Public Lecture Series

CHEMICAL ENGINEERING FOR THE DEVELOPMENT OF A STRONG NATION

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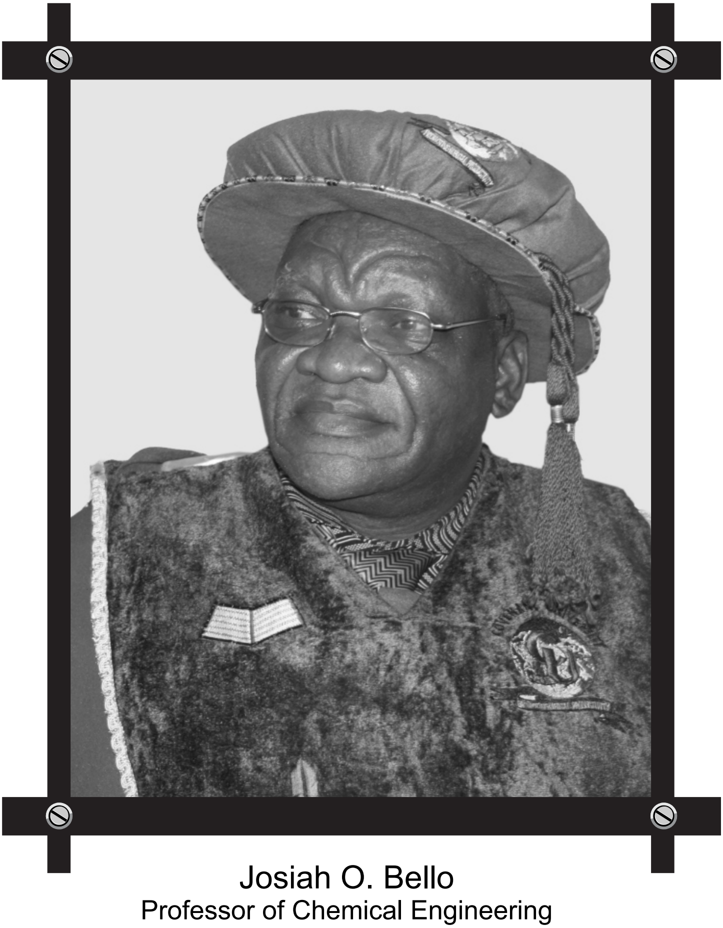

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1.0 INTRODUCTION:

This world in which we are in is characterized by a multitude of natural phenomena. It is a world of change, of movement and energy; of storms, earthquakes, cosmic rays and solar flares. The range and complexity of these changes is so great, that it would seem the height of foolishness to attempt to find a common trend, or a theme that runs through them all. Never the less, men have come to the understanding of the factors involved. At the heart of such a science is the concept of energy, the capacity to do work.. There is a close link between the per capita consumption of energy, and the state of physical advancement of a Nation. Thus if the energy consumed per person in a Nation is very high, more industries are working, which leads a strong Nation..

The measure of the development of a nation is therefore by implication, the level of her Technological Advancement viz a-viz energy consumption. If a Nation is so developed that she can produce motor cars for example, other nations will buy from her, thereby bringing in foreign exchange. If a nation can produce certain chemicals which she needs for herself, then there will be no need to import these chemicals. We are not talking about chemicals for warfare, however as the topic suggests , we are building up not destroying or defending as the case may be. Water is essential to life. Medically 50% or more of the body consists of water. Every individual must take water to survive. We can survive for a few weeks without food but not water. The water must be treated to avoid water borne diseases. Hence the end users of water treatment chemicals abounds.

In this lecture, five chemicals that could contribute in no small way to the development of this nation will be highlighted. They are as follows:

- Fufural
- Hydrated lime
- Castor oil derived chemicals
- Tantalum/Niobium, and
- Papain
- Sawdust

Ironically these chemicals, which can be produced in Nigeria are imported to a very large extent.

The petroleum industry sustains the nation presently. There are quite a number of vehicles in the Nation that must use petrol and engine oil. In the treatment of the **black gold** to engine oil, a particular chemical, called furfural, is of great importance. Other names for the chemical are: **furol, fural, furfuraldehyde,** and **2-furancarboxaldehyde**. No company in Nigeria produces this chemical, yet engine oil can not be made without it , especially based on our refinery set up. Other refinery set up can use **sulphur dioxide** process called " **Edeleanu process"** to replace the furfural process. This 1907 process applies widely to light distillates such as heavy naphtha, kerosene, and diesel fuel. At the boiling point of sulphur dioxide(-10 ^{o}C), aromatic and unsaturated hydrocarbons are completely miscible with liquid sulphur dioxide but the paraffins and naphthene hydrocarbons are not. It is my humble submission that Covenant University will produce this chemical on a pilot plant scale, in the very near future. The raw materials needed are farm renewable waste, viz:

* Corn cobs
* Groundnut shell
* Rice husks
* Oats hull
* Sawdust
* Bagasse

By a clever addition of a mineral acid to the raw material, the chemical is formed. Subsequent steps include separation techniques to isolate the chemical.

The chemicals that I have highlighted are also sources of new industries, in that they are feed stocks for the production of other chemicals. They are discussed latter in the text.

A strong nation in the context of this lecture is the nation that

- o can feed herself
- o can provide avenue for high proportion of her citizen to earn work and earn a living

- o has a high defense capability
- o is backed by good infrastructure.

2.0 SELECTED FUNCTIONS OF CHEMICAL ENGINEERS.

Let us consider the following:

- * the role of chemical engineers in industry
- * the chemical engineers in the development of small scale industries
- * the chemical engineer as an educator
- * the role of chemical engineers in research and development
- * future prospects for chemical engineers in the Nigerian economy

2.1 The role of chemical engineers in industry.

There is no universally accepted definition of chemical engineering, but the definition that appeared in the publication of the American Institution of chemical engineers (AIChE 1983) may be considered to be the best of what chemical engineering stands for , viz " **Chemical Engineering is a profession in which a knowledge of mathematics, Chemistry and other natural Sciences gained by study , experience, and practice is applied with judgment to develop economic ways of using**

materials and energy for the benefit of mankind" The strong emphasis attached to the economic concept is in fact the back bone of the work of the chemical engineer. He/she is concerned with the optimization of operating conditions for each unit with the aim of bringing down the overall cost of production.

