well as old, are fond of their appearance and recognition in the public. They use various kinds of skincare and colour cosmetics for health and mostly, social reasons. The increasing demand for these products has brought about daily additions that exponentially expand the global market which has long exceeded the $60 billion mark. Search for ingredients and production of cosmetics stop at the cosmetic chemist's desk. The cosmetic chemist and other cosmetic scientists are always looking for interesting and exotic ingredients that improve skin's appearance and health (Oyedeji and Oderinde 2004). An array of compounds is required and there are more than 10,000 possible raw materials available according to Cosmetics, Toiletries and Fragrances Association (CTFA) dictionary.

Skincare formulations date back to 3000 BC in Egypt. Most concoctions in our studies were prepared from natural materials (Oyedeji and Oderinde 2006). Rouge preparations involved the use of iron oxide and eye paints, using the copper-based green ore called malachite. A good understanding of the fundamentals of emulsion chemistry and skin physiology is a prerequisite when formulating personal care products. Majority of creams and lotions we use are emulsions. An emulsion is simply two immiscible fluids in which one liquid is dispersed as fine droplets in the other. Emulsifiers keep the oil/fat phase from separating in emulsions. Most emulsifiers are surface-active, able to reduce the surface tension of water. For example, beeswax is an emulsifier for many cosmetic emulsions as it contains many compounds that are surface-active. Non-ionic emulsifiers are often used in skincare emulsions because of their safety and low reactivity.

Glycerin is commonly added to cosmetic emulsions for its humectant properties and it is the backbone of emulsifiers like glyceryl esters. These esters are effective emulsifiers because they contain both polar hydroxyl groups and non-polar fatty acids. Emollients used in personal care and beauty items are majorly fats and oils (lipids) (Oyedeji and Oderinde 2005). Cosmetic chemists often use blends of glyceryl esters and polyethylene glycol esters with a high and a low Hydrophilic-Lipophilic Balance (HLB) values to determine the required polarity to emulsify various fats and oils. Key characteristics required in good emollients are good spreading properties/low toxicity and skin irritation and good oxidative stability. Hence, stearic and palmitic acids are often used in cosmetic formulations. Paraffin oils and silicon oils like dimethicone and cyclomethicone are also used to increase lubricating qualities of emulsions.

Depending on the products intended purpose, ingredients can range from exfoliants and cell stimulators to antioxidants (Oyedeji and Oderinde 2005). Often, cosmeceutical products combine different types of ingredients to treat multiple aspects of a condition. All necessary factors are therefore carefully measured and monitored throughout the formulation process to ensure optimal product efficacy (Oyedeji 2003). The ingredients must not only be pure, they should be able to communicate with each other. If the star ingredients are not compatible, the product can cause irritation, redness, and inflammation on the skin. A good chemist is able to combine science and art to create products with the feel and look that consumers desire. As long as the society puts great emphasis on looking young and beautiful, Cosmetic Chemistry will continue to flourish with new and exotic products released into the market. However, I advise users to choose skincare and cosmetics that work with their skin, not against it, and remember to keep it simple, rather than flamboyant.

Environment

The state of the environment in which we live, work and operate also adds quality to, or if you prefer, spices to our life. By 'environment', we mean our surroundings—air, land and water. If the rivers are polluted, there is the risk of an outbreak of waterborne diseases, apart from the effect of such pollution on the aquatic life that supplies us our fishes, etc. Environmental monitoring is a multi-disciplinary affair. Chemists have a very important role of helping to determine the pollutants in the air, soil, surface water and ground water, by measuring internationally accepted parameters such as pH, turbidity, total dissolved solids (TDS), total suspended solids (TSS), biological oxygen demand (BOD), chemical oxygen demand (COD), dissolved oxygen (DO), oxides of nitrogen and sulphur (NO_X and SO_X), nitrate (NO_3^-), sulphate (SO_4^{2-}), total organic carbon (TOC), oil and grease, heavy metals like Hg and Pb, etc. The results are compared with standards laid down by the Ministry of Environment, Department of Petroleum Resources (DPR) and World Health Organization (WHO) for the particular use that the water is to be put to.

Most of the environmental work I have been involved in is in the Niger Delta area and Lagos State. Water pollution is perhaps the most complex and difficult type of environmental pollution to understand and deal with (Dobbs 1976), because a very large number of different sources and pollutants exist. Moreover, water pollution is an international problem, since water has no boundaries. Water pollution may be described as the addition of some substances or materials or the alteration of some physical, chemical or biological properties of water which permanently or temporarily renders that water less suitable for the particular purpose for which it is intended, viz: industrial, domestic, municipal, agricultural or recreational purposes. The water quality standards for these various activities differ.

Natural water pollution comes mainly from industrial and municipal wastes, where there are waterways close to such establishments. Industrial effluents are readily and recklessly discharged into nearby water bodies which serve domestic and agricultural purposes. The indiscriminate use of waterways as dumping grounds has led to intolerable levels of pollution, thereby upsetting the delicate balance among insects, plants, and fish, and posing problems regarding quality of water for human consumption. While talking about surface water, let us not forget ground water on which many homes and communities depend for their domestic water supply. Underground water can be very badly polluted by seepage of pollutants into the aquifer, with time.

