Formulating Medicines Round the Globe: Lessons for the Growth of the Pharmaceutical Industry in Nigeria.

By
Rev. Canon Prof. Jacob Okwuchukwu Onyechi – May 28, 2015

PROTOCOL
The Vice-Chancellor, Prof. Benjamin Chukwuma Ozumba
Deputy Vice-Chancellors
Principal Officers of the University
My Lord Bishop of Nsukka Diocese, Church of Nigeria, Anglican Communion
Chairman, Senate Ceremonials Committee
Distinguished Professors of our Great University
Eminent Past Inaugural Lecturers
Respected Academics
Other Staff of the University
Ministers of the Gospel
Distinguished and Highly Honoured Guests
Your Royal Highnesses
My Lords, Spiritual and Temporal
Great Lions and Lionesses
Ladies and Gentlemen

1. INTRODUCTION

It is with gratitude to Almighty God that I deliver the ninety-third (93rd) Inaugural Lecture of the University of Nigeria. Counting, this lecture is the second from the Department of Pharmaceutical Technology and Industrial Pharmacy, and the sixth from the Faculty of Pharmaceutical Sciences. I am humbled to be adjudged fit to give this lecture and do so with great pleasure.

1.1 Inaugural Lecture

The Inaugural Lecture is delivered by a professor (newly promoted or long-tenured) to inform the university community and the

public of activities undertaken to become a professor. It includes current research activities and future plans in his chosen field. It is a very significant occasion in the career of an academic staff in the university and an integral part of university academic life.

For me, Vice-Chancellor Sir, this Inaugural Lecture is an opportunity to share my experiences in an odyssey through four out of the seven continents of our world. The odyssey involved studying about medicines and formulating medicines. I also played a game called cricket, lovely cricket, as the opportunity presented. However, I intend to highlight achievements in drug research and development, innovation and teaching. I will seize the opportunity to thank my research associates here and abroad who collaborated with me over the years. They are the ones really responsible for the success story we tell today.

1.2 Early Education

Jacob Okwuchukwu Onyechi was born at Ama-Nwanyi Womenôs Training Centre, Awka on 18th October 1951, the 3rd child, in a family of 10 children, born to the Late Revd Jacob Aniemeka and Late Mrs. Mabel Onyechi of Abatete in Idemili North Local Government Area of Anambra State. Jacob had his primary education in many schools in the present Abia State and Rivers State of Nigeria (St Silas School, Okaiuga, Umuahia; St Matthiasô School, Okomoko, Etche, Rivers State and Holy Trinity School, Nchia, Eleme, Rivers State) finishing with Division One with Distintion in 1965. Jacob attended the prestigious Government Secondary School, Afikpo, obtaining WASC Division One with Distinction. Jacob also won School Colours in Athletics, Football, Hockey and Cricket. He captained Hockey and Cricket in the school and was Captain of School too. Jacob was admitted to read Pharmacy in the Faculty of Pharmaceutical Sciences, UNN from which he graduated with Second Class Upper Division in 1979.

1.3 Impetus for Formulation Sciences and Industrial Pharmacy Practice

Today's lecture titled *Formulating Medicines around the Globe: Lessons for the Growth of the Pharmaceutical Industry in Nigeria* was borne out of a rich experience in research formulating medicines, which started as an undergraduate student of the University of Nigeria. As a second year pharmacy student in the Department of Pharmacy, I requested and was obliged with a posting for Industrial Training at the Pfizer Ltd Manufacturing Plant at Alausa, Ikeja in 1977. I reported at the Pfizer Plant armed with a notebook and writing materials, rather to the surprise of an austere looking American educated Egyptian Plant Manager. The manager gave me my first lessons ever in intellectual property rights. My subsequent deployment to the production department of the plant and drafting as substitute for an injured machine operator, only a month into my training, ensured that I acquired sufficient interest in industrial pharmacy practice to last a life time. The machine operator was involved in a car accident on his way to work and I was found a suitable substitute. In that industrial attachment, I successfully operated a 32-station rotary tablet press making Tetracycline tabs; Marax tabs; Delta Cortril tabs; Prednisolone tabs; Pyrantel Pamoate tabs, among other tablets. I also successfully manned the Cam MG2 Capsule filling machine manufacturing Vibramycin caps; Diapec caps; Obron caps, and Urobiotic caps, among other capsules. I liked what I did, and till date I have continued to make medicines. What was a problem for somebody became an opportunity for me.

2. THE LECTURE

Vice-Chancellor Sir, in this inaugural lecture, because of time constraints I will only highlight my work and research findings including collaborations with scientists in pharmaceutical and allied sciences within and outside Nigeria. I have supervised only few postgraduate students in pharmaceutical technology and industrial pharmacy, I will not bore you with my modest contributions to research and development of pharmaceutical technology and drug delivery through supervision of higher degrees. My research work is mainly in the area of formulation

sciences and drug delivery. Compartmentalized, a fair listing of the research areas would be:

- Raw Materials Processing/Excipient Design
- Drug Development
- Airways Delivery of Medicines
- Medicines Formulation for Extemporaneous Dispensing
- From Research to Manufacturing Laboratory: The story of MedPharm Ltd., UK.

2.1 Drug Discovery and Development

Drug discovery/development is the process through which potential new medicines are identified and developed. Pharmaceutical development is one of the most challenging aspects of pharmaceutical and biopharmaceutical innovations. It involves navigating the complexities of pharmaceutical sciences and manufacturing, while achieving regulatory compliance (Fig. 1).

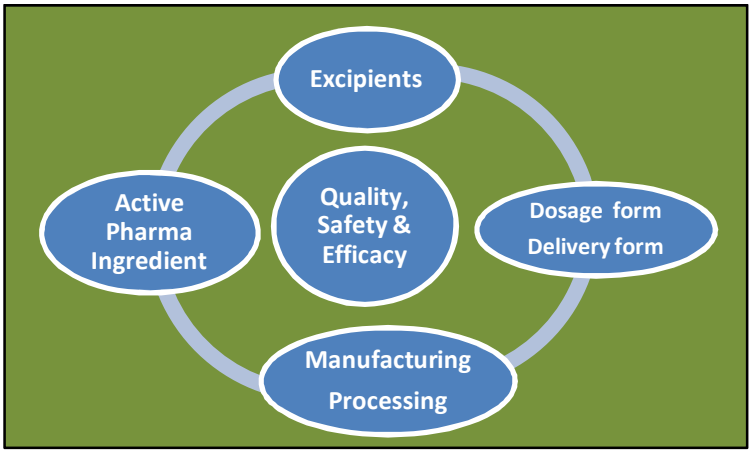

Fig.1: Complexity of drug development

Modern drug discovery involves the identification of screening hits, medicinal chemistry and optimization of those hits to increase

the affinity, selectivity (to reduce the potential of side effects), efficacy/potency, metabolic stability (to increase the half-life), and oral bioavailability. However, it should be noted that discovery of new drugs alone is not sufficient to ensure progress in therapy. Choosing the right excipients can make all the difference in the efficient production of a robust drug delivery system.

There are two quite different cultures that coexist within the research and development (R&D) organisation. Some of the differences are highlighted in Table 1. Throughout my odyssey I found myself working within the development section of the R&D divide. I was comfortable. Given the option, I would not have made another choice.

Table 1: Differences between the Discovery and Development Environment

	Discovery	Development
Overall Objective	Select a development candidate	Submit New Drug Application or PLA
Corporate Mandate	Broad, loosely defined	Narrow, focused
Compounds Tested	Many and diverse	One
Types of Studies Used	Few	Many
Regulatory Control	Little or none	Extensive
Timetable	Loose, flexible	Strict, constrained
Basis of Recognition	Innovation	Speed
Culture	Chaotic	Structured
Workstyle	Entrepreneurial	Interdependent

Vice-Chancellor Sir, having introduced drug discovery and development and defined my preferences, solid state pharmaceutics (excipients), I will now focus on my research in the area.

2.2 Raw Materials Development/Excipient Development

My earliest foray into research was in the area of raw materials development. Raw materials processing and design is a synonym for excipient development and design.
Most drug formulations contain active pharmaceutical ingredients and excipients. The excipients confer some desirable characteristics on the dosage form.

My early research focused on the development of tabletting excipients. The tablet dosage form contains medicament or mixture of medicaments plus other ingredients in a compressed form.

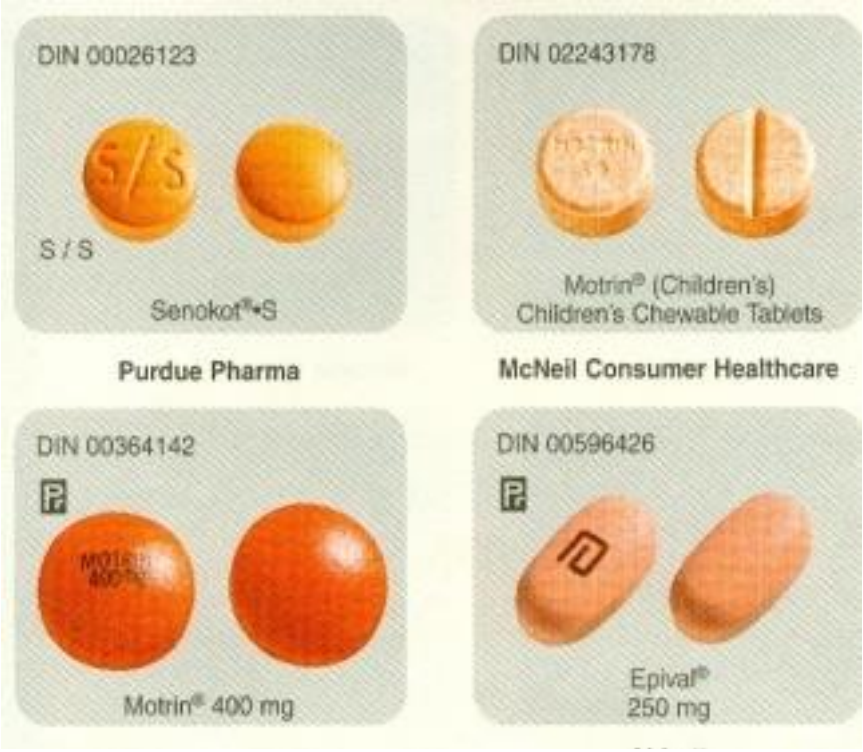

Fig. 1: Examples of tablets in commerce

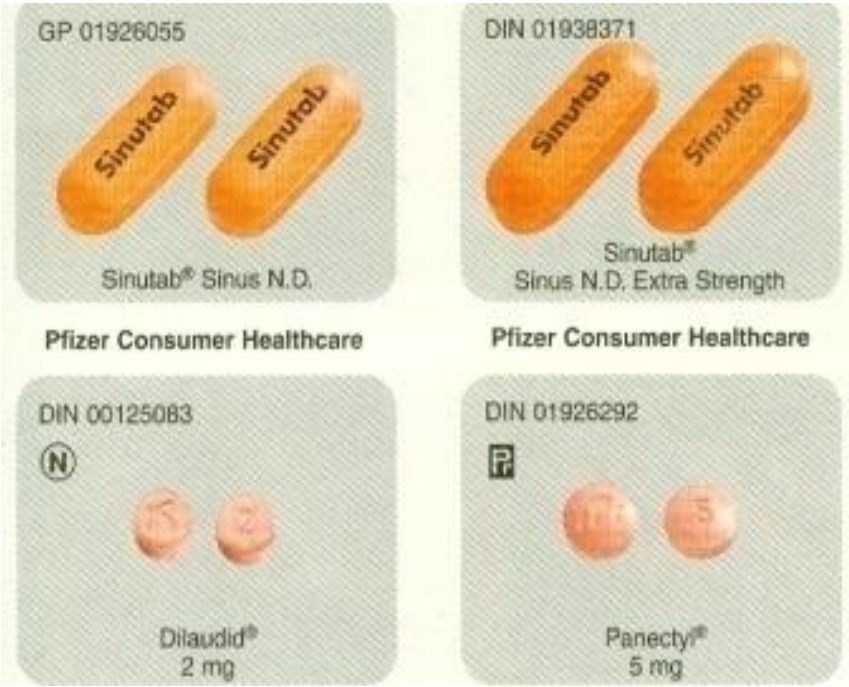

Fig. 2: More examples of tablets in commerce

Several types of tablets are available in commerce:

1. Uncoated tablets
2. Effervescent tablets
3. Coated tablets
4. Gastro resistant (Enteric coated)
5. Modified release tablets
6. Soluble tablets
7. Dispersible tablets

Tablets are usually administered orally, may be swallowed whole (uncoated, coated, gastro-resistant, modified release), or chewed

(uncoated e.g. antacids), or dispersed in solution before administration (effervescent, soluble, dispersible), or retained in the mouth to release active principle (sublingual).
The advantages of the tablet dosage form are many:

- accurate dose;
- simple administration;
- easy transportation;
- uniform final product;
- more stable than a liquid; and
- economical to produce.

The disadvantages are few:

- may be difficult to swallow for some patients; and
- loss of some properties.

The essential properties of tablets include:

- Contain known amount of drug
- Uniform in weight, appearance and diameter
- If swallowed whole, rapidly disintegrates in the stomach
- Optimum dissolution rate
- Stable to air, temperature, light and moisture
- Robust

The components of tablets are:

a. DRUG/S or ACTIVE INGREDIENT/S
b. EXCIPIENT/S

- Diluent
- Wet Binder
- Direct Compression Binder/Diluent
- Disintegrant
- Lubricant
- Glidant
- Anti-adherent
- Adsorbent and
- Surfactant

Not all these components may be required to make a tablet.
Some excipients can perform more than one function.

- Drug release from a tablet
- Bioavailability of drug
- Physical properties of the tablet

The first excipient we researched in detail was dika fat, a tablet lubricant. Dika fat is a solid vegetable oil extracted from the kernels of *Irvingia gabonensis* var *gabonensis* and var *excelsia.* The dika fat was obtained by soxhlet extraction, purified, bleached and deodorized to acceptable pharmaceutical grade by standard techniques.The processing we set out to achieve included assurance that dika fat can be used in formulating pharmaceutical dosage forms.
It is desirable to determine the compatibility of a drug substance with excipients used in pharmaceutical formulations in preformulation studies. Several techniques have been used to study drug-drug and drugï excipent interactions: thin layer chromatography (TLC), diffuse reflectance spectroscopy (DRS), tristimulus reflectance (TR), and quantitative assay after isothermal stress (IS), differential thermal analysis (DTA) and differential scanning spectroscopy (DSC).
The term differential scanning calorimetry (DSC) was first used by Watson *et al*, 1964 to describe the instrumental technique developed by the Perkin-Elmer Corporation in 1963. DSC is a technique of recording the energy necessary to establish zero temperature difference between a substance and reference materials against either time or temperature as the two species are subjected to identical temperature regimes in an environment heated or cooled at a controlled rate (Perkin Elmer Manual, 1983). DSC was used as screening technique for assessing compatibility between dika fat and drug substances. Thermal analyses were performed on dika fat, pure drug and 1:1 (w/w) physical mixtures of dika fat and named drug respectively. Samples (2-8 mg) were weighed and after being finely powdered were encapsulated in flat-bottomed aluminum pans with crimped-on lids.

Thermal curves were obtained using a Perkin-Elmer DSC-4 differential scanning calorimeter (Perkin-Elmer Corporation, Norwalk, CT, USA) equipped with a Bascom Turner Recorder and Data Acquisition System (Bascom Turner Instruments, MT, USA). A model DSC Intracooler (Perkin Elmer Corporation, Norwalk, CT, USA) provided a convenient means of cooling the sample holder enclosure block of the calorimeter.

Thermograms were obtained at a constant heating range setting of 20 mcal per minute, in an atmosphere of nitrogen and recorded at a constant chart speed of one inch per minute. The individual substances and 1:1 mixtures of drug and dika fat prepared were heated over the temperature range, 20 to 220 ^{o}C.

Dika fat was found to be compatible with aspirin, ascorbic and, paracetamol, sulphanilamide, phenylpropanolamine hydrochloride, bromopheniramine maleate, chlorpheniramire maleate, diazepam, phenobarbital and phenobarbital sodium. It appears that dika fat can be used as a formulation aid in medicinal or veterinary products containing any of these substances. Some of the thermograms are shown in the Figs. 3-21.