The use of hot fluids to heat up cold ones in a double wall heat Exchanger is a typical illustration of the economic measures built into the design philosophy of plant equipment.

Chemical engineering has to do with industrial processes in which raw materials are changed or separated into useful products. The chemical engineer must develop, design, and engineer both the complete process and the equipments used in it. He must choose the proper raw materials, he must operate his/her plant efficiently, safely, and economically; and he/she must see to it that his/her products meet the requirements set by his/her customers.

Chemical engineers are employed in many industries in which raw materials are converted to products by chemical reactions and physical changes. The manufacture of sulphuric acid from sulphide ores, the production of ammonia, and the conversion of petroleum into a variety of petrochemicals is by chemical reaction while physical changes predominate in the production of sugar from sugar beets or sugar cane, and the extraction of oil from corn or any seed,. The work of many engineers in the industry involves the development of processes and the design and operation of plants. Process development is a term used by engineers to describe the search for optimum equipment and conditions for the process. The steps constituting the process are usually known and these steps are combined in a way to make the process profitable, when carried out in large scale equipment. The job of chemical engineers in design is usually to determine certain general characteristics and dimensions of the equipment, like the column height and diameter, number of plates required for the separation and the required method of control for the distillation column. The thickness of the column wall, the dimensions of the foundation are likely to be specified by mechanical engineers and civil engineers respectively. The electrical engineers will specify the details of the control systems. The function of engineers in plant operation is not only to supervise routine production but to improve plant efficiency by making changes within the existing process.

2.2 Chemical Engineers in the development of small scale industries.

Small scale industries has contributed immensely to the strengthening of Nations and this nation can not be an exception. Chemical engineers are capable of designing simple, but commercially viable processes which will be useful in uplifting the national development. Countries like India, Brazil, Korea and Japan have developed their small scale industries to the extent of being considered as developed Nations. By the application of such techniques as distillation, extraction, evaporation, crystallization, filtration, and drying to mention a few, chemical engineers will provide appropriate technologies employable . Such small scale industries include, the recycling of paper, iron and steel, tin, copper cuttings, non-ferrous metals, plastics, textiles, rubber, minerals, chemicals oil, human and household wastes.

Small scale industries which produce goods for local consumption play an important role in bringing about a healthy economy. They subsequently feed bigger industries and thus provide work. Chemical engineers will help in building up in-house expertise in process, equipment and project development, modernization, scaling-up, project execution and challenge shooting.

2.3 The Chemical Engineer as an educator

In Nigeria today, many chemical engineers are engaged in teaching in the Universities and Polytechnics. Greater co-operation between the academic sector and the industry is capable of making us a great Nation. Chemical engineers who have retired from industry should also be encouraged to go into teaching, in order to share their wealth of experience. Certainly, the more industries we have in the Country the better for us, as people will be gainfully employed. Goods, hitherto imported from other Countries will find roots here. The foreign exchange is thus preserved. Also the many research results wasting on the shelves of some Universities will come alive through the interaction of the academics and the industries. It is not gainsaying that industries fund research in Universities and Polytechnics of the developed country. It is only in this part of the world that industries carry out their on research, hence creating a pipeline for the evacuation of much of their profits. One may ask this question, what do you need to add to lube oil that cannot be source in Nigeria, to the extent that the expensive additive is imported. It is true that the company has to protect their trade secrets, notwithstanding, reoriented Nigerians can keep such secrets. After all, there are Nigerians in High Managerial Level in Multinational Companies in Nigeria.

2.4 The role of chemical engineers in research and development.

Research and development is the bed rock of serious companies to be at the learning edge. Research and development is needed to take industries to the next level. It is what is responsible for keeping them at the cutting edge, bleeding edge , learning edge as the case may be. A typical advert by a very important company put this clearly.

"Procter & Gamble Pharmaceuticals is seeking candidates for engineer positions in their global Market Support Technology Organization located in Norwich, New York. This individual will be responsible for technical support of marketed

pharmaceutical products process engineering support of drug product processes, modification of existing products/processes, to solve supply, quality, and regulatory issues and to improve processes.” These tasks may be explained as follows:

* Doing research to develop new and improved chemical manufacturing processes
* Determining the most effective design for industrial plants
* Making recommendations to management about a manufacturing process, design of a new plant, or modification of an existing plant
* Selecting equipment and instruments to regulate processing
* Developing safety procedures

While some chemical engineers specialize in a particular operation, like oxidation or polymerization, other s devote themselves to a particular area like pollution control, or the production of specific products like fertilizers, pesticides, automotive plastics and chlorine bleach. They may also research and evaluate chemical processes on a contract basis for other firms and companies.

2.5 Future prospects for chemical engineers in the Nigerian Economy

In the beginning of this Nation, Public sector growth Strategy dominated the thinking at that time. State owned enterprises (SOE) became the order of the day , controlling the heights of the economy with a choking hold on the private sector. This scenario provided stunts development of indigenous private sector. Large scale wastage became unavoidable and many State owned companies went under. These companies such as

* **Oku Iboku and Jebba Paper mills,**
* **Aluminum Smelting Company of Nigeria , Iwopin (ALSCON),**
* **National Fertilizer Company of Nigeria (NAFCON)**
* **Steel Rolling Mills**
* **Nigerian Railway Corporation**
* **Federal Super Phosphate Fertilizer Company, Kaduna**

However, reforms have been ongoing in Nigeria for several decades to improve the situation. The latest economic reform policy is tagged "National Economic Empowerment and Development Strategy" (NEEDS) at the National level and SEEDS (State Empowerment and Development Strategy) at the State level. This NEEDS package placed the private sector as "the executor, investor and manager of businesses, while the government will be the enabler, facilitator and regulator, thus helping the private sector to grow, create jobs and consequently creating wealth . Under NEEDS, deregulation and liberalization are designed to diminish government's control and thereby attracting increased private sector investment. The effect of reforms on economic growth is shown in table 1. It is heart warming to note that the real GDP growth rate has been on the increase since 1999, the beginning of President Olusegun Obasanjo's administration.