Let me, at this juncture, alert all industrialists and would-be industrialists in our midst today, that there are laws and regulations enacted by the Federal Government, governing environmental issues. The regulatory agencies are the Ministry of Environment (former Federal Environmental Protection Agency (FEPA)), and in matters of oil and gas, the Department of Petroleum Resources (DPR) in collaboration with the Ministry of Environment. One of the most important laws by FEPA is Environmental Impact Assessment (EIA) Decree No. 86 of 1992, which makes it mandatory for any persons or companies wishing to establish any type of business or embark on certain projects in Nigeria to carry out an EIA, and obtain permission from the Ministry of Environment and/or DPR before starting the projects. The purpose of EIA is primarily to identify, quantify and qualify the potential impacts of the proposed activities. The environmental assessment is to cover the activities connected with or envisaged in the project, from the site preparation, through the construction stage, to the abandonment or de-commissioning stage. The EIA therefore enables planning, modifying, designing and adoption of appropriate mitigation measures.

I have for many years been involved in EIA, as a member or project leader of multi-disciplinary teams acting as consultants to Environmental Study Companies. Also during my sabbatical leave, as an in-house consultant to Chevron Nigeria Limited (CNL) Environmental Affairs Department based in Lagos, Port Harcourt and Escravos.

Mr. Vice-Chancellor, Sir, let me at this point briefly discuss one of the projects I proposed and executed during my stay at Chevron Nigeria, and at Chevron Research Institute, Richmond, California, US. The project was a field study to improve the scientific understanding of the fate and effects of crude oil and existing spill response techniques in the Nigerian mangrove environment. The project site was the Niger Delta. The Niger Delta has always been Nigeria's treasure base. I worked with an interesting group that was put together by Chevron Nigeria Limited (CNL). CNL was fully committed to this project, due to their concern for the environmental impacts of their activities, and also, to avoid major disasters. CNL took this proactive position so as to ensure that they understand the environment in which they operate. Our assignment was brief with clearly defined objectives, however, it required from us, profound thinking, deep commitment and an inclusive process of decision making. Thus, I was mandated to design and execute a field study on the "Fate and Effect of Crude Oil in Nigerian Mangrove Environment". The information resulting from this study would strengthen the database available to support decision makers during spill and would allow a scientifically defensible approach to spill response.

For the fact that the results from this assignment would be disseminated globally, our activities required a large-scale test which could only be achieved in a field experiment where stimulated spill would be possible. The accessibility of stimulated spill would further facilitate the project to confront the challenges that had been encountered by some previous workers in this area of study. Some of these challenges are loss of pre-spill information on the ecosystem; non-usage of reference plots in most studies, and inappropriate usage of statistical sampling technique. Considering all these challenges, some basic principles were designed to guide the projects. In the study, a limited set of relevant environmental parameters was selected for measurement in a single habitat, the mangrove ecosystem.

Mr. Vice-Chancellor, Sir, why did we choose to use mangroves? Mangroves are the basis of the ecosystem upon which all other organisms depend. Most people living in the Niger Delta areas depend upon the rich fishery for their livelihood; considering the food chain in that ecosystem, the fishes depend on worms, insects larvae, and amphipoda to survive; while these groups also depend on fungi, protozoa, bacteria and sometimes on mangrove leaves. To complete the chain, the fungi, protozoa and bacteria decompose mangrove leaves. The scheme for this food chain is illustrated in figure 9.

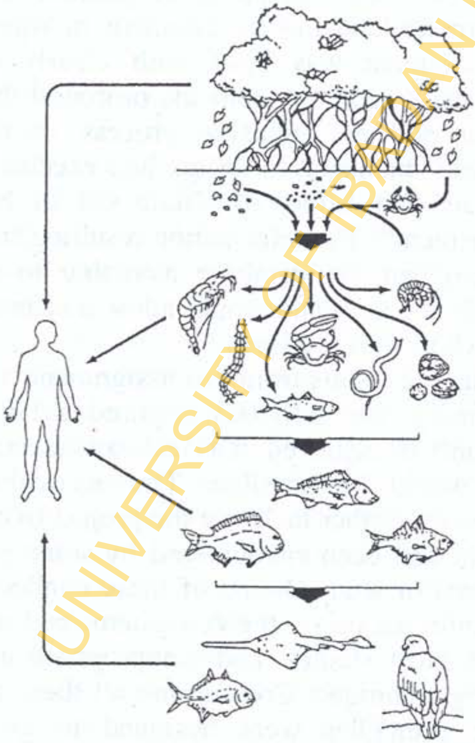


Fig. 9. Food chain in the mangrove environment

Aside its importance in the food chain, the mangrove protects the coastal ecosystem against storm and current erosion by trapping and stabilizing sediments. A mangrove forest, like a temperate swamp is a particularly challenging environment in which to mount a spill response. The clean-up activities often appear more damaging than the spill itself. Understanding the effects of spilled oil on the mangrove system will result in spill response techniques which minimize impacts on the mangrove ecosystem, and hence minimize the economic impact on human inhabitants.