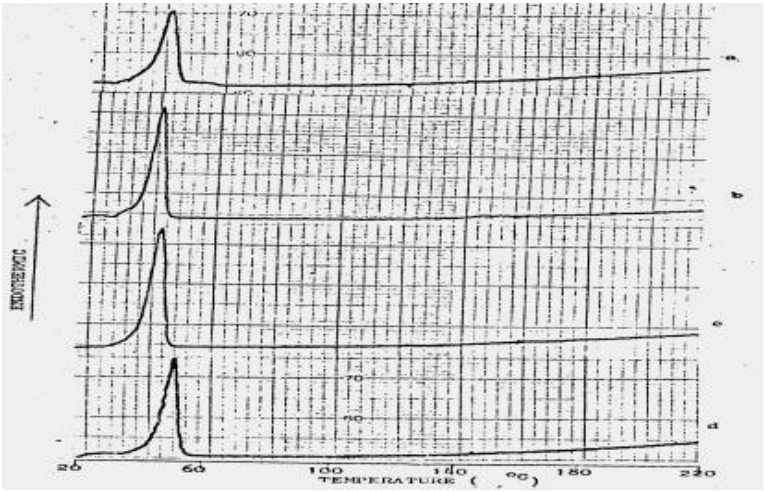

Fig. 3: DSC thermograms of different dika fat varieties

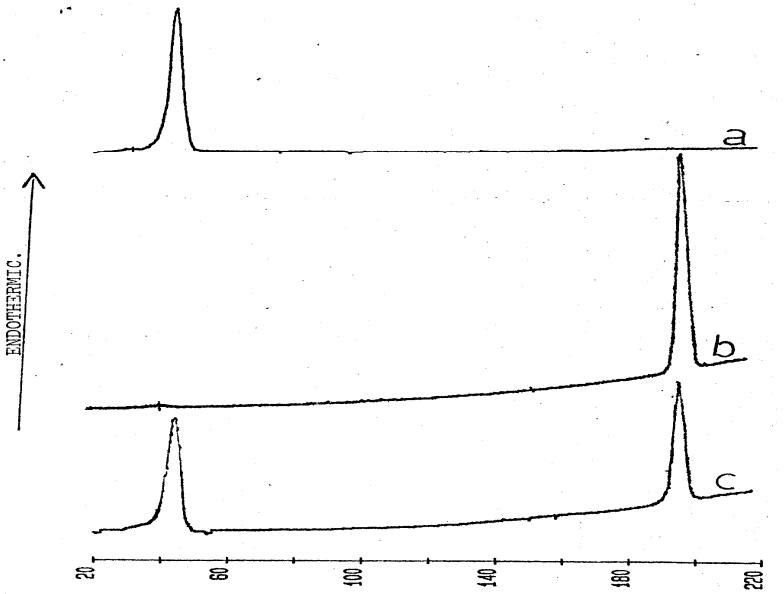

Fig. 4: DF-paracetamol compatibility thermograms

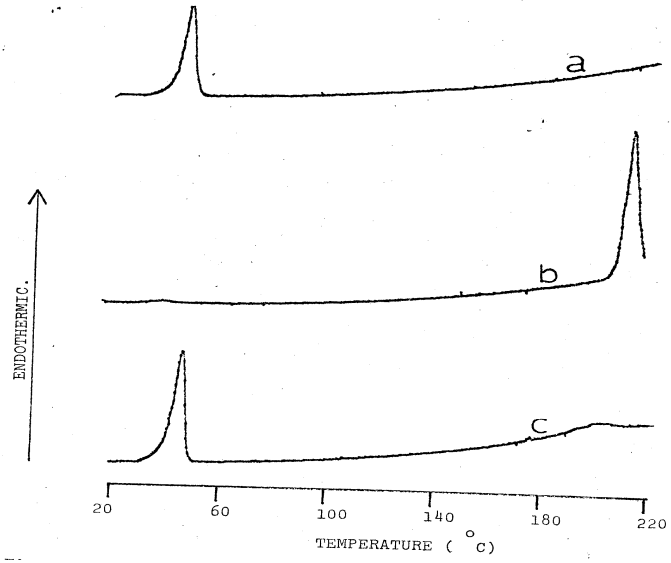

Fig. 5: DF-norgestrel compatibility thermograms

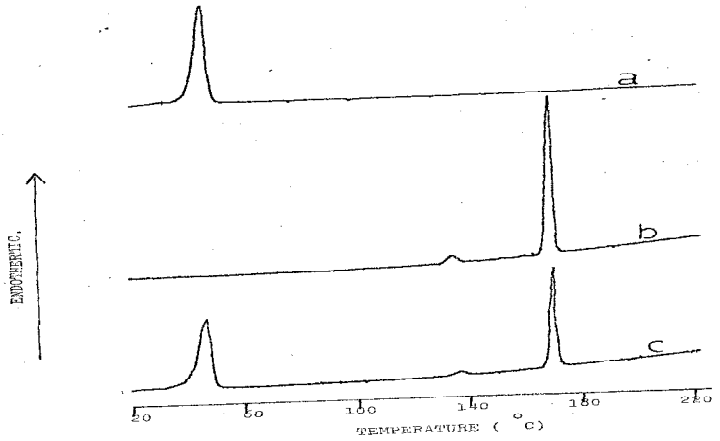

Fig. 6: DF-sulphanilamide compatibility thermograms

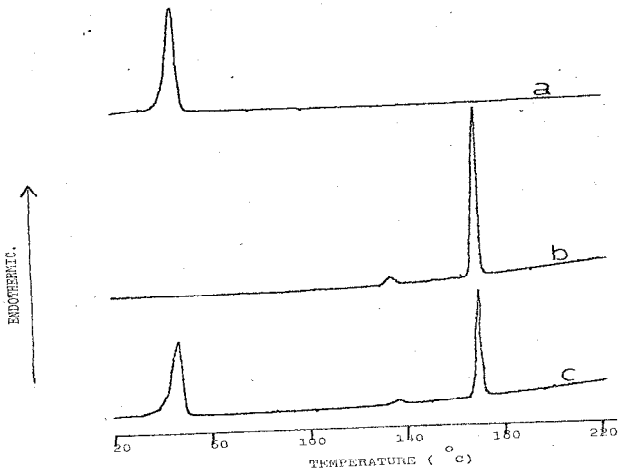

Fig. 7: DF-ascorbic acid compatibility thermograms

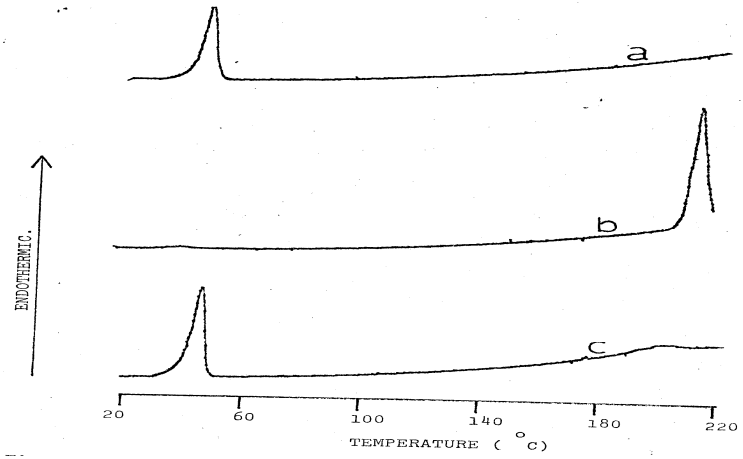

Fig. 8: DF-norgestrel compatibility thermograms

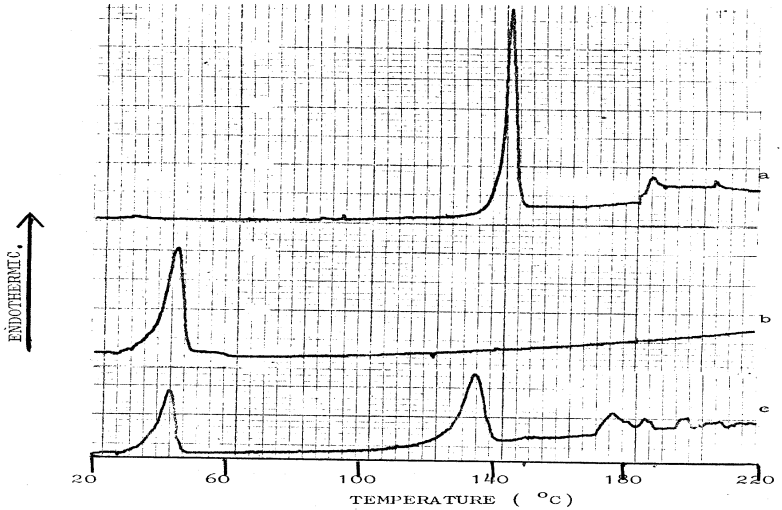

Fig. 9: DF-aspirin compatibility thermograms

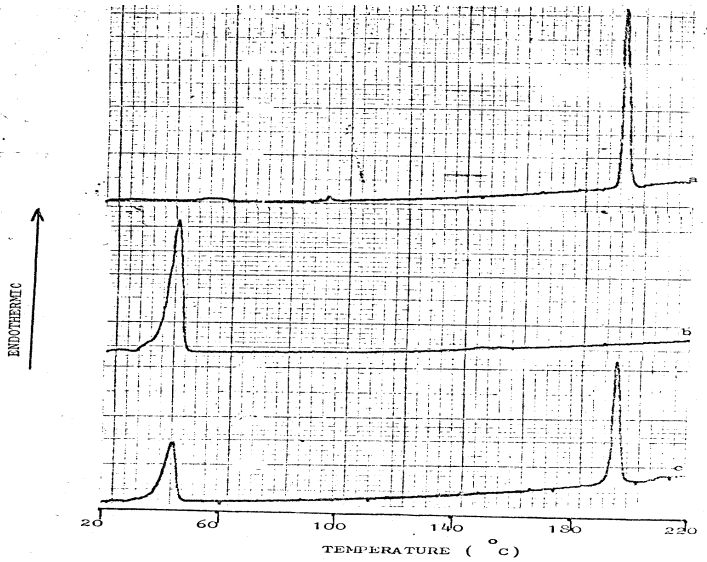

Fig. I0: DF-propanolol hydrochloride compatibility thermograms

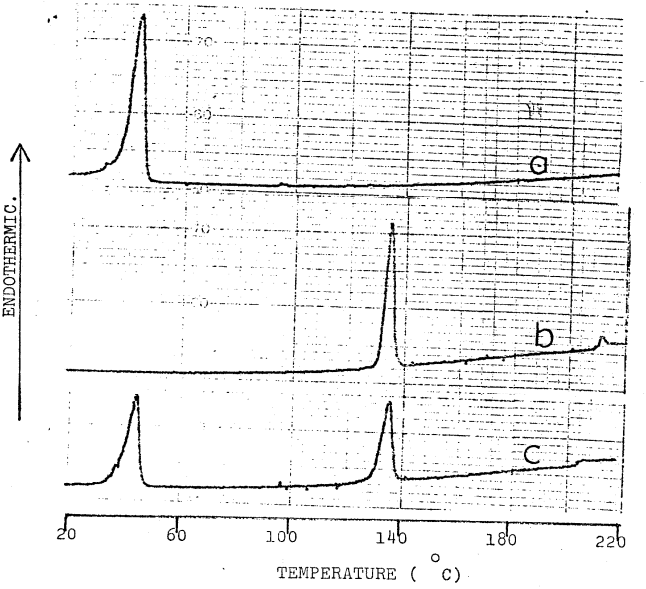

Fig.11: DF-chlorpheniramine maleate compatibility thermograms

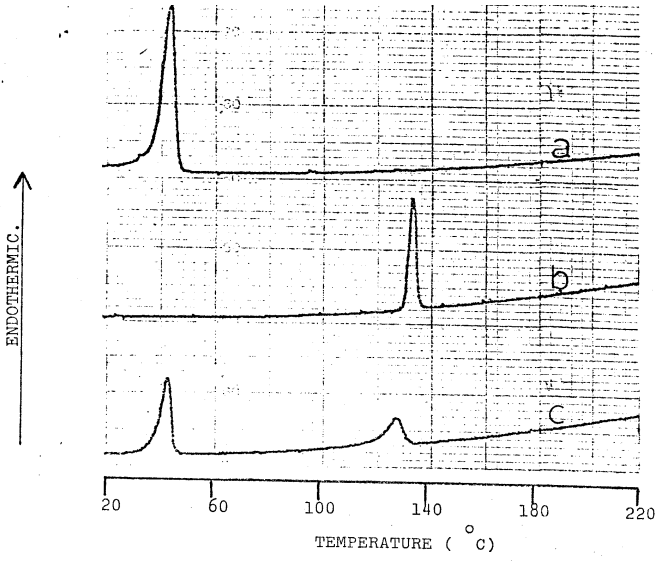

Fig. 12: DF-diazepam compatibility thermograms

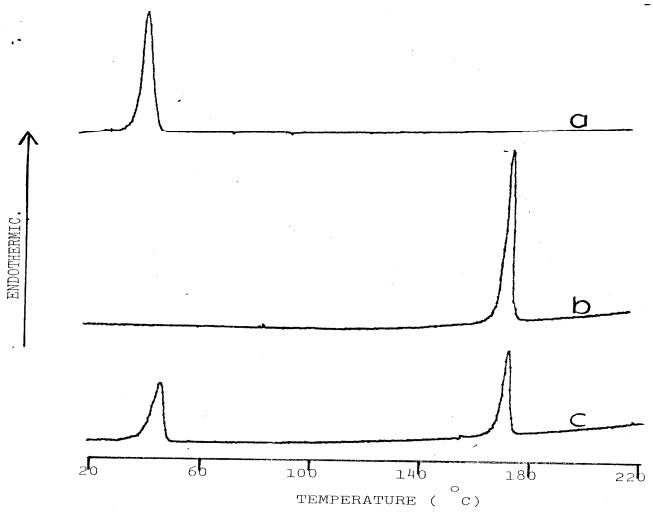

Fig. 13: DF-phenylpropanolamine hydrochloride compatibility thermograms

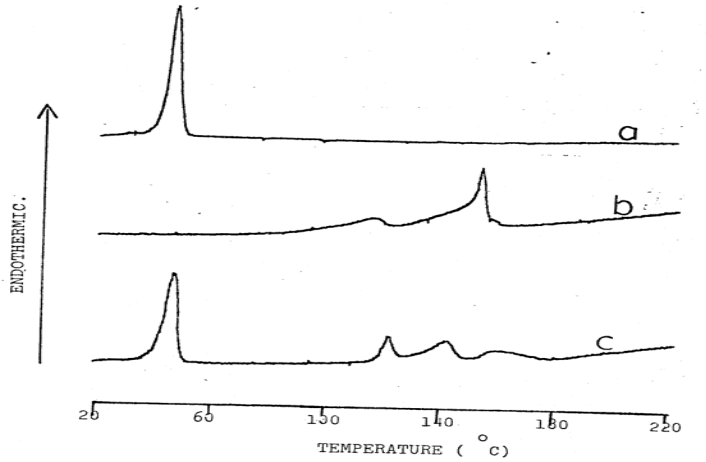

Fig. 14: DF-aminophylline compatibility thermograms

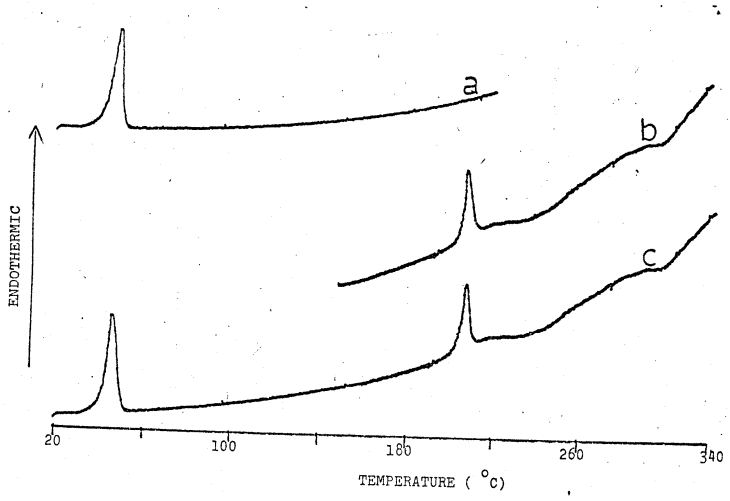

Fig. 15: DF-benzothiazide compatibility thermograms

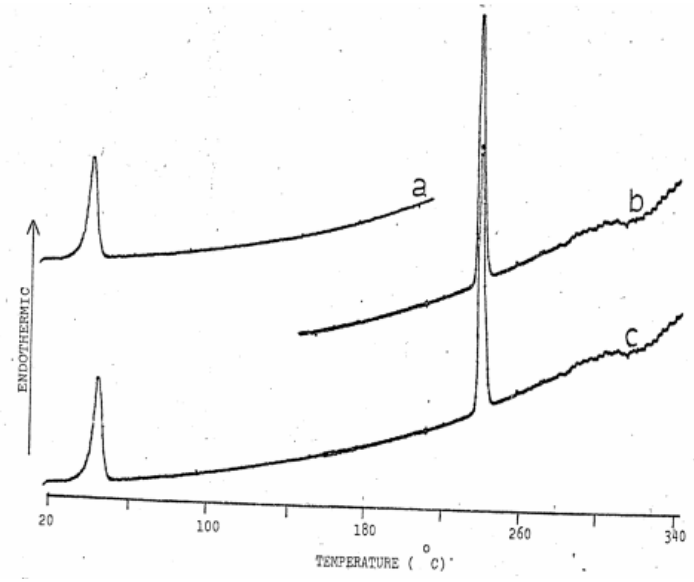