In industrialized countries , chemical engineers dominate the management of the contracting industry a opposed to Accountants and Lawyers.

Chemical engineers have a positive contribution to make in the area of energy needs for the Country, in that they can develop simple technology that will suit the energy requirement of the rural areas. They also do well in the area of environmental protection, because of their position in process plants and their knowledge in the design of the plant.

Chemical engineers are knowledgeable in the tools requires for cleaning the environment such as Liquid /solid separation, ion exchange, electrolysis, electrodialysis, osmosis, reverse osmosis, ultra filtration, decolourising agents, etc. A strong national will always strife to put the citizens at work so that they can produce goods and services. Engineers are needed to make a country strong as evident in table 2.

The earnings of chemical engineers should also be highest for all engineering as obtained in developed countries like United States of America as shown in table 3.

Table 1. Effect of reforms on economic growth.

YEAR	1999	2000	2001	2002	2003
Real GDP Growth Rate	0.40	5.40	4.60	3.5	10.23
Oil Sector Growth Rate	-7.50	11.10	5.20	-5.70	23.90
Non-Oil Sector Growth Rate	4.40	2.90	4.30	3.60	3.25
Agric sector Growth Rate	5.29	2.90	3.90	4.30	7.00

Source: Federal Office of Statistics/National Planning Committee, 2004

Table 2. United kingdom Employment of Graduate Chemical Engineers in different fields, 1980 –82

TYPES OF JOB	TOTALS, %
Professional Engineering	74.9
Administration, operational Management	4.0
Scientific	3.7
Buying, Marketing, Selling	3.4
Technological	3.0
Management Services	2.3
Financial	2.1
Scientific Engineering Support	1.9
Teaching , Lecturing	0.7
Aircraft and ships offices	0.6
Legal	0.5
Others	2.9

Table 3. Average starting salary offers for engineers, according to a 2005 survey by the National Association of colleges and Employers of U.S.A

CURRICULUM	BACHELOR'S	MASTER'S	Ph.D
Aerospace/aeronautical/astronautical	$50,993	$62,930	$72,529
Agricultural	46,172	53,022	
Bioengineering & biomedical	48,503	59,667	
Chemical	**53,813**	**57,260**	**79,591**
Civil	43,679	48,050	59,625
Computer	52,464	60,354	69,625
Electrical/Electronics/communications	51,888	64,416	80,206
Environmental/environmental health	47,384		
Industrial/manufacturing	49,567	56,561	85,000
Materials	50,982		
Mechanical	50,236	59,880	68,299
Mining & mineral	48,643		
Nuclear	51,182	58,814	
Petroleum	61,516	58,000	

3.0 SUGGESTED CHEMICALS OF LARGE MULTIPLYING EFFECTS

3.1 Fufural

Furfural was first isolated in 1832 by the **German** chemist **Johann Wolfgang D bereiner**, who formed a very small quantity of it as a bye product of formic acid synthesis. At that time, formic acid was formed by the distillation of dead ants. In 1840, the **Scottish** chemist **John Stenhouse** found that the same chemical could be produced by distilling a wide variety of crop materials, with sulphuric acid, and determined that this chemical had an empirical formula of $C_5H_4O_2$. In 1901, the **German** chemist **Carl Harries** deduced the structure of furfural.

Except for occasional use in perfume, fufural remained a relatively obscure chemical until 1922, when the Quaker Oat company began mass-producing it from oats hulls. Today furfural is still produced from agricultural byproducts. The chemical compound furfural is an industrial chemical derived from a variety of agricultural byproducts, including **corncobs**, **oat bran**, **wheat bran**, and **sawdust**. The name furfural comes from the **Latin** word **furfur**, meaning bran, referring to its usual source.

Fufural is the only monomer used in an industrial organic synthesis that is not obtained from oil but from the vegetation raw materials. Furfural production began in 1922 and it has been unceasingly developed since then, especially since the oil crisis in 1973. Furfural competes successfully with oil chemistry products due to the regeneration of its raw materials, simple obtaining scheme and large application possibilities as well as the unique characteristics of several substances and materials obtained from it. As a result of all these qualities, the price of furfural in the world market have grown 5 times for the last 20 years, but the number of countries where furfural is produced has increased from 9 to 19. A lot of patents can be accredited to furfural usage and production.

* **Production.**

Many plant materials contain **polysaccharide hemicellulose,** a **polymer of sugars** containing five carbon atoms each. When heated with sulphuric acid, hemicellulose undergoes **hydrolysis** to yield these sugars, principally xylose. Under the same condition of heat and acid, **xylose** and other five carbon sugars undergo dehydration, losing three molecules to become **furfural**. Furfural and water evaporate together from the reaction mixture, and separate upon condensation.

*** Properties.**

Furfural is an aromatic aldehyde which dissolves readily in most polar organic solvents but it is only slightly soluble in either water or alkanes. In its pure state, it is a colourless oily liquid with odour of **almonds**, but on exposure to air, it quickly becomes yellow.

Chemically, furfural participates in the same kinds of reactions as other hydehydes and other aromatic compounds. Furfural participates in hydrogenation and other addition reactions more readily than other aromatics.

When heated above 250°C , furfural decomposes into furan and carbon monoxide, sometimes explosively.

When heated in the presence of acids, furfural irreversibly solidifies into hard thermosetting resin.

*** Uses.**

Furfural is used as a solvent in petrol chemical refining to extract dienes (which are used to make synthetic rubber) from other hydrocarbons. Furfural is used in deodourization of kerosene for use in the manufacture of insecticide aerosols as a carrier.