Sir, my experience as an industrial Chemist became very useful in this project during the measurement (analysis) of oil fate in the ecosystem. Using standard techniques of analysis and also incorporating my ideas gained over the years from teaching and research in this great university of ours, we were able to investigate the following parameters in water, sediments, air, mangrove barks and mangrove seeds—total petroleum hydrocarbons (TPHs), polycyclic aromatic hydrocarbons (PAHs) and some heavy metals. Also, we measured oil effects in mangroves and some benthic organisms.

The results of our investigations in this project revealed that prevention of oil spill is the ultimate, but because it is a human activity, accidents resulting from oil explorations are inevitable. However, if an accident occurs, it is important to mobilize all the necessary response teams to the incident site as soon as possible so as to recover the site from enormous catastrophe (Oderinde *et al.* 1997).

Conclusion and Recommendations

Mr. Vice-Chancellor, Sir, distinguished ladies and gentlemen, I have presented to us in this lecture, the beauty, relevance and indispensability of chemistry applications to life, industry and wealth creation. Chemistry now more than ever before continues to unfold ample and valuable opportunities for quality living, industrial revolution and national development. Unlike in our insensitive world, this is very much glaring in the western world where opportunities and privileges are never allowed to slip away. Since man must win in a competitive race as is being witnessed in the world today between increasing human needs and decreasing or stagnant supplies, chemical products play the ready bail-out. Chemistry applications indeed have an over-riding presence in the things we use, wear, sit upon, ride in, eat from, and otherwise find in our everyday environment. All these things constitute spices to our lives in fascinating ways. The world is now focused on green chemistry for natural resource renewal, sound chemical pollution control and management, wastes recycling and management, less hazardous alternative energy sources, and environmentally sound management (ESM).

In the near future, taking into account the relationship between research in chemistry within academic institutions and the needs of industry for societal benefits, the need for well-trained, imaginative chemists, and the need to encourage and deepen our understanding of the properties of matter and of the way in which and the speed at which chemical processes occur, are discernible essential priorities. Chemistry will take an increasing role as creator and enabler in materials science and biology, in particular, learning from nature how she assembles molecules and how such molecules recognize each other, and learning how to mimic biological processes by simpler chemical reactions. In the long term, chemistry is going to create materials with extraordinary properties—as yet undreamed of—which will dramatically improve communications, healthcare, environmental monitoring and transport. Chemistry will stimulate and support innovation in all of the other branches of science and technology.

Mr. Vice-Chancellor, for our University of Ibadan to humbly but proudly fulfill her vision and mission to the public and assume the esteemed role of a think-tank and revolutionary for our beloved country, Nigeria, in the evolving dispensation of chemistry for new life, industry and wealth creation, a lot has to be done by the Federal Government to strengthen capacity in human resource for science research and state-of-the-art research facilities in this university. Nigeria is abundantly endowed with human and natural resources and therefore has no excuse not ranking among the top twenty world industrialized nations. The components of the platform for easy and speedy realization of the Vision 20:2020 are the universities and research institutes and the only proven formula for it is adequate Federal Government presence and funding. May I use this opportunity to commend the Federal Government and the University Administration for the current ETF special intervention projects in the University of which my Department is a beneficiary. It will be very nice if this trend can continue and our University of Ibadan becomes the trend-setter in intellectual revolution.

Mr. Vice-Chancellor, Sir, distinguished ladies and gentlemen, let the town criers in our midst today take note! Let the ears that care to listen hear! Let the message echo in the high places of governance in the country! Nigeria cannot afford to commit herself to perpetual life of servitude to the industrialized western nations. Our education system must develop to preserve our heritage and impact on quality of life, industrial growth and national development. The university is itself an industry where the bests of minds are produced for the best of life in the best of time. Now is the time and not later for our education system to be saved and improved upon. Watch therefore, and so act, that the very foundation of our development, which is education, be not destroyed by sheer insensitivity and arrogant nonchalance at the helm.

Acknowledgments

> *"It is a good thing to give thanks unto the Lord and*
> *to sing praises unto Thy name Most High."*
> *(Psalm 92: 1)*

First and foremost, I give praises and thanks to the Almighty God, the Alpha and Omega, the Creator of heaven and earth, for His infinite mercies, love and protection in my life and career expedition and, in particular, for the joy and honour of academic testimonies of today. I am forever grateful to Him, the good Lord!

I gratefully acknowledge all my teachers, right from the elementary school to the tertiary institutions, for the impacts of their training on my personal and career developments. I particularly thank my PhD supervisor and teacher, Prof. Robert N. Haszeldine (FRS), for his generous support and encouragement, and for providing the fund for my research work at the University of Manchester Institute of Science and Technology, United Kingdom. I remember with thanks and appreciation, all my mentors and senior colleagues, most of whom I teamed-up with, particularly on different research projects in which I have been involved over the years—Profs. J. Hirst (late), T.O. Bamkole, J.A. Faniran, J.I. Okogun, E.K. Adesogan, B.B. Adeleke, I. Iweibo and G.B. Ogunmola. I thank them all for accepting me as a research team member.