Fig. 16: DF-polythiazide compatibility thermograms

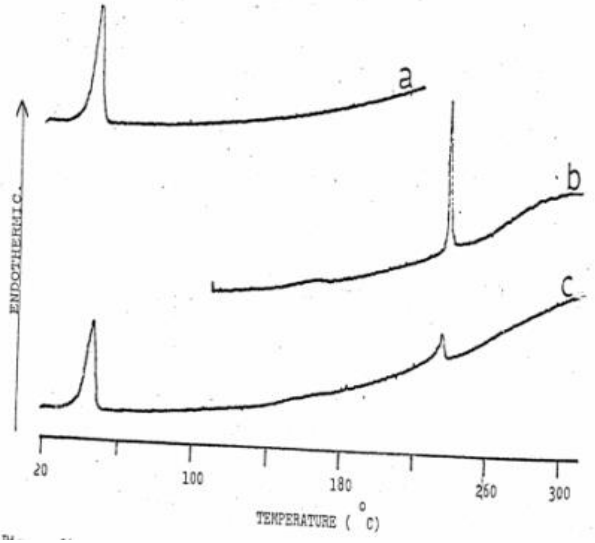

Fig. 17: DF-caffeine compatibility thermograms

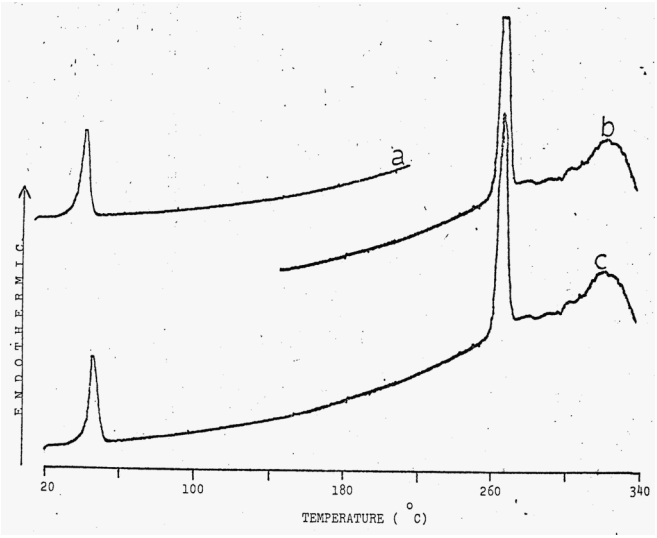

Fig. 18: DF-hydroflumethiazide compatibility thermograms

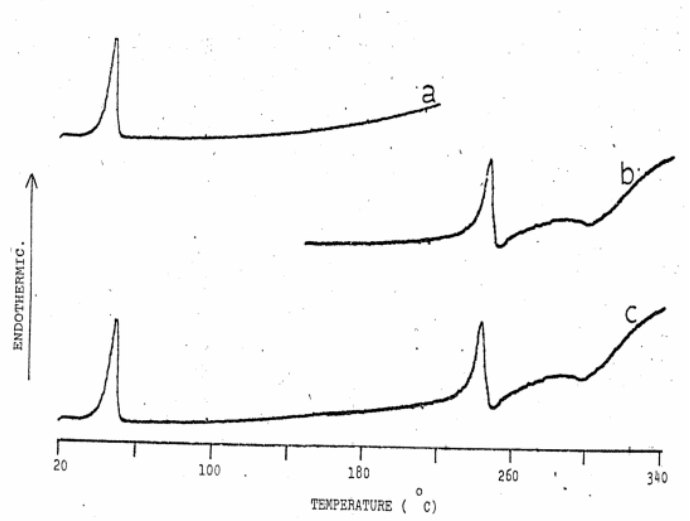

Fig. 19: DF-hydrochlorothiazide compatibility thermograms

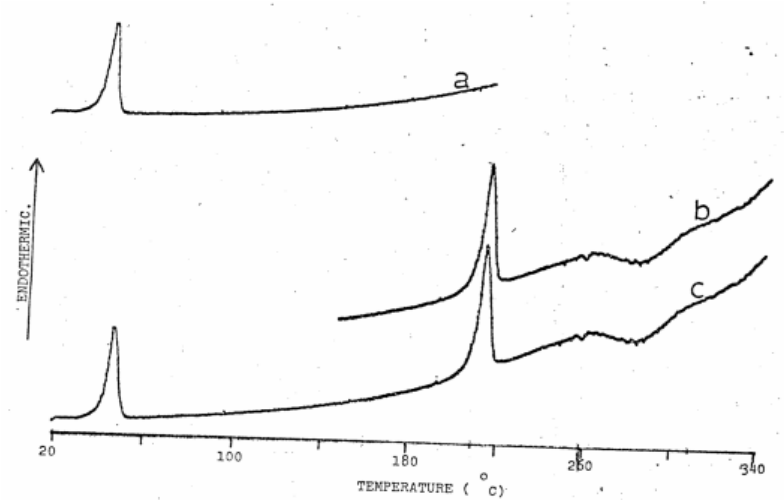

Fig. 20: DF-methylchlothiazide compatibility thermograms

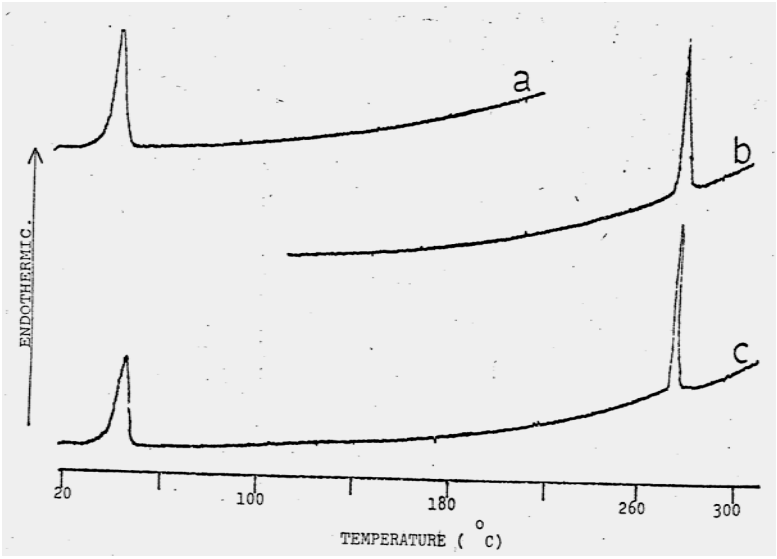

Fig. 21: DF-theophylline compatibility thermograms

Differential scanning calorimetry (DSC) was also used as screening technique for assessing compatibility between dika fat and some other formulation excipients. Dika fat was found to be compatible many classes of tabletting excipients, the soluble tablet fillers: anhydrous dextrose, sucrose and sorbitol; tablet binders: acacia, gelatin, hydroxypropylmethylcellulose, methylcellulose, povidone and carboxymethylcellulose and, the lubricants: fumed silicon dioxide, magnesium stearate, sodium lauryl sulphate, talc, native clay, polyethylene glycol 4000, compactrol and maize starch. The indication is that dika fat may be used in formulations containing some of these excipients.The thermograms generated are shown in Figs. 22-27.