Furfural, as well as its derivative furfuryl alcohol , can be used either by themselves or together with **phenol**, **acetone**, or **urea** to make **solid resins**. Such resins are used in making **fiberglass**, **some aircraft components**, and automotive **brakes**. Furfural is also used as a chemical intermediate in the production of solvents **furan** and **tetrahydrofuran.**

At present two plant designs are commercially available, continuous and batch . The only technology now available is the so-called Chinese batch technology. The Chinese produce extremely simple and inefficient plants, with the following typical running conditions:

Yield	30 to 35%
Reactor cycle	4.5 to 5 hrs.
Time of HS addition	4% by weight solids
Operating Pressure	6 bar
Steam utilization	55 to 60 f steam/f furfural
Effluent Loading	700 to 1,000 kg COD/t Furfural

As a rule of thumb, if these plants operate for a 10-month season at an 86% time efficiency processing corncobs, then the production capacity will be 333.30 t/season/21 m reactor. The reactor efficiency will be 2.34 kg/hr/m^3 of reactor volume. With bagasse as the raw material, the production capacity drops to 106/t/season/21m reactor with a reactor efficiency of 0.74kg/hr/m^3 of reactor volume.

The following is indicative of other furfural potential raw materials

• Cleaned oats	20% theoretical furfural
• Corn cobs	19
• Cottonseed hull bran	17.5
• Rice hulls	12
• Flax shrives	12
• Peanut hulls	11
• Buckwheat hulls	15
• Corn stalks	16.5
• Bagasse	15

3.2 **Hydrated Lime**

Lime has been one of man's most vital chemicals from the earliest times. In one of the first manufacturing processes ever developed, early cultures learned to make lime by heating limestone (calcium carbonate) to high temperature, and it is manufactured by this method today. This process, know as calcining, results in quicklime, or calcium oxide. Hydrated lime (calcium hydroxide) is produced by reacting quick lime with water. Depending on the source of the raw material, dolomitic quicklime and dolomitic hydrated lime containing magnesium as well as calcium compounds could also be produced. The percentage of calcium and silica present in some limestone deposits is shown in table 4, while table 5 is for the location of a few mineral deposits in Nigeria.

A locally constructed kiln of N1.0million naira will process 3 ton of limestone in 5hours , while N350,000= could buy a 500kg lime stone processing capacity kiln. The firing temperature is in the range of 1,100 to 1200 C using locally fabricated burners. The fuel for the burners could be any of gas, kerosene, diesel oil, or low pour fuel oil.

Lime earliest uses were in building and agriculture. Indeed, it was used in building the pyramids of ancient Egypt, and in many construction projects of imperial Rome. With the rapid growth of chemical process industries at the turn of the twentieth century, progressively large, quantities of lime began to be used in industry as a chemical reagent until, today, more than 90 percent of the total amount of lime produced is sold or used as a chemical in its oxide and hydroxide form. Hence, lime is now regarded as a basic or industrial chemical, as well as a building and agricultural material.

It is extensively used in steel manufacturing, mining, and glass manufacture, and has numerous applications in the environmental sector, including use in air and water pollution control. Lime plays a major and growing role in soil stabilization for highway and runway construction, as an asphalt additive, and as a precipitant in the paper and sugar industries.

Lime is used, directly or indirectly, in the manufacture of virtually every consumer or industrial product. Chemical and industrial processes require lime for purifying metals (as a flux), Neutralization, causticization, coagulation, precipitation, hydrolysis, dehydration, high temperature processes, exothermic reactions, dissolution, gas absorption , and saponification. In the United States of America, lime ranks fifth among industrial chemicals in both tons shipped and tons consumed. Recent annual U.S commercial lime production was more than 19 million metric ton. The lime is produced in 33 states in the United States of America. This tonnage is exclusive of the regenerated lime mainly arising from the sulphate pulp plants and water treatment plant where waste calcium carbonate sludge is dewatered and re-calcined in kilns for reuse along wit some "make-up" lime.

The term "lime" refers primarily to six chemicals produced by the calcinations process and hydration, where necessary.

- CaO quicklime
- $CaO + MgO$ dolomitic quicklime
- MgO dead burned dolomite
- $Ca(OH)_2$ hydrated lime
- $Ca(OH)_2 + MgO$ type N dolomitic hydrate
- $Ca(OH)_2 + Mg(OH)_2$ type S dolomitic hydrate.

The percentage usage may be listed as follows:

	35 %	Metallurgy
	28 %	Environmental uses
	13%	Construction and building materials
	8 %	Chemicals
	7 %	as precipitated calcium carbonate
	4 %	in Pulp and paper
	3 %	in sugar refining
	1 %	miscellaneous uses
Less than	1 %	glass products
Less than	1 %	agriculture, food & food by-products.

The world lime production is substantially stable :

- 2002 116 millions metric tons
- 2003 120 millions metric tons
- 2004 121 millions metric tons

Lime is the only material that can perform so many functions at a reasonable cost. Indeed, lime is substantially less expensive than potential substitutes for virtually all of its application. In most cases, lime could only be replace d by highly expensive synthetic materials. The purity of the product from Nigeria's limestone deposit is shown in table 3.

3.2.1 Iron and steel manufacture:

In the metallurgical field, quicklime ,both high calcium and dolomitic , enjoys its most extensive use as a flux in purifying steel in the traditional basic oxygen furnace (BOF) and the new are electric arc furnace (EAF). Hydrated lime (either dry or as a slurry) has a number of miscellaneous applications, in the manufacture of steel products. It is commonly used in wire drawing, acting as a lubricant as the steel rods or wires are drawn through dies, and in pig and stag casting, in which lime white wash coating on the moulds prevents sticking. Lime is employed in the neutralization of sulphuric acid based waste pickle liquor, in which iron salts are also precipitated

3.2.2 Nonferrous metals industries :

- **Ore Concentration:** both quicklime and hydrated lime are widely used in floatation or recovery of many non-ferrous ores, in particular copper ore floatation in which lime acts as a depressant (settling aid) and maintains proper alkalinity in the floatation circuit. In the recovery of mercury from **cinnarbar,** lime is used to remove sulphur. Lime is also used in the floatation of zinc, nickel, and lead bearing ores. It is often used as a conserving agent to assist in the recovery of **xanthates**, another floatation chemical. Lime is extensively used in the recovery of gold and silver in the cyanide leaching process to curtail the loss of cyanide, a costly dissolution agent, and for pH control.