My appreciation goes to Prof. Kayode Oyebode Adebowale, the Dean of Science whom God used to facilitate today's lecture. I give special recognition and thanks to him and Drs. G.O. Adewuyi, A.J. Odola, A. Adewuyi, I.A. Oladosu and F.O. Agunbiade (my academic grandson), for their support and precious time spared during the preparation and arrangement of this lecture.

I acknowledge with thanks the immense contributions of all my students, past and present, with whom I have worked and who have made my research efforts fruitful and rewarding. They are Prof. K.O. Adebowale (current Dean of Science), Prof. E.O. Olanipekun (former Head of Chemistry and currently, Director of Pre-degree Programme, UNAD), Prof. A.A. Olajire (former Head of Chemistry and currently, Director of Academic Planning, LAUTECH); Mr. Niyi Olukoya (Director, Glo Business, West), Drs. F.O.J. Oboh, A.O. Tairu, Ibironke Ajayi, Folashade Oyedeji, L.C.M. Nwokocha, B.C. Ejelonu, O. Ogunkunle, A. Adewuyi; Messrs M. Onigbinde, T.O. Owoyokun, J.A. Olanrewaju and Miss Durotimi Akinwunmi. I dedicate today's lecture to them all for their tolerance and understanding during our various research endeavours over the years. I apologize for works not mentioned in this lecture due to time and space limitation.

Worthy of special mention in this lecture are my colleagues in the Industrial Chemistry Unit - Prof. K.O. Adebowale, Drs. Mopelola Omotosho, F.A. Dawodu, Ibironke Ajayi, Folashade Oyedeji, L.C.M. Nwokocha and B.O. Ogunsile for their comradeship and cooperation at all times. I acknowledge the friendship and understanding of Profs. B.B. Adeleke, A.A. Adesomoju, O. Osibanjo, O. Ekundayo, F.O. Bamiro, J.A. Obaleye, J.A.O. Woods, P.C. Onianwa and T.I. Odiaka. I appreciate all other academic and non-academic staff in the Department of Chemistry, including the administrative staff in the Head of Department's office.

The invaluable contributions and support of the University Administration under the leadership of Prof. Ayodele Falase, FAS, which made my sojourn as Dean of the Faculty of Science a memorable and cherished one are highly acknowledged. I express my gratitude for the support of some members of staff of Chevron Nigeria and United States - Drs. M.E. Moir, D.E. Ogbebor, Barbara J. Smith, G.A. Rausina (late), M. Tabugbo and L.A. Jackson for their comradeship while I was there.

I sincerely thank all my friends within and outside the Faculty too many to be listed. To my childhood friends here present- my most sincere appreciation. My appreciation also goes to my neighbours and family friends - HRH Oba and Olori K. Olusa, Pastor and Prof. (Mrs.) T.O. Obajimi, Pastor and Mrs. S.A.M. Adebowale, Prof. and Mrs. A.I. Olayinka, Prof. and Mrs. J.A.I. Omueti, Prof. and Mrs. T. Ikotun, Dr. and Mrs. K.O. Ojo, Mr. and Mrs. T.A. Olaleye, Dr. Dayo Alo, Dr. and Mrs. G.A. Adeniran LOYOLA 628 and a host of others. I thank very much my spiritual fathers and mothers, members of the Chapel of the Resurrection, and members of the Resurrection Morning Star Society for their constant prayers and supports.

I acknowledge with unalloyed gratitude, my parents—Mr. Emmanuel Olympus Adebowale and Mrs. Beatrice Olusola

Oderinde (both of blessed memory), who as a pharmacist and tutor/educationist respectively, struggled hard to send me to school. They taught me the virtues of honesty, hard work, and the fear of God. I remain ever grateful to them both. I want to make one special note of thanks to my father—I am here today largely because of his strict discipline; I now realize that I needed it then as the only son and youngest child among his four children. I express my sincere joy and appreciation to all my siblings—Chief (Mrs.) E.Y. Rockson, Major Gen. (Rtd) Dr. Aderonke Kale and her spouse, Prof. O.O. Kale and my late sister whom I fondly referred to as sister Nike, for every moral and financial support given all of the way. I thank all my extended family members—The Rocksons, the Kales, the Abioyes, the Oredugbas, the Olaosebikans, the Ogunleyes and the Giwas for being there for me always.

I thank profoundly and most specially my dearly beloved wife, Mopelola, my trusted supporter, best friend and confidant for whom I have the greatest esteem and respect, for standing by me and giving me a life of love and of beautiful memories I most cherish. I thank her very much for her priceless companionship. I thank in a very special way my beloved children—Dr. Ayobami Ogunleye (nee Oderinde) and her spouse, Dr. Lekan Ogunleye who elevated us to the status of 'grandparents' about a month ago with the birth of their bouncing baby girl, Anjola; Dr. Motunrayo Oderinde and the baby of the home, Mr. Ayotunde Oderinde and my niece, Dr. Opeyemi Giwa, who has become a member of my nucleus family following the demise of her parents. They are all very wonderful and precious to me.