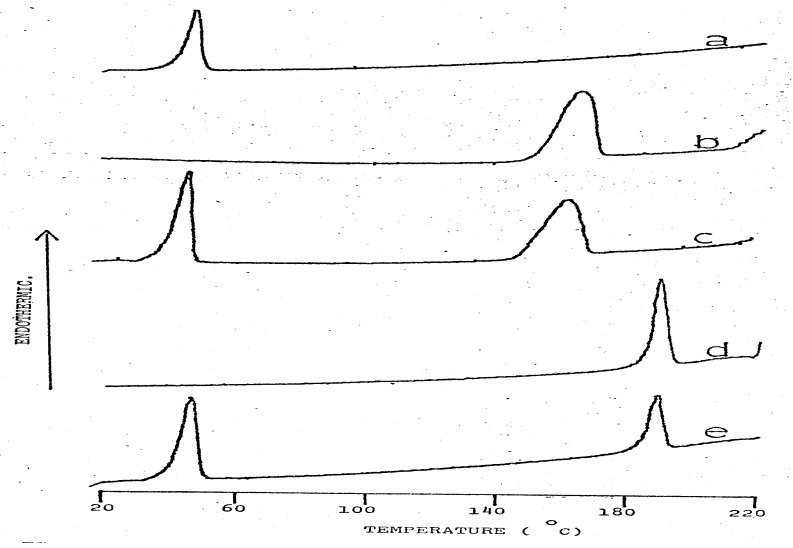

Fig. 22: DF-excipient compatibility thermograms

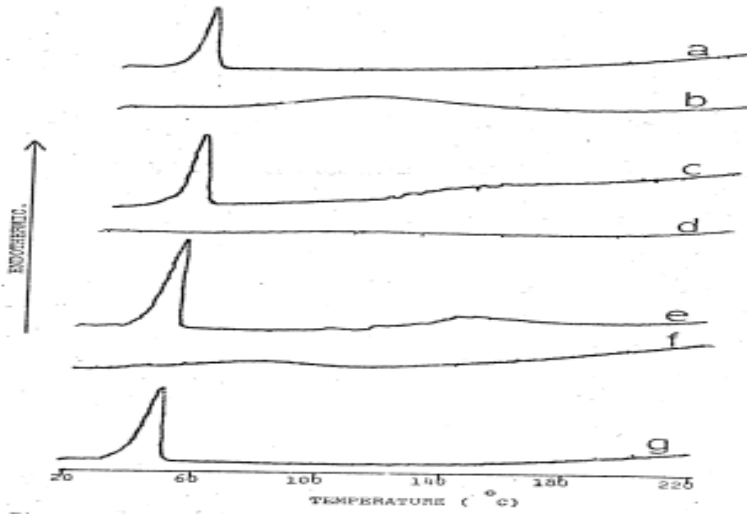

Fig. 23: DF-excipient compatibility thermograms

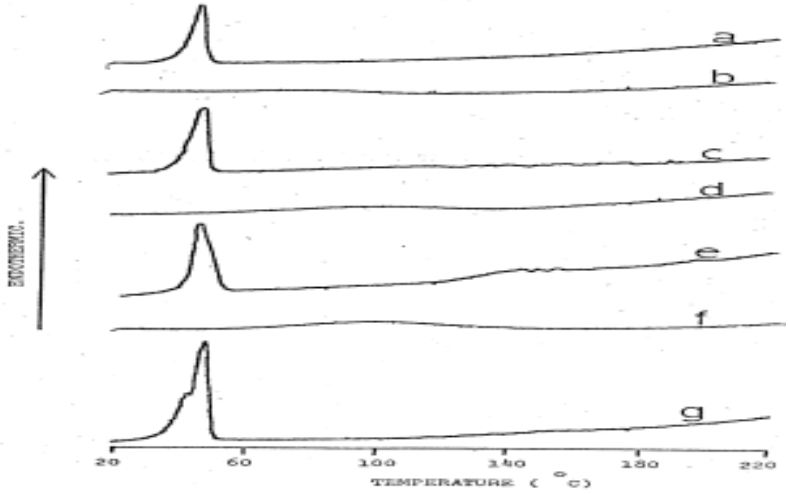

Fig. 24: DF-excipient compatibility thermograms

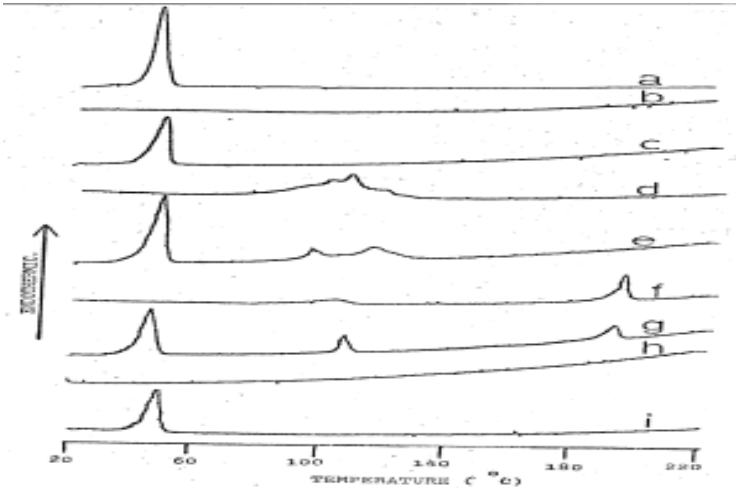

Fig. 25: Dika fat-excipient compatibility thermograms

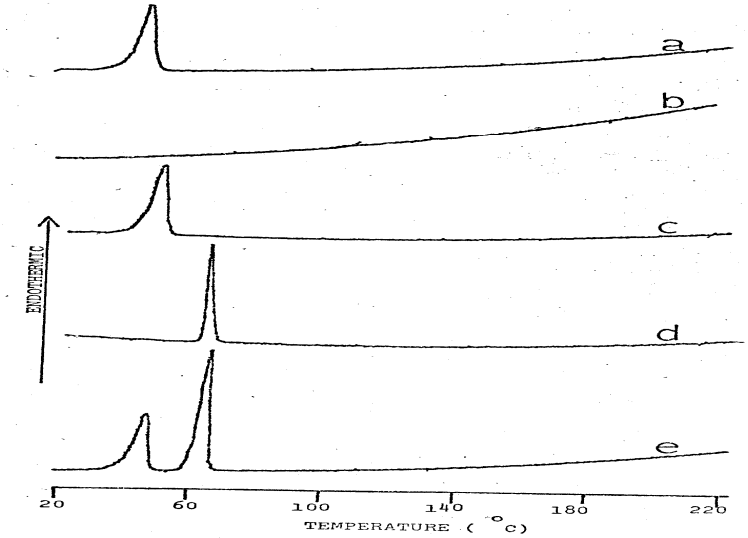

Fig. 26: Dika fat-excipient compatibility thermograms

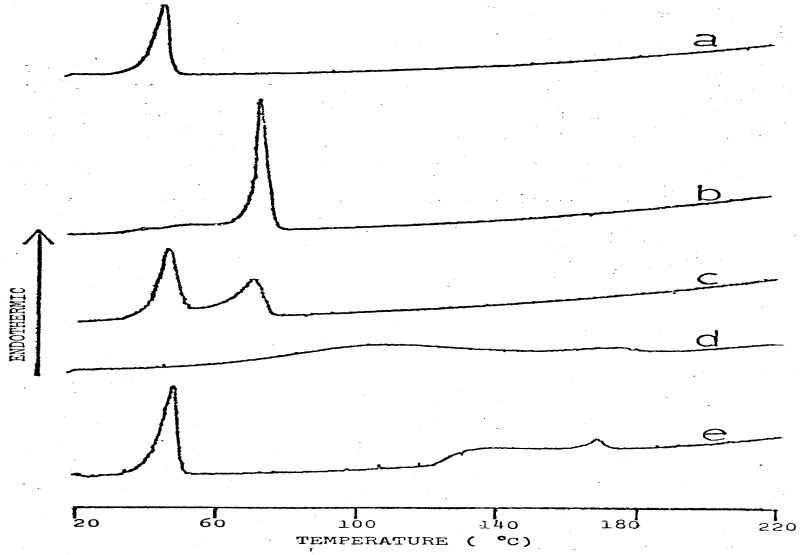

Fig. 27: Dika fat-excipient compatibility thermograms

Instrumented tablet machines (ITMs), are useful for the fingerprinting of pharmaceutical powders and granules. ITMs are used to profile the compaction properties of materials. The compaction properties of granules have a major influence on the mechanical strength of tablets and may also affect disintegration or dissolution and hence the efficacy of tablets.

- By measuring punch forces and displacements during compaction:
    - the effectiveness of excipients such as binders can be studied and optimised
    - changes to the granulation process and their effect on compaction can be evaluated
    - the effect of compaction force on tablet properties can be studied; and
    - the consolidation mechanisms of materials can be determined to help formulation design.

Some equipment used to investigate compaction properties include:

- Mechanical Testing Machines
- Single Punch Tablet Machines
- Rotary Tablet Machines
- Compaction Simulators
- Instrumentation fitted to above for punch force measurement
- Strain gauges bonded to punches or machine frame
- Piezo-electric load cells or strain-gauged load cells

Mechanical Testing and Single Punch Machines

- **Mechanical Testing Machines**
  - Screw driven crosshead
  - Slow constant punch speeds (less than 1mm/s)
  - Usually single-ended compaction
  - Of limited value in evaluating compaction behaviour
- **Single Punch Tablet Machines**
  - Relatively easy-to-fit force and displacement transducers
  - Single-ended compaction
  - Moderate punch speeds (around 100 mm/s)

Rotary Tablet Machines

- Double-ended compaction
- Realistic punch speeds (100-400 mm/s)
- Some evaluation of powder flow and time-dependent lubrication effects
- Applicability of results to other rotary machines?
- Instrumented Punches
  - Awkward to fit; data transmission by IR link or radio telemetry
  - Accurate displacement measurements difficult
  - Accurate force measurements

Instrument machine frame

- Easy to use
- Displacement measurements impossible
- Force measurements less accurate

Strickland's definition (Strickland, 1959) of lubricants appears to be the most complete and all-inclusive. He identified three functions associated with the term "Lubricant". These are:

- prevention of sticking to punch faces and the die wall (anti-adherent activity);
- improving the flow properties of the granulation (glidant activity); and
- reducing the friction at the tablet-die wall interface during tablet formation and ejection (true lubricant activity.

A given lubricant may exhibit one or more of these functions in varying degrees but the primary function of a lubricant is the reduction of die wall friction.

Instrumentation of Rotary Tablet Press

A Stokes model RB-2 rotary tablet press (Stokes Engineering Philadelphia, PA, USA) which was instrumented as described previously (Salpekar and Ausburger, 1974) and used in our researches.

Fig. 28: A Rotary Tablet Press

Metal foil resistance 'self temperature compensating strain guages' were used for the measurement of forces. The eyebolt of the tablet press was instrumented to measure compression forces in the manner of Wray *et al* (1966). Tablet ejection forces were monitored by instrumenting a modified ejection cam according to Vincent *et al* (1968).

Measurement of Compression Forces

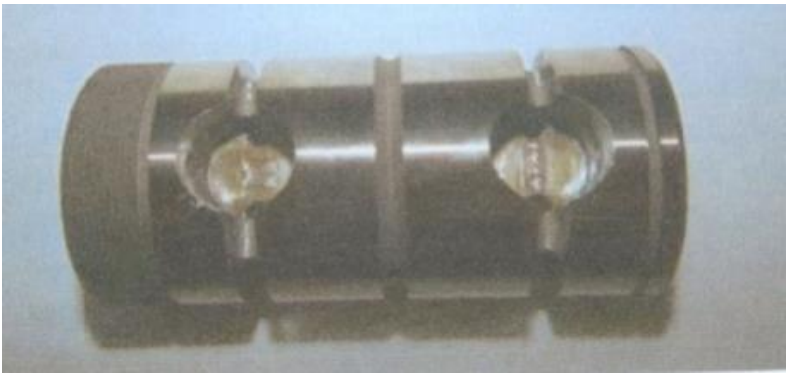

Fig. 29: Compression Force Transducer

The eyebolt of the Stokes RB-2 machine was instrumented to measure compression forces. The instrumentation technique has been described previously (Salpekar and Augsburger, 1974). Essentially, a pair of SR-type gauge units was bonded to either side of a 'filed-off-area' of the eyebolt. The bonding was such that one gauge element of each unit was parallel to the axis of the eyebolt and the other at right angles to it. The gauge elements parallel to the axis of the eyebolt formed the active arms of the Wheatstone bridge circuit and were compressed along with the eyebolt during compression. During compression, force was applied to the lower punch through the lower compression wheel supported by the eyebolt of the pressure regulatory mechanism of the rotary press. The strain gauge bridges were energized via a D.C. bridge amplifier recorder (Model 13-1615-30 Gould Inc., Cleveland, Ohio). The bridge imbalance output signal was passed through an HP 6940 B multiprogrammer which contains scanner analogue to digital converter cards. The multiprogrammer was interfaced with HP 9825 B desktop calculator/computer. This was fed with software specially written for it to scan and calculate compression force and ejection force simultaneously. Calibration of the eyebolt for the measurement of compression force was effected as reported

previously (Salpekar and Augsburger, 1974). The software program yields the calibration factors automatically.