- Alumina and bauxite: Quicklime is used in varying amounts to remove silica from bauxite ore and for causticization in the manufacture of alumina.

- Magnesium: lime is used to produce metallic magnesium

- Other metallurgy; in the smelting and refining of copper, zinc, lead, and other non-ferrous ores, noxious gas fumes of SO_2 can be neutralized by passing these gases through "milk of lime" (dilute hydrated lime in aqueous suspension) in a scrubber to avert the formation of sulphuric acid in the atmosphere, as well as corrosion of plant equipment.

3.2.3 Environmental uses:

The use of lime to address environmental problems is one of the fastest growing markets for lime products. Lime has found key uses in almost every area of pollution prevention and abatement, including treatment of air emissions, treatment of both drinking water and waste waters, and remediation of hazardous wastes. Lime's unique characteristics, couples with its low cost, makes it an attractive choice for these applications.

In the treatment of flue gas, lime reacts with sulphur dioxide to form calsium sulphite

$$SO_2 + Ca(OH)_2 \rightarrow CaSO_3 + H_2O$$

The sulphite can then be air oxidized to form calcium sulphate di-hydrate, or gypsum:

$$2CaSO_3 + O_2 \rightarrow 2\,CaSO_4$$

$$CaSO_4 + 2\,H_2O \rightarrow CaSO_4.2H_2O$$

The overall reaction of lime with hydrochloric acid is

$$HCl + Ca(OH)_2 \rightarrow CaCl_2 + 2H_2O$$

Hydrochloric acid Calcium chloride

3.2.4 **Municipal wastewater treatment:**

Lime precipitation is employed in processes in which phosphorous is precipitated along with other suspended and dissolved solids. When alum and ferric chloride are employed for coagulation, lime is used to counteract the low ph induced by these acid salts and to provide the necessary alkalinity for efficient nitrogen removal.

3.2.5 Industrial wastewater:

In steel plants, sulphuric acid based waste pickle liquors are neutralized with lime in which the iron salts are precipitated.

Lime is also a neutralizer and precipitant of chrome, copper, and heavy metals in processes for treating discharges from plating plants.

3.2.6 Treatment of sludge:

In sludge treatment, quicklime and calcium hydroxide have been used to treat biological organic wastes for more than100years.

3.2.7 Treatment of animal wastes:

Lime can be used to control the environment needed for the growth of pathogens, similar to the way that lime stabilization is used for human sewage sludge (biosolids).

Table 4. Percentage of Calcium and silica present in some limestone deposits in Nigeria.

TOWN	STATE	% $CaCO_3$	% SiO_2
Nkalagu	Anambra	84.2	9.5
Igunmale	Benue	96.6	Trace
Yander	Benue	92.8	2.5
Mopa	Kogi	93.8	1.0
Ukpilla	Edo	93.1	1.17

Table 5 . The locations of a few mineral deposits in Nigeria.

LIME STONE	GYPSUM	TANTALITE
Abia	Abia	
Adamawa	Adamawa	
Akwa Ibom		
Bauchi		Bauchi
	Benue	
Borno	Borno	
Cross River		
Ebonyi	Eboyi	
Edo	Edo	
Ekiti		Ekiti
	Enugu	
Gombe	Gombe	
Imo		
	Katsina	
Kogi		
Kwara		Kwara
Niger		
Ogun	Ogun	
Osun		
Sokoto	Sokoto	
Taraba	Taraba	Taraba
Yobe	Yobe	

3.3 CASTOR OIL

Castor (Ricinus Communis Linn) is an annual plant requiring about 280 days from seeding to drying. which could live for a number of years with constant supply of water. The seeds are carried in the spikes of between 3 and 30 per crop. There is a variation in the seed size from as small as 7.95 mm x 5.30mm to 20.95mm x 13.50 mm. The leaves, the seed are shown in plate 1. The oil which is obtainable by mechanical expression or by solvent extraction has a wide range of industrial uses including the manufacture of surface coating, wetting agents for industrial disinfectants and for pest control products. It finds other uses in lubricants, textile processing, detergents , dyeing brake fluid, and manufacture of foam.. Other proven usage is in the manufacture of nylon 11, plasticizers, varnish, ester of ricinoleic acid, in the production of sebacic acid and secondary octyl alcohol. The ricinoleic acid is used as an ingredient in chemical contraceptives (Kulkani 1959) to lower surface tension, thereby disturbing the sperm activity. Castor oil has a strong laxative action (Vllette 1936) due to the presence of the ricinoleic glycerides. If the oil is cracked under pressure, its products could be used for motor and diesel fuels(Mandlekar 1947). The amides from castor oil are usually pyrolysed (Du pont 1946) to give **undocylamides** which are used in fly sprays and insecticides. The lower grade of castor oil is used in the manufacture of transparent soaps and typewriter ink. Large quantities of the oil ae “sulphonated” to produce the familiar turkey-red-oil long employed in dyeing cotton fabrics, particularly with alizarin.

The crude oil is normally about 49 percent of the whole seed. It has a high content of ricinoleic acid, which gives the oil certain distinctive properties, viz: high specific gravity, refractive index and viscosity. The low saponification value and the near-insolubility in light petroleum ether is an added advantage. The oil is miscible with ethyl alcohol. Fine quality, almost colourless, castor oil is used for medicinal purposes and also for aero engine lubrication purposes. The outlets for the oil is enormous but the principal uses, in most of the country producing it, is for surface coating (paint) industry.