Mr. Vice-Chancellor, Sir, distinguished ladies and gentlemen, I thank you most sincerely for your kind attention.

References

Adewuyi A. and Oderinde R.A. 2011. Analysis of the mineral nutrient, chemical composition and distribution of fatty acids in the lipid classes of the seed oils of underutilized legumes from Nigeria. *La Rivista Italiana Delle Sostanze Grasse* LXXXVIII, 86-92.

Adewuyi A., Oderinde R.A. and Ayodele G.A. 2011. Antimicrobial activity of diethanolamide: A nonionic surfactant from *Calophyllum inophyllum* and *Cyperus esculentus*. *La Rivista Italiana Delle Sostanze Grasse* (In press).

Adewuyi A., Oderinde R.A. and Ojo D.F.K. 2011. Production of biodiesel from *Terminalia catappa* seed oil with high free fatty acid using acid-catalysed pretreatment step. *International Journal of Sustainable Energy* (In press).

Adewuyi A., Prasad R.B.N., Rao B.V.S.K. and Oderinde R.A. 2010. Oil composition, mineral nutrient and fatty acid distribution in the lipid classes of underutilized oils of *Trilepisium madagascariense* and *Antiaris africana* from Nigeria. *Food Research International* 43: 665–670.

Agbaji, A.S., Terry, De and Agbaji, E.B. 1993. Composition of tobacco (*Nicotiana tabaccum*) seed and seed oil grown in Nigeria. *Riv. Ital Delle Sostanze Grasse* 70: 454.

Ajayi I.A. and Oderinde R.A. 2002. Studies on the oil characteristics of Dacryodes edulis pulp and seed. *Discovery and Innovation* 14 (1/2): 20- 24

Ajayi I.A., Oderinde R.A., Ogunkoya B.O., Egunyomi A. and Taiwo V.O. 2007. Chemical analysis and preliminary toxicological evaluation of *Garcinia mongostana* seeds and seed oils. *Food Chemistry* 101: 999-1004.

Ajayi I.A., Oderinde R.A., Taiwo V.O. and Agbedana E.O. 2004. Dietary effects on growth, plasma lipid and tissues of rats fed with non-conventional oil of *Telfairia occidentalis*. *J. Sci Food Agric* 84: 1715 – 1721.

Ajayi I.A., Oderinde R.A., Taiwo V.O. and Agbedana E.O. 2008. Short-term toxicological evaluation of *Terminalia catappa, Pentaclethra macrophylla* and *Calophyllum inophyllum* seed oils in rats. *Food Chemistry* 106: 458-465.

Alamu O.J., Waheed M.A. and Jekayinfa S.O. 2007. Biodiesel production from Nigerian palm kernel oil: Effect of KOH concentration on yield. *Energy for Sustainable Development* 11(3): 77-82.

Batidzirai B., Faaij A.P.C. and Smeets E. 2006. Biomass and bioenergy supply from Mozambique. *Energy for Sustainable Development* 10(1): 54-81.

Cannel, M. G. R. 1989. Food crop potential of tropical trees. *Experimental Agriculture* 25: 313–326.

Canterford, J.H. 1975. Leaching of laterites in mineral acids. *Minerals Sci. Eng.* 7:3-17.

Choudhary, A.Q and Pirt S.J. 1966. The influence of metal-complexing agents on citric acid production by *Aspergillus niger*. *Journal of General Microbiology* 43: 71-81.

Corbett, L.W. 1969. Composition of asphalt based on generic fractionation using solvent deasphalting. *Anal. Chem*. 41:576-579.

Emoyan, O.O., Akpoborie I.A. and Akporhonor E.E. 2008. The oil and gas industry and the Niger Delta: Implications for the environment. *Journal of Applied Science and Environmental Management* 12(3): 29 – 37.

Esuoso K.O., Oderinde R.A., Vega-Catalan, F.J. and Bamiro, F.O. 1993. Optimization of batch alcoholic fermentation of *Cyperus esculentus*. *Die Nahrung* 37: 274-276.

Federal Environmental Protection Agency (FEPA). 1991. National policy on the environment. The Presidency, Garki, Abuja, Nigeria, pp 43.

Fluck, R.C. 1992. Energy for farm production. *Energy for World Agriculture* Vol. 1, Amsterdam: Elsevier.

Girard, P. and Fallot A. 2006. Review of existing and emerging technologies for the production of biofuels in developing countries. *Energy for Sustainable Development* Vol. X, No. 2. pp. 92-108.

Griffin, R.L.; Simpson, W.C. and Miles, T.K. 1959. Chemical composition of bitumen. *J. Chem. Eng.* 41:349-352.

Jekayinfa, S.O. and Bamigboye A.I. 2005. Estimating energy requirement in cashew (*Anacardium occidentale* L.) nut processing operations. *Energy* 31: 1203-1320.

Jewell, D.M., Welber, J.H., Bunger, J.W., Plancher, H. and Lantham, D.R. 1972. Ion-exchange, coordination and adsorption chromatographic separation of heavy-end petroleum distillates. *Anal. Chem.* 44: 1391-1394.