Measurement of Ejection Forces

Fig. 30: Instrumented Ejection Cam

Tablet ejection forces were monitored by instrumenting a modified ejection cam in the manner of Vincent *et al* (1968). The modification of the ejection cam involved replacement of a portion of the ejection cam track with a tool steel cantilever beam. The beam conformed to the ejection cam track with just enough clearance to allow a bending motion when the lower punch travelled over it. The far end of the beam (away from the cam track) was fastened to the machine by means of two bolts. The ejection track portion of the cantilever beam was case hardened to permit its use during normal operation of the tablet press without excessive wear of the modified cam track. A pair of SR-4 type gauge units was bonded to either side of the cantilever beam. The gauges were connected in series to a Wheatstone bridge circuit. In operation, the lower punch travels up the cam and depresses the cantilever beam. Thus, the top surface of the beam experiences elongation as the bottom surface undergoes compression. The strain

gauges on each side deform in conformation to the surface deformation of the cantilever beam, thus causing imbalances in the bridge circuit. This imbalance was monitored on the same ampilifier and recording system decribed previously for measurement of the compression forces. Calibration of the modified ejection cam to measure ejection forces was carried out as previously described (Salpekar and Augsburger, 1974). Essentially, known weights were applied to the cantilever beam of the modified ejection cam. This caused a deflection of the beam. The deflection corresponding to the weights was amplified and recorded by the monitoring system described previously for compression forces. The software program also yielded the calibration factor automatically. The desktop calculator/computer was programmed to scan and calculate 10 values each of compression and ejection forces. To eliminate bias due to differences in tablet thickness, recorded ejection forces were converted to unit ejection force.

There are two major reasons for tablet press instrumentation:

Product and Process Development

- compression force measurement;
- precompression force measurement;
- ejection force measurement; and
- take-off force measurement.

Formulation Development

- compactibility profile
- lubricant profile
- lubricant study

We instrumented for lubricant study and determined the hardness, ejection, friability, disintegration and dissolution profiles which are all used for excipient and/or lubricant evaluation (Figs. 31-44).

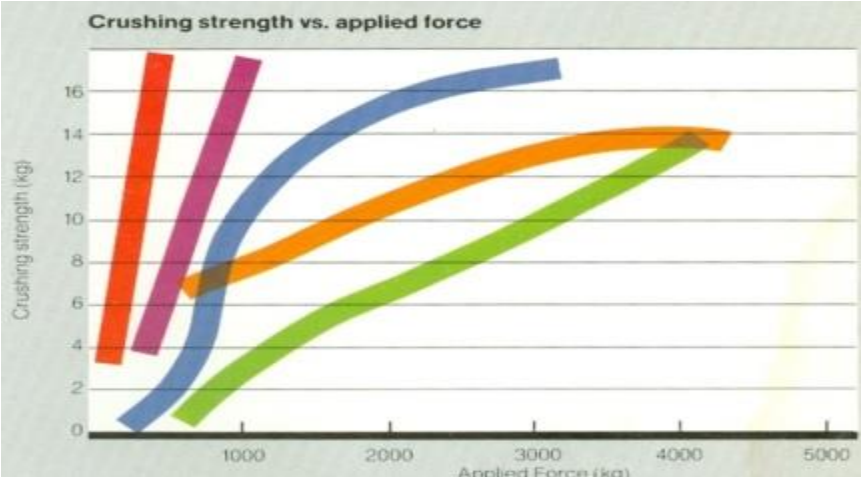

Fig. 31: Typical CF vs Hardness profile for tablet formulation

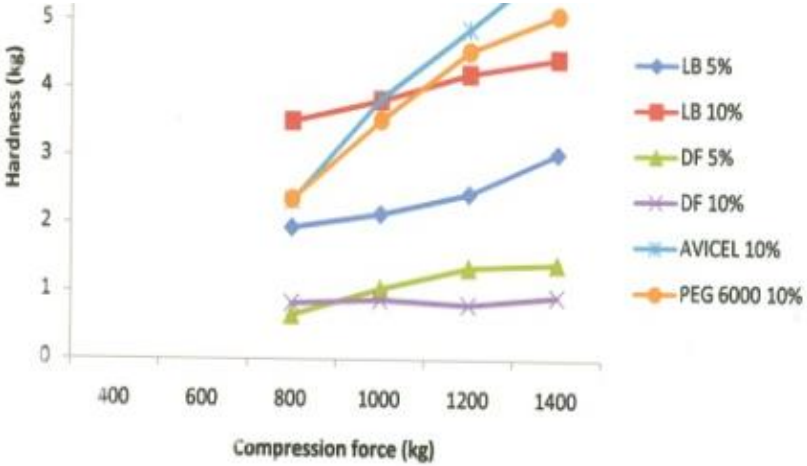

Fig. 32: CF vs Hardness profiles in paracetamol tablet formulation containing Lubritab, dika fat, Avicel and PEG 6000

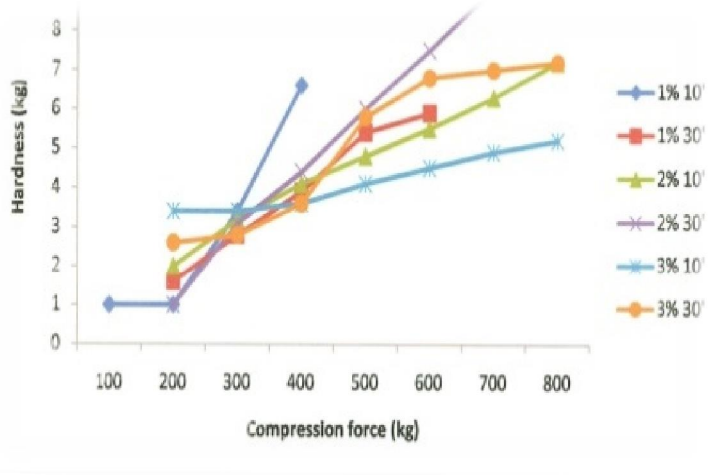

Fig. 33: CF vs Hardness profiles in acscorbic acid tablet lubricated with Lubritab

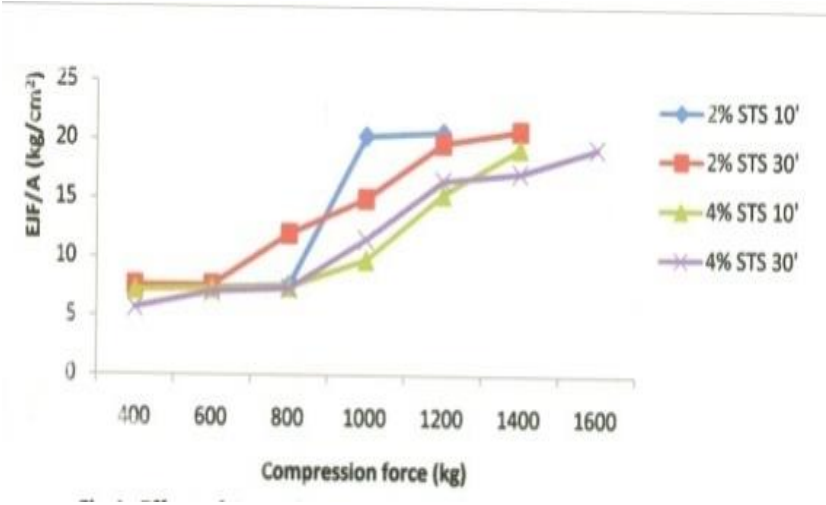

Fig. 34: CF vs Ejection force for tablets lubricated with Stearolac-S

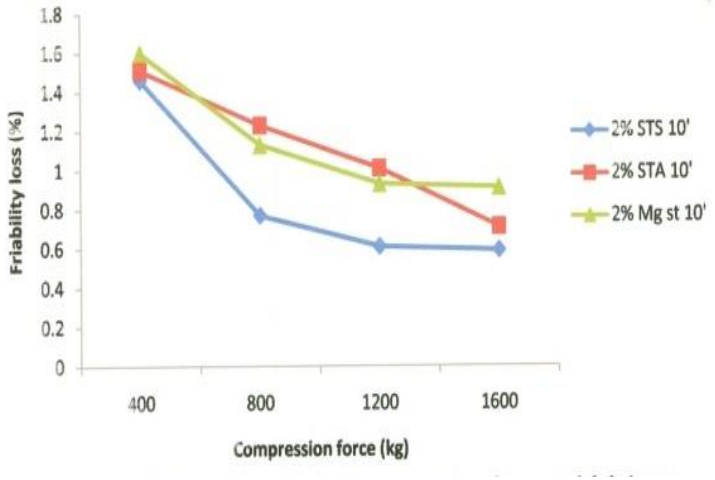

Fig. 35: CF vs Friability loss for tablets lubricated with stearic acid (STA), stearolac-S (STS) and magnesium stearate (Mg st)

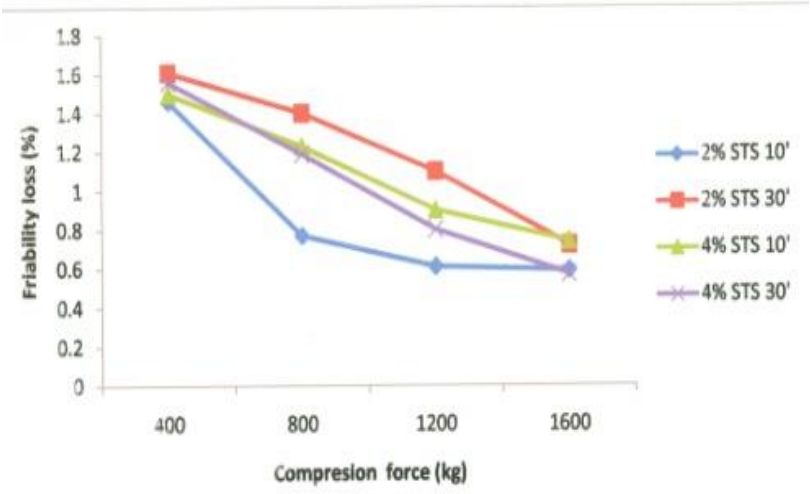

Fig 36: CF vs Friability loss profiles for tablet formulation containing Stearolac-S as lubricant.