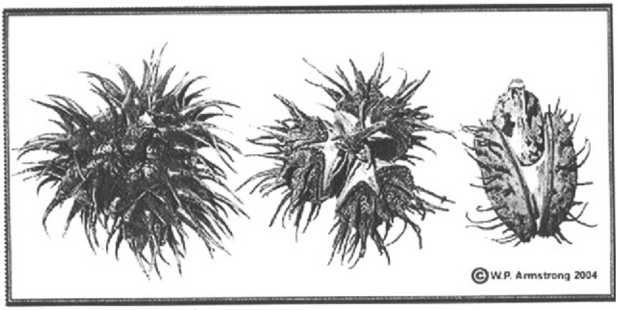

Plate 1 Castor bean fruit (Ricinus communis). The spiny seed capsule (left) dries and split into 3 sections called carpels (center). Each carpel (right) split open to eject the seed.

3.4 **TANTALUM.**

Tantalite ores are found in Australia, Canada, Brazil and Nigeria. The deposits in Nigeria are located in Bauchi, Ekiti, Kwara and Taraba States, table 5. Tantalum is obtained from tantalite ore by extraction and subsequent refining. The extraction method separates tantalum from niobium , an equally important metal. A mixture of hydrofluoric and sulphur acid at elevated temperature is used for the extraction. This causes the tantalum present to dissolve as complex fluorides including some impurities. These impurities often include silicon, iron, manganese, titanium, zirconium, thorium and rare earth metals. Methyl Isobutyl Ketone (MIBK) is usually the solvent for the extraction. Further processing will give tantalite fluoride (K_2TaF_7) or tantalum oxide. Niobium is recovered as niobium oxide (Nb_2O_5) from Niobium fluoride complex with ammonium hydroxide.

The primary tantalum chemicals of industrial significance, in addition to K_2TaF_7 and Ta_2O_5, are tantalum carbide (TaC), tantalum chloride ($TaCl_5$), and lithium tantalate ($LiTaO_3$). Tantalum metal powder is generally produced by the sodium reduction of the potassium tantalum fluoride in a molten salt system at high temperature. The metal can also be produced by the carbon or aluminum reduction of the oxide or the hydrogen or alkaline earth reduction of tantalum chloride. Capacitor grade powder is produced by the sodium reduction of potassium tantalum fluoride. The choice of process is based on the specific application and whether the resultant tantalum will be further consolidated by processing into ingot, sheet, rod, tubing, wire, and other fabricated articles.

Capacitor grade tantalum powder provides about 60% of the market use of all tantalum shipments. Additional quantities are consumed by tantalum wire for the anode lead as well as for heating elements, shielding, and sintering tray assemblies in anode sintering furnaces.

The consolidation of metal powder for ingot and processing into various metallurgical products begins with either vacuum arc melting or electron beam melting of metal feed stocks, comprised of powder or high purity scrap where the elements with boiling points greater than tantalum are not present. Double and triple melt ingots achieve a very high level of purification with regard to metallics and interstitials. Ingots are used to produce the various metallurgical products named earlier. Ingot stock is also used for the production of such alloys as tantalum-10% tungsten. Ingot and pure tantalum scrap are used in the production of land and air-based turbine alloys.

The applications of tantalum is shown in table 6. The use of columbite and tantalum bearing ores, such as tantalite, as feed stocks for the production of Tantalum necessitate the separation of Niobium. In similar processing, niobium oxide (Nb_2O_5) is obtained. This niobium oxide is generally the starting point for the production of other compounds, such as niobium chloride ($NbCl_5$), niobium carbide(NbC), lithium niobate ($LiNbO_3$) and ultimately the niobium metal. The applications of niobium are shown in table 6.

These metals (Tantalum and Niobium) and their compounds fetches a lot of money in the international market. Nigeria should not be content about selling the ore alone but adding value to it. This will provide employment, save foreign exchange and earn foreign exchange.

A small percentage of Niobium and Niobium compounds produced in the World is being used in sophisticated electronic components and systems, such as capacitors, piezoelectric devices and optical circuits. This paper briefly describes the outline of the production process of these materials and their main characteristics.

Niobium: From Ore to Sophisticated Products

The Niobium Market In 1999, about 87,60% of the total worldwide requirements (50,6 Mlb of contained Nb) for niobium was marketed in the form of Ferro niobium for the high strength low alloy (HSLA) steel and stainless steel industries . About 2% of niobium was converted into special alloys like NbTi, NbZr, NbCu and roughly 10% took the form of chemical compounds like Nb_2O_5, $NbCl_5$ and vacuum grade FeNb, NiNb. Most niobium metal is used for the production of niobium based alloys and high purity oxide. Other uses for pure niobium metal are:

- Corrosion resistance (e.g. impressed current cathodic protection anodes ICCP)
- High temperature parts (e.g. furnace hardware)
- Medical applications (e.g. surgical implants)
- Sputtering targets (e.g. glass and electronic industry, razor blades)

Table 6. Various uses of Tantalum

Tantalum Product	Application	Technical Attributes/Benefits
Tantalum carbide	Cutting tools	Increased high temperature deformation, control of grain growth
Tantalum oxide	- Camera lenses - X-ray film - Ink jet printers	- High index of refraction for lens compositions - Yttrium tantalate phosphor reduces X-ray exposure and enhances image quality - Wear resistance characteristics. Integrated capacitors in integrated circuits (ICs)
Tantalum powder	Tantalum capacitors for electronic circuits in medical appliances such as hearing aids, pacemakers, also in airbag protection systems, ignition and motor control modules, GPS, ABS systems in automobiles, laptop computers, cellular phones, Play station, video cameras, digital still cameras.	High reliability characteristics and low failure rates, operation over a wide temperature range from -55 to +125°C, can withstand severe vibrational forces, small size per microfarad rating/electrical storage capability.
Tantalum fabricated sheets, plates, rods, wires	- Sputtering targets - Chemical process equipment - Cathodic protection systems for steel structures such as bridges, water tanks - Prosthetic devices for humans - hips, plates in the skull, also mesh to repair bone removed after damage by cancer - Suture clips - Corrosion resistant fasteners, screws, nuts, bolts - High temperature furnace parts. - High temperature alloys for air and land based turbines (e.g. jet engines)	- Applications of thin coatings of tantalum, tantalum oxide or nitride coatings to semi-conductors - Superior corrosion resistance - equivalent in performance to glass. Attack by body fluids is non-existent. Melting point is 2996°C, but protective atmosphere or high vacuum required. Alloy compositions containing 3-11% tantalum offer high temperature reliability, resistance to corrosion by hot gases.