Kirk, R.E. and Othmer, D.F. 1978. *Encyclopedia of chemical technology*, 3rd Edn., New York: *Interscience*, pp. 278-279.

__________ 1981. *Encyclopedia of chemical technology.* 4th Edn., New York: *Interscience*, pp 98.

Kotlyan. L.S.; Morat, C. and Ripmeester, J.A. 1989. Analysis of malthene fractions by means of carbon 13 NMR technique. *Bull. Mag. Res.* 11:324-324.

Lysikhina, A.I. 1947. A method for determining the composition of bitumen. *Stroited Danog* 10:17-18.

Majid, A. Bornais J. and Hutchison, R.A. 1989. Characterization of various bitumen from tarsands. *Fuel Sci. Technology Int.* 7:507-533.

Manskaya, S.M. and Dryozdova, T.V. 1968. Geochemistry of organic substances, pp 92.

Neou-Singourna, P. and Fourlaris, G. 1990. A Kinetic study of the ferric chloride leaching of an iron activated bulk-sulphide. *Hydrometallurgy* 23:203-219.

Noguchi, Y., and Johnson, M. J. 1963. Penicillin acyltransferase in penicillium chrysogenum. *Journal of Bacteriology* 83: 538-541.

Nunez. C.; Espiell, F. and Garcia–Zayas, J. 1990. Kinetics of galena leaching in hydrochloric acid-chloride solutions. *Metal trans. B.* 12B:11-17.

Oboh F.O.J. and Oderinde R.A. 1988. Analysis of the pulp and pulp oil of the *Tucum Astrocaryum* vulgare mart fruit. *Food Chemistry* 30: 277-287.

__________ 1989. Fatty acid and glyceride composition of *Astrocaryum vulgare* mart kernel fat. *J. Sci.Food Agric.* 48: 29-36.

Oderinde R.A. 1985. Studies on Nigerian petroleum: Part 1. Varietal differences in the vanadium and titanium content. *Nig. J. Sc.* 18: 143-145.

Oderinde R.A., N.C. Ngoka and E.K. Adesogan 1986. Comparative study of the effect of ferrocyanide and EDTA on the production of ethyl alcohol from molasses by *Saccharomyces cerevisiae. Biotechnol. Bioeng.* Vol. XXVIII, 1462-1465.

Oderinde R.A. 1988. Studies on Nigerian petroleum: Part 2. Nature and distribution of sulphur compounds in UQCC crude and the comparative evaluation with selected Middle East crudes. *Nig. J. Sc.* 23: 64-66.

__________ 1988. Evaluation of the properties of the oils of citrus fruits wastes. *Riv. Del. Sos. Grasse* Vol. LXV, 501-503.

__________ 1990. Chemical and technological characteristics of *Lagenaria breviflora* seeds: A lesser known cucurbit. *Seifen Oel Fette Washe* 16(20): 809-10.

Oderinde R.A. and Ajayi I.A. 2000. Physico-chemical and metal composition of *Calophyllum inophyllum* seed and seed oil. *Pak. J. Sci. Ind. Res.* 43: 357-358.

Oderinde R. A. and Oladimeji G. R. 1990. Oil characteristics of *Thevitia peruviana* (yellow oleander) and *Plumeric alba* (white frangipani). *Rev. Del. Sos. Grasse Vol. LXVII, 635-637.*

Oderinde R.A. and Tairu A.O. 1988. Chemical investigation of Nigerian *Cyperus esculentus* (L) tuber for possible industrial application. *Nig. J. Sc. 22: 70-73.*

__________1988. Evaluation of the properties of yellow nutsedge *Cyperus esculentus* (L) tuber oil. *Chemistry* 28: 233-237.

__________ 1989. Utilization of yellow nutsedge tuber for composite flour. *Pak. J. Ind. Res.* 32(8): 570-573.

__________1992. Determination of the triglyceride, Phospholipid and unsaponifiable fractions of yellow nutsedge tuber oil. *Food Chemistry* 45: 279-282.

Oderinde R.A., Adewuyi A. and Ajayi I.A. 2008. Determination of the mineral nutrients, characterization and analysis of the fat-soluble vitamins of *Caesalpinia pulcherrima* and *Albizia lebbeck* seed and seed oils. *Seed Science and Biotechnology* 2(2): 74 – 78

Oderinde R.A., Ajayi I.A and Adewuyi A. 2008. Preliminary toxicological evaluation and effect of the seed oil of *Hura crepitans* and *Blighia unijugata* bak on the lipid profile of rat. *EJEAF*che 8 (3): 209 – 217.

Oderinde R.A., Ajayi I.A. and Nwogu C.D. 2006. A preliminary investigation into the biofuel characteristics of *Calophyllum inophyllum, Pentaclethra macrophylla, garcinia mangostana and telfairia occidentalis* seed oils. *Biosciences, Biotechnology Research Asia* 3(1a): 35-40

Oderinde R.A., Tairu A.O. and Atinsola F.M. 1989. Chemical investigation of the *Cyperecae* family-1.The proximate analysis of *Cyperus rotundus* tube (choqui). *Riv. Del. Sos .Grasse Vol. LXVI,* 211-213.