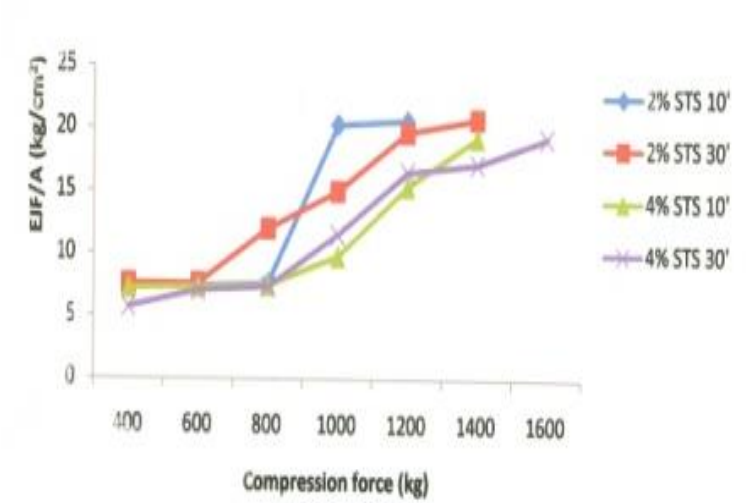

Fig. 37: CF vs Ejection force profiles for tablet formulation containing the lubricant Stearolac-S

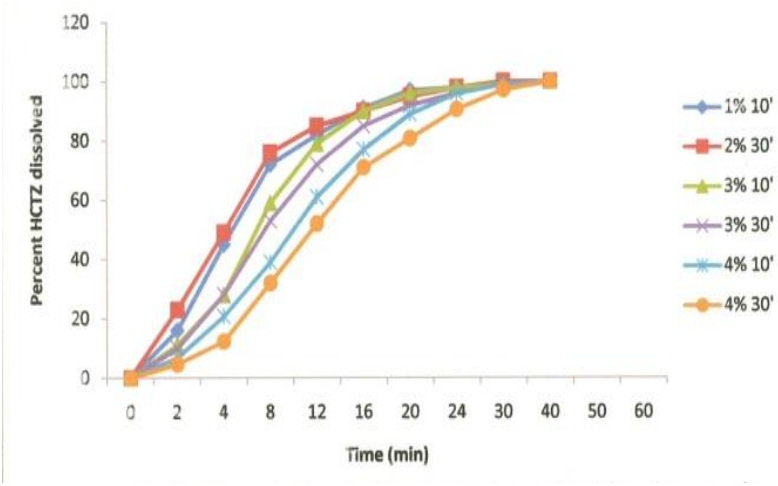

Fig. 37a: Dissolution profiles of hydrochlorothiazide tablet formulation containing Stearolac-S as lubricant

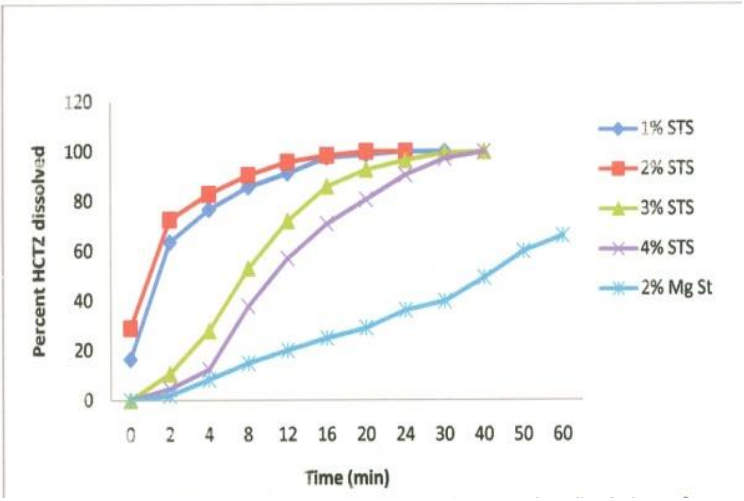

Fig. 38: Dissolution profiles of hydrochlorothiazide tablets lubricated with Stearolac-S and magnesium stearate

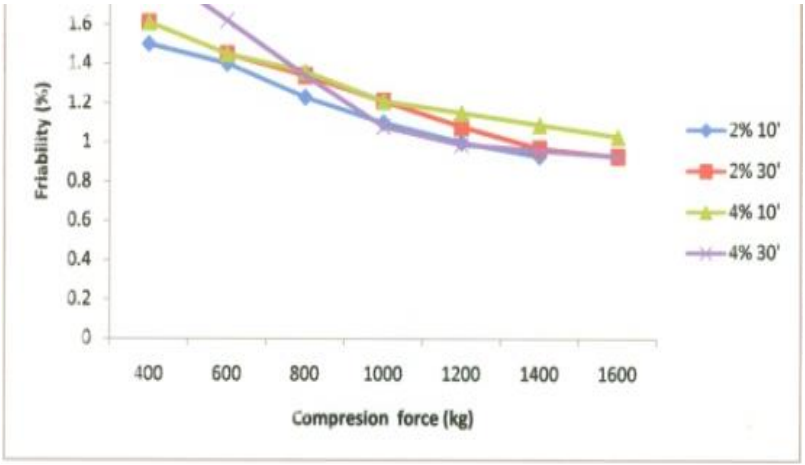

Fig. 39: CF vs Friability loss profiles of direct compression tablet formulation containing Sterotex

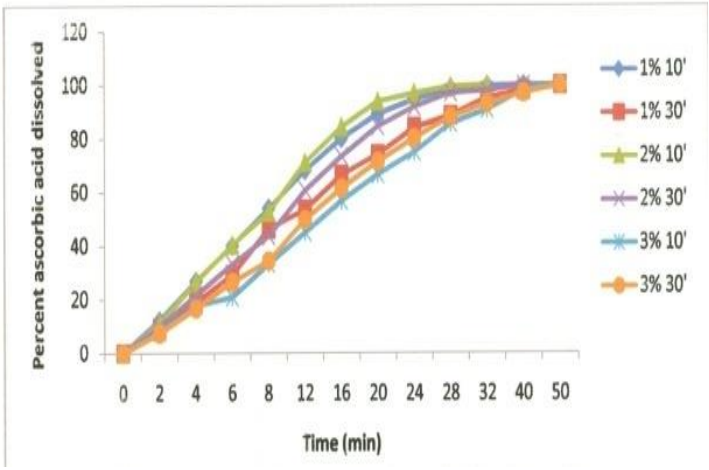

Fig. 40: Dissolution profiles of ascorbic acid tablet formulation

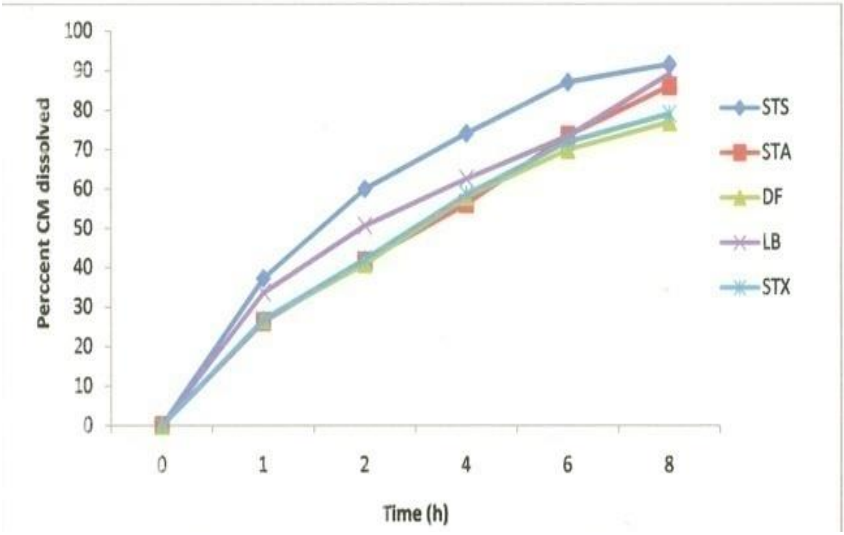

Fig. 41: Dissolution profiles of sustained release chlorpheniramine tablets containing hydrogenated vegetable oils

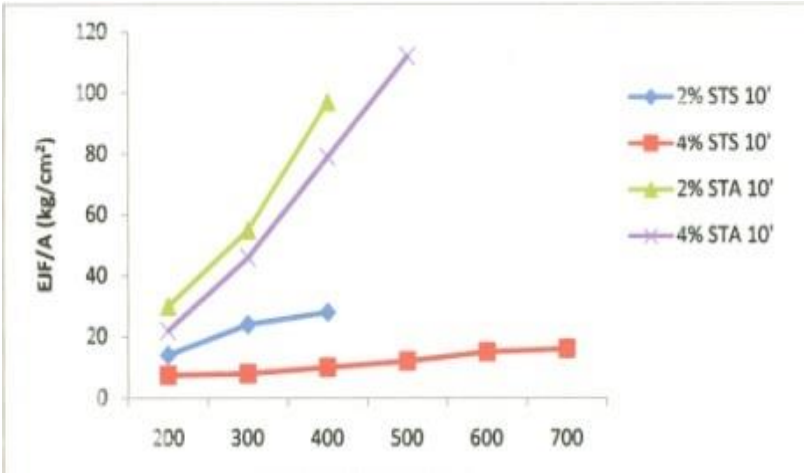

Fig. 42: CF vs Ejection force profiles of ascorbic acid tablet formulation lubricated with STS and STA.