Table 7 Various application of Niobium Product.

Niobium Product	Application	Technical Attributes/Benefits
HSLA Ferro-niobium (~60%Nb)	Niobium additive to ‘high strength low alloy’ steel and stainless steel for oil and gas pipelines, car and truck bodies, architectural requirements, tool steels, ships’ hulls, railroad tracks.	Imparts a doubling of strength and toughness due to grain refining. Weight reduction.
Niobium oxide	- Manufacture lithium niobate for surface acoustic wave filters. - Camera lenses. - Coating on glass for computer screens. - Ceramic capacitors.	- High index of refraction. - High dielectric constant. - Increase light transmittance.
Niobium carbide	Cutting tool compositions.	High temperature deformation, controls grain growth.
Niobium powder	Niobium capacitors for electronic circuits.	High dielectric constant, stability of oxide dielectric.
Niobium metal plates, sheets, wire, rod, tubing	- Sputtering targets. - Cathode protection systems for large steel structures. - Chemical processing equipment.	Corrosion resistance, formation of oxide and nitride films. Increase in high temperature resistance and corrosion resistance, oxidation resistance, improved creep resistance, reduced erosion at high temperatures.
Niobium-titanium alloy Niobium-tin alloy	Superconducting magnetic coils in magnetic resonance imagery (MRI), magneto-encephalography, magnetic levitation transport systems, particle physics experiments.	Electrical resistance of alloy wire drops to virtually zero at or below temperature of liquid helium (-268.8°C).
Niobium-1%zirconium alloy	- Sodium vapor lamps - Chemical processing equipment	Corrosion resistance, fixation of oxygen, resistance to embrittlement.
Vacuum-grade ferro-niobium and nickel-niobium	Super alloy additions for turbine blade applications in jet engines and land-based turbines..	Increase in high temperature resistance and corrosion resistance, oxidation resistance, improved creep resistance, reduced erosion at high temperatures.

3.5 PAPAIN

Carica papaya (paw paw) is an excellent source of vitamin A and C, and potassium. Papaya is consumed fresh when ripe while the green fruits are grated in salads. The green fruits could be added to meat while boiling to make the meat tender. The latex of the papaya plant and its green fruits contains two proteolytc enzymes, **papain** and **chymopapain**. The latter is most abundant but papain is twice as potent, see plate 2

Papain is a product extracted by bioengineering technique from the unripe papaya (pawpaw). It is natural and safe. Papain is useful as a digestive aid and has putative Anti-inflammatory activity. Papain is widely used in food industry, cosmetic, medical, forage industry etc. it can be packaged in stabilized, refined or crude form

A company in India, delta international, Mumbai, export this product to these countries: USA, Canada, Brazil, Europe, Russia, Middle east, Egypt, and South East Asia. The papain imported to the USA is used for meat-tenderizers and chew gums.

Papain, the proteolytic enzyme, has a wealth of industrial uses. It is used for degumming natural silk and wools before dying. It is use to remove hair from hides during tanning and also used to extract oil from tuna (a kind of fish) liver.

Papain enzyme is a protein with papain proteinase, chymopapain and lysozyme. Papain from papaya fruit, is active over a wide pH range and helps the body to digest proteins, fats and sugars, why amylase digests carbohydrates and sugars. By enhancing digestion, Papaya Enzyme help us get the most nutrition from the food we eat and may ease the bloating, gas and digestive disturbances that many people often experience after eating.

Plate 2 Pawpaw fruit (top), and pawpaw leave

Brewery

Alcoholic beverages are generally chilled before use, it tends to have turbid appearance due to the formation of protine-polyhydric phenol complexes during brewing and chilling. The difficulty is overcome by use of Papain which degrades these complexes to smaller particles which are too small to form haze. In U.S.A. 80% of the beers are made chill-proof by using Papain. Papain is used to improve attenuation in high gravity worts and to assist in stuck fermentation.

Other uses include:

- Enzyme for liquefaction of starch to dextrin.
- Silica Gel / Xero Gel that improves filterability and shelf life of beer.
- Enzyme for production of diet (low carbohydrate) beer.
- Chill proofing protease that is used in tackling chill haze in beer.
- Foam stabilizer that increases volume and compactness of the head.
- Mash enzyme for improving yield filterability and fermentation of wort.
- Enzyme used for better lautering efficiencies and to tackle Betaglucan haze.
- Anti-oxidant used to remove dissolved oxygen in beer and to increase shelf life.
- Helps promote the healthy growth and fermentation of yeast.

Meat Industry

Papain is used as meat tenderizer in different processes. viz. ante-mortem injections, a postmortem or carouses injection etc.

Dairy Industry

Papain is consumed in the manufacturing of cheese which gives product excellent quality and softness.

Photographic Industry

Papain is used in the preparations for the recovery of silver from spent film in photographic processing laboratories.

Optical Industry

Papain is used in certain face creams, cleansers and face lift preparations and also in tooth pastes .

Tanning Industry

It is used for bating and hair removal.

Cereal Industry

Papain is used to enrich protein cereals, instance food and high-protein foods. It is also used in manufacture of instance foods to facilitate more rapid cooking.

Cosmetic Industry

Papain is used in certain face creams, cleansers, face lift preparations and toothpaste.

Animal & Fish Feed

Papain

- Splits chains of protein, producing small peptides and free fatty acids, and helps in protein digestion.
- Hydrolyses starch molecules into smaller oligosaccharides, glucose and maltose.

- Ensures availability of adequate nutrient supply for growth and performance.
- Responsible for the absorption of ingested fats and mobilization of storage fats in animals.
- Helps in degrading cellulose and various plant fibrous material.
- Digests high molecular weight Arabinoxylans in animal feeds.
- Degrades phytin phosphorus and converts it into available form, thereby reducing the quantity of supplemented phosphorus. A cocktail enzyme preparation, tailor-made to suit the customer's requirements, is also available.