Oderinde R.A., Tairu A.O. and Ogunnowo O.O. 1992. Further studies on the *Cyperaceae*: triglyceride, phospholipid and unsaponifiable composition of *Cyperus tuberosus* tuber. *Rev. Del. Sos. Grasse Vol. LXIX,* 11-13.

Oderinde R.A., Tairu A.O., Awofala F.A. and Ayediran D. 1990. A study of the chemical composition of some members of *Cucurbitaceae* family. *Riv. Del. Sos. Grasse Vol.LXVII,* 259-261.

__________ 1990. A study of the chemical composition of some members of *Cucurbitaceae* family. *Riv. Del. Sos. Grasse Vol. LXVII,* 259-261.

Oderinde R.A., Tairu A.O., Dawodu F.A. and Bamiro F.O. 1990. Chemical investigation of the Cyperaceae family. 2: Preliminary report on *Cyperus tuberosus* tube composition. *Riv. Del. Sos. Grasse Vol. LXVII,* 301-303.

__________ 1994. Chemical investigation of the Cyperaceae family. 2: Preliminary report on *Cyperus tuberosus* tube composition. *Riv. Del. Sos. Grasse, Vol. LXVII, 301-303.*

Oderinde, R.A. and Esuoso, K.O. 1988. Batch alcoholic fermentation of molasses. Effects of pH, temperature and sugar concentration. *Pak. J. Sci. Ind. Res.* 31(11): 807-811.

__________ 1989. Hydrolysis and alcoholic fermentation of *Cyperus esculentus* (imumu). *Ghana J. Chem.* 1(1): 48-53

Oderinde, R.A., Esuoso, K.O. and Adesogan, E.K. 1990. The effects of lipids on alcoholic fermentation of molasses using Saccharomyces cerevisiae. *Die Nahrung.* 34(8): 681-688.

Oderinde, R.A., Esuoso, K.O. and Okogun, J.I. 1990. The influence of CDTA and DPTA on ethyl alcohol production from sugar cane molasses. *Die Nahrung.*34: 171-175.

Oderinde, R.A. and Olanipekun E.O. 1991. Composition analysis of the oil component of the Nigerian bitumen *J. Afri. Ean. Sci.* 12:483-487.

__________ 1990. Densimetric characterization of the asphaltene, resin and oil components of the South-western Nigeria bitumen. *Pak. J. Sci Ind. Res.*33: 421 – 424.

Oderinde, R.A. and Olanipekun, E.O. 1992a. Kinetics of hydrochloric acid leaching of laterite. *Pak. J. Sci. Indi. Res.* 35:77-80.

__________ 1992b. Chemical beneficiation of Nigerian ilmenite one-part 1. Hydrochloric acid leaching. *Pak. J. Sci. Ind. Res.* 35:313-316.

Oderinde, R.A., Olanipekun, E.O. and Esuoso, K.O. 1992c. Kinetics of ilmenite ore dissolution in acid solutions. *Bull. Chem. Soc. Ethiop.* 6:81-86.

Olajire, A.A. and Oderinde R.A. 1992. Characterization of Nigerian crude, middle distillate and heavy residual oils by infrared spectrophotometry. *Ghana J. Chem.* 1: 324-333.

__________ 1993. Effects of weathering on the infrared characteristics of Nigerian crude oils. *J. Afri. Earth Sci.* 17: 323-331.

__________1994. Trace metal analysis in fresh and weathered crude oils. *Pak. J. Sci. and Ind. Res.* 37: 349-351.

__________ 1996. Characterization of Nigerian crude oil aliphatics by gas chromatographic technique. *Bull. Chem. Soc. Ethiop.*, 10: 115-120.

__________1998. Study of aromatic hydrocarbons in heavy residual oils by a combination of spectroscopic analytical techniques (Communication). *J. Afri. Earth Sci.* 27: 165-174.

Olanipekun, E.O. 2002. Leaching of imenite with agueous and methanol solutions of hydrochloric acid *J. Chem. Soc. Nigeria* 27:177-179.

Olanipekun, E.O. and Oderinde, R.A. 1999a. The dissolution of galena in hydrochloric acid chlorate solutions. *Trans-Indian Inst. Met.* 52:391-395.

__________1999b. Hydrochloric acid leaching of sphalerite in the presence of an oxidizing agent. *Pak. J. Sci. Ind. Res.* 42:204-208.

Omode, A.A., Fatoki, O.S. and Olaogun, K.A. 1995. Physicochemical properties of some under-exploited and unconventional oil seeds. *J. Agric. Road Chem.* 43: 2850–2853.

Oyedeji F.O. 2003. Production, physicochemical and stability studies of cosmetic emulsions from some natural lipids (PhD Thesis, Department of Chemistry, University of Ibadan, Nigeria).

Oyedeji F.O. and Oderinde R.A. 2004. Stability of cosmetic emulsions from water melon and paraffin oils. *International Journal of Chemistry* 14(3): 149-154.

_______2005a. Analysis of samples of cosmetic emulsions from a market in Ibadan, Nigeria. *International Journal of Chemistry* 15.1: 35-41.