Pharmaceutical Industry

- The major use of Papain is in the drug heparin. vaccines and digestive enzyme. It is also as an excellent enzyme for breaking down proteins.
- Is widely used for replacement therapy in pathological conditions in which the concentration of bile acids in upper intestine is low, such as biliary fistula, disease of the ileum, hepatic or extra-hepatic cholestasis.
- Is an excellent fibrinolytic and caseinolytic enzyme which in combination with amylase and lipase proves to

be formidable digestive aid. It may be administered in acid solution to increase the digestive power of gastric juices, particularly where there is a deficiency of pepsin secretions.

- It is used as a debriding agent for cleaning of necrotic wounds, ulcers, sinuses and fistulas. It also finds application as an anti-inflammatory agent in the treatment of bronchial asthma, bronchitis and thrombophlebitis.

A brief summary of the uses of papain is shown in table 8.

Table 8 Uses of papain in different industries.

INDUSTRY	**USES**
Pharmaceuticals	Protein hydrolysable, lacto peptones
Food industry	Manufacture of chewing gum, clarifying juices and tenderizing of meat
Breweries	Clarifying beer or removing the haziness in beer
Textiles	De-gumming textile materials
Cosmetic Industry	Making of face creams, cure of skin diseases e.g. ringworm

3.6 SAWDUST

Various industrial and consumer goods can be derived from common wood wastes such as sawdust. Wood wastes are frequently combusted (burned), fermented (to create methane , methanol or ethanol) or used in bioreactors (to make carbon and hydrogen) for the production of energy or to produce fuels or industrial chemicals. The methods for the conversion of sawdust to methanol and ethanol are well documented. Sawdust can also be used for the production of activated carbon.

A small scale manufacturing enterprise could be set-up to produce powdered activated carbon. This can be done by chemical activation process using sawdust and phosphoric acid. The carbon manufactured by this process has high surface area in excess of 800sq.m/gm. Annual production rate of 350 - 400MT of powdered chemically activated carbon is feasible in Nigeria, considering the amount of sawdust available. Steam activated carbon could then be added at a latter stage.

There are two main methods of producing activated carbon: **chemical activation** and **steam activation.** Chemical activation involves mixing an organic chemical compound with sawdust. The most widely used activating agents are phosphoric acid and zinc chloride. Zinc chloride usually ends up in trace amount in the end product., thus making phosphoric acid preferable. Steam activation is generally used for coal-based, coconut shell and grain based activated carbons.

3.6.1 Uses.

The major importers of activated carbon are the **breweries** and **the soft drink** industries. They use activated carbon in purifying the water used in their production. Activated carbon and a more refined form of charcoal ,**carbon black**, are used in **inks** or **toners for copiers and laser printers**, in **wastewater** treatment systems and **industrial processes.** Activated carbon produced from sawdust cost less than those produced from natural gas (Lartey et al 1999).

4.0 CONCLUSION

There is hardly any facet of human living that is not affected by products of industrial application of chemical engineering principles. From food to fuel, from automobile to space rocket, from beer brewing to petrochemical manufacture, from cement industry to steel industry, all, without exception, are fundamentally affected and determined by the practice of chemical engineering profession. Indeed ,it is highly improbable that a nation can achieve any significant economic development without chemical engineers.

The development of our local raw materials will go a long way to the development of the nation. The most basic sources of raw materials are agricultural products , mineral resources, petroleum, the air we breathe, and water. It would appear , therefore, that the problem lies in how to convert these primary raw materials into secondary raw materials usable to the modern industries.

Petroleum by itself or in conjunction with air and/water must be converted to petrochemical feedstock and to petrochemicals.

Corn must be converted to alcohol

Iron ore and coal must be converted into carbon steel or alloy steel in conjunction with other minerals,

How do we solve this problem without chemical engineers in particular and engineers in general? The truth of the matter is that we cannot . then how do we solve this problem for our nation in such a way as to assure that the long term strategic control of our economic development, social well being, and territorial integrity remains firmly under our command without indigenous Nigerian engineers? The answer to that is that we cannot.

The American engineers, or Japanese, Italian, Germans, British, Brazilian, Indian, Chinese, Korean or Filipino have come, are coming, and may still be coming, to design and construct a refinery for us, or a petrochemical plant, or a dam or a soap factory or an acid plant. Each time these expatriate engineers do " **their thing**" , they take away our foreign exchange and knowledge and experience which should rightfully be acquired buy our indigenous engineers. After all civilization is nothing but an accumulation of human knowledge.

6.0 RECOMMENDATION

The following are recommended for implementation in order to further strengthen the national economy

- Small to medium scale industries based on the six highlighted raw materials base ought to be put in place by Entrepreneurs in any Local Government Area where they are available.

- Federal, State and Local Government Authority should create an enabling environment for the take off of the SME (Small to Medium Scale Enterprise).

- Castor plant farming should be encouraged in Nigeria to provide the industrial raw materials.

- Pawpaw plantation , particularly the short variety, should be encouraged in Nigeria for the production of papain. Intercropping with runners like beans is an added advantage.

- The limestone and dolomite of Oreke, the kaolin of Idofian, and the highly exportable rich tantalite deposit in Iporin, all in Kwara State should be developed by the State Government in partnership with private entrepreneur to provide added revenue and work for the people of the State.

- The completed research results in Nigeria should be pooled together and made into a book series.

- Each State, must as a necessity, go through the book and implement applicable research results depending on the raw materials available to theme.

- Engineers have traditionally been concentrated in slow-growing manufacturing industries, in which they will continue to be needed to design, build, test, and improve manufactured products. However, employment of engineers in faster growing service industries should be encouraged.

- Continuing education is important for engineers because much of their value to their employers depends on their knowledge of the latest technology, so that they are able to deliver the best solutions and be of the greatest value.

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