__________ 2005b. Determination of best base for use in skin care formulations. *International Journal of Chemistry* 15(2): 211-214.

__________ 2006. Characterisation of isopropanol-extracted vegetable oils. *Journal of Applied Sciences* 6(11): 2510-2513.

Sambo, A.S. 1981. Renewable energy technology in Nigeria: resource availability and potential for application to agriculture. *Journal of Agricultural Technology* 3(1): 1-4.

Singh, M. 2006. Economics of biofuels for the transport sector in South Africa. *Energy for Sustainable Development* Vol. X, No. 2, pp. 40-47.

Sozonov, M.L. Lunskii, M.K. Zhiltsova, L.I., Palzanskaya, I.L. and Chuvilyaeva, N.I. 1986. Gas chromatographic determination of the composition of unfractionated natural hydrocarbon mixtures.*J. Chromatogr.* 364: 267-298.

Streiter, O.G. 1994. Determining components of bitumen *J. Res. Nat. Bur. Std.* 2:415-418.

United States Energy Information Administration (USEIA). 1997. *Commercial Buildings Energy Consumption and Expenditures.* Office of Energy Markets and End Use. U.S. Department of Energy. Washington D.C.

BIODATA OF
PROFESSOR ROTIMI AYODELE ODERINDE

Rotimi Ayodele Oderinde was born on eleventh of November, 1950 in Ifo, Ogun State to Pharm. Emmanuel Olympus Adebowale and Mrs. Beatrice Olusola Oderinde (both of blessed memory). He had his Primary education at United School, Ilorin (1956 -1961) and his Secondary education at Loyola College, Ibadan (1962 - 1966). He continued in Loyola College for his Higher School Certificate education (1967 – 1968) before proceeding to the University of Lagos for a degree in Chemistry, graduating with Bachelor of Science (Special Honours) in Chemistry in 1972.

Professor Oderinde received his MSc and PhD degrees in Petrochemical & Hydrocarbon Chemistry and in Industrial Chemistry from the Victoria University of Manchester, Institute of Science and Technology, UK in 1973 and 1976, respectively. His Doctoral studies on "Products from Bromination of Hydrocarbons" unravelled their uses as precursor monomers to *fire-retardant* plastics. He joined the services of the University of Ibadan as the nucleus and foundation staff member of the Industrial Chemistry programme in September 1976 as Lecturer II. He was promoted to the grade of Senior Lecturer in 1984 and Professor in 1989.

Rotimi Oderinde was a recipient of the following honours and awards: Federal Government of Nigeria Bursary Award, University of Lagos (1969-70); Deutscher Akademischer Auschdienst - West German Academic Exchange Service (DAAD) Scholarship, University of Lagos, Nigeria (1970-72); Herbert Stelner Prize, University of Manchester—a prize awarded to the student who is adjudged by the Academic Board to have shown the best performance on a postgraduate course associated with the Chemistry Department (1973); British Council Award (1974) and Research/Teaching Assistantship, University of Manchester (1974-76). Since graduation, Professor Oderinde has worked in renowned academic centres and universities in Nigeria, the UK, and USA. He was in Chevron Research Institute, Richmond, USA and at Chevron Nigeria Limited, Lagos as an in-house environmental consultant between 1996 and 1999.

Prof. Oderinde is a member of professional organizations, including: American Chemical Society, Science Association of Nigeria, Chemical Society of Nigeria (He was Assistant National Secretary from August 1987 to August 1990), Nigerian Environmental Society and Institute of Public Analysts of Nigeria. He is a Fellow of the Nigerian Academy of Science and the Institute of Chartered Chemists' of Nigeria. He is a regular reviewer for many indexed and cited professional journals and an external examiner to many Nigerian Universities and those of other African nations. He has received many local and international research grants in his area of research interest – Industrial Chemistry. He has published over one hundred (100) scientific articles in local and international indexed and cited journals and well over thirty (30) conference presentations, monographs and technical reports.

His major research contributions have been in the areas of (i) generating basic chemical data that are essential for the industrial processing of indigenous solid minerals (bitumen, galena, ilmenite, laterite, phosphorite and sphalerite) into useful and consumable end-products, (ii) improved bench scale of ethanol and citric acid through fermentation, (iii) nonconventional seed oils for industrial applications, (iv) fate and effects of crude oil on the environment, and (v) industrial and agricultural wastes utilization. He has supervised many undergraduate and graduate students for their BSc, MSc and PhD degrees over the years. Three of Professor Oderinde's graduate students are Professors of Industrial Chemistry in Nigerian Universities, including the University of Ibadan.

Prof. Oderinde was Director, Laboratory Technology Training School from January 2003 until August 2003 when he was elected Dean of Science, a position he held till July 2005. He has also at different times served the University of

Ibadan on various boards and committees as chairman/member. He also served as a member of the Ogun State Hospital Management Board (during the military regime). He is the current Head of Department of Chemistry, a position he assumed in 2009.

Professor Oderinde is happily married to Pharm. Mopelola Oderinde, a retired Deputy Director, Pharmaceutical services and former Head of Pharmacy Department, University College Hospital, Ibadan. They are blessed with three (3) children.