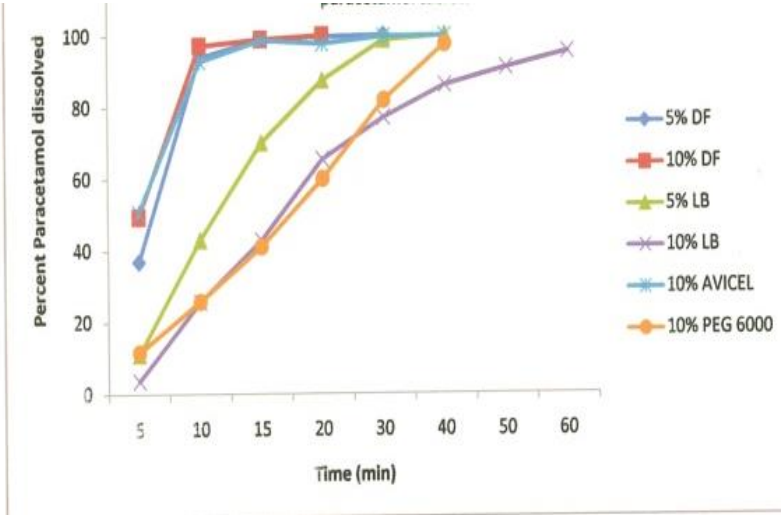

Fig. 43: Paracetamol dissolution from aspirin-paracetamol tablets containing different excipients

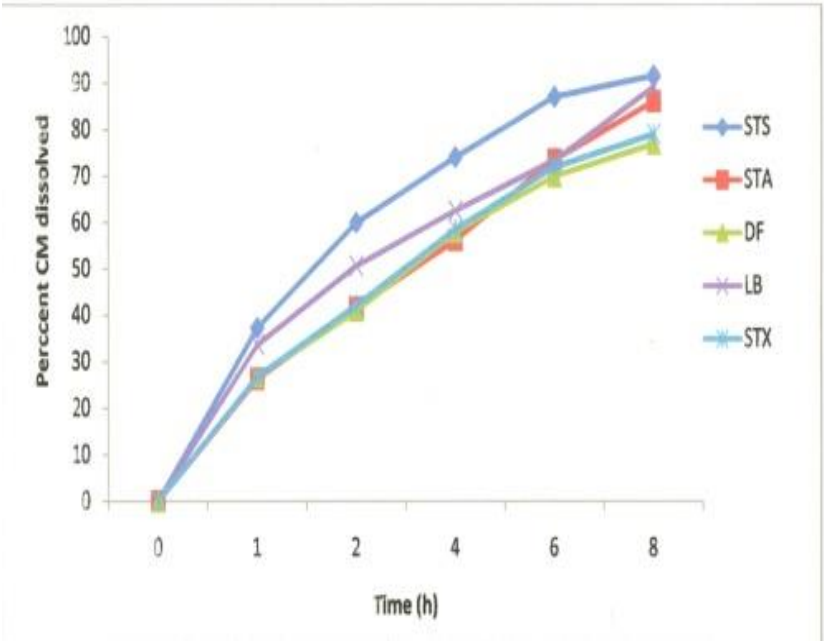

Fig. 44: Dissolution profiles of sustained release chlorpheniramine tablets containing various hydrogenated vegetable oils

Other lubricants evaluated like dika fat included:
1) Stearolac-S (Onyechi and Udeala, 2011);
2) Sterotex (Onyechi, 2011);
3) Stearolac-C (Onyechi, 2011); and
4) Lubritab (Onyechi, 2011).

Dika fat and these other hydrogenated vegetable oils (HVOs) were also used in the formulation of several drug delivery dosage forms. In other tabletting applications, dika fat and the HVOs were used in the formulation of sustained release drug delivery systems. A sustained drug delivery system can be defined as any drug or dosage form modification that prolongs the therapeutic activity of the drug. Dika fat has been used to prolong the release of drugs by dissolution methods, by coating individual drug particles or

granules with varying fat thicknesses. Dika fat can also be used as a matrix material for direct compression sustained-release tablets.
Other tabletting applications of dika fat and the HVOs are shown in the Table 2:

Table 2: Some of My Other Researches in Drug Development

S/No.	Nature of investigation	Result	Reference
1.	The tabletting properties of Stearolac-S	Stearolac-S useful as tablet lubricant and sustained release matrix for tablets	Onyechi and Udeala, 2011
2.	Sodium stearoyl-2-lactylate as SR tablet matrix	The HVO is useful in SR tablet formulation	Onyechi and Udeala,1988
3.	Dika fat used in the formulation of capsules	Dika fat can be used to formulate capsules with the soft centre	Onyechi and Udeala, 2010
4.	Formulation of sustained release diclofenac sodium tablets	Methocel used in diclofenac tablets	Onyechi, 2010
5.	Lubricant properties of Sterotex	Sterotex at 1-3% is a useful lubricant	Onyechi, (2011)
6.	Auxilliary dry binding properties of hydrogenated vegetable oils	HVOs useful as dry binders in direct compression tabletting	Onyechi, 2010

7.	Tabletting properties of Lubritab	Lubritab useful lubricant at 1-3% concentration levels and as useful SR tablet matrix	Onyechi, 2011
8.	Tabletting properties of Stearolac-C	Stearolac-C acted as tablet lubricant at 2-5% level and can be used as SR tablet matrix	Onyechi, 2011

Innovative technical investigations drive the selection of appropriate excipients in modern formulations. Due to negative effects on mechanical and biopharmaceutical properties of tablets, the amount of lubricants to be used requires optimization. The lubricants are difficult to evaluate in terms of effectiveness. A popular method used to evaluate lubrication in tablet technology is to determine unit ejection force. We used unit ejection force to perform a comparative study of dika fat with different tablet lubricants. The effectiveness of 3% dika fat was very close to the effectiveness of 2.5% Sterotex and very close to the effectiveness of 0.5% magnesium stearate, without the disadvantage of the sensitivity to the mixing time of the magnesium stearate affecting tablet hardness and disintegration time.

Vice-Chancellor Sir, in addition to our work with lubricants, we worked on many other tablet excipients, including starches from different sources. We have added value to some of the starches by modification and co-processing with actives and other excipients. The starches include those from yam, cassava and maize. Our shelves are replete with information on starch from various sources, and many other tablet excipients. We await the lucky local entrepreneur who would exploit and benefit from our years of hard work processing and making available in suitable pharmaceutical form, our manifold local raw material resources.

2.3 Drug Development

One of our researches concerning drug development involved KS Biomedix, a small UK Biotechnology group. KS Biomedix had an antibody (Kab104M) potentially useful for the treatment of ulcerative colitis. We were requested to develop a solid formulation of the antibody to deliver the drug selectively to the colon. We were asked to generate sufficient data to support pre-clinical trials. In Phase 1 of the study, we developed simple solution and solid antibody dosage forms. In Phase 2, we optimized the processing technique to produce the final solid dosage form. In Phase 3, Kab104M was converted into solid dosage form by freeze drying or spray drying using common formulation excipients.

Any formulation or processing of Kab104M must ensure that the activity of the biomaterial is retained. Submission of such a stability data file for evaluation is a regulatory requirement before approval can be given for clinical trials.

Some of our other published researches in the area of drug development are presented in Table 3.

Table 3: Some of My Researches in the Area of Drug Development

S/No.	Nature of investigation	Result	Reference
1.	Adhesion studies on Anusol Formulations 3:Water uptake pattern of suppositories at RT and 37^{o}C	Bioadhesive Anusol suppository dosage formulation	Onyechi *et al*,1994
2.	Adhesion studies on Anusol	Bioadhesive Anusol suppository	Onyechi *et al*,1994

	Formulations 4: Effect of Methocel on the MP range of the suppositories	dosage formulation	
3.	Adhesion studies on Anusol Formulations 5: Water uptake pattern and bioadhesion of Anusol cream and ointment formulations.	Bioadhesive Anusol cream and ointment dosage formulation	Onyechi *et al*,1994
4.	Adhesion studies on Anusol Formulations 6: Characterisation of Lambda 2903 suppository base	Excipient evaluation for bioadhesive suppository dosage formulation	Onyechi *et al*,1994
5.	Adhesion studies on Anusol Formulations 9: The formuation and tensile strength of Anusol creams containing varying concentration of Methocel	Bioadhesive Anusol cream and ointment dosage formulation	Onyechi *et al*,1996
6.	Adhesion studies on Anusol Formulations 10: An assessment of suppository	Bioadhesive dosage formulation	Onyechi *et al*,1996

	formulations containing Suppocire M suppository base		
7.	Adhesion studies on Anusol Formulations 11: Stability of Anusol cream formulations conataining Methocel and effectof propylene glycol on Anusol suppositories containing Methocel	Bioadhesive Anusol cream and suppository dosage formulations	Onyechi *et al*,1996
8.	Adhesion studies on Anusol Formulations 12: Bioadhesive properties of Anusol ointment formulations containing Methocel	Bioadhesive ointment dosage formulation	Onyechi *et al*,1996
9.	Evaluation of the bioadhesive properties of some liquid Fluconazole preparations 1	Bioadhesive liquid dosage formulation	Onyechi *et al*,1997

10.	Evaluation of the bioadhesive properties of some liquid Fluconazole preparations 2	Bioadhesive liquid dosage formulation	Onyechi *et al*,1997
11.	Development of an antibody formulation for ‘a proof of conceptô study for the treatment of ulcerative colitis I, II, III, IV and a Project Report	Simple solution formulation, choice of excipients, compatibility screening, solid dosage formulation for clinical trials	Onyechi *et al*, 2001, 2002, 2003.

Table 4: Some Studies on Conventional Formulations/Drug Delivery Systems

S/No.	Nature of investigation	Result	Reference
1.	Preliminary evaluation of dika fat, a new tablet lubricant.	Dika fat established as tablet lubricant	Udeala, Onyechi and Agu, 1980
2.	Evaluation of sodium stearoyl-2-lactylate in the formulation of sustained release tablets.	Sodium stearoyl-2-lactylate useful in the formulation of sustained release (SR) dosage forms	Onyechi and Udeala, 1988
3.	Tabletting properties of dika fat lubricant.	Dika fat can be used in direct compression	Onyechi and Udeala, 1990

		tabletting as lubricant and in SR matrix tablets	
4.	Moisture sorption characteristics of four modified starches from Zea mays L., Oryza sativa L., Manihot esculenta Crantz and Xanthosoma sagittifolium L (Schott)	Moisture sorption isotherms of starch varieties established	Okafor and Onyechi, 2007
5.	Use of dika fat in the formulation of SR Theophylline Tablets and Capsules	SR tablets and capsules containing Theophylline were formulated.	Umeokoli, Onyechi and Udeala, 2009
6.	Microscopic appearance and compression characteristics of four modified starches	Compression properties and disintegrant mechanism of starches established	Okafor, Udeala and Onyechi, 1991
7.	Use of dika fat in the formulation of SR Theophylline Tablets and Capsules	Stability of capsules and tablets enhanced	Umeokoli, Onyechi and Udeala, 2009
8.	Dika fat a potential prolonged release tablet excipient.	Mechanism of release of the drug from the tablets were predicted	Onyehi and Udeala, 1990

9.	Preformulation drug/excipient compatibility testing: Application of differential scanning calorimetry and isothermal stress tests in the evaluation of dika fat-drug/excipient comp atibility.	Preformulation compatibility testing	Onyechi and Udeala, 1986
10.	Pregelatinisation of starches for direct compression tabletting.	Co-processing excipient design	Onyechi, 1988

11.	Co-processed paracetamol and ascorbic acid granules for tabletting.	Dissolution rate increased with increase in trona concentration	Onyechi and Emenike, 1988
12.	Vitacel, a new direct compression excipient for vitamin tablets.	Vitacel not too good for direct compression tabletting	Onyechi and Maduka, 1988
13.	Evaluation of starch-lactose mixes in direct compression tabletting I: Granule and tablet properties.	Good DC tabletting exccipient	Onyechi, 1989

14.	Evaluation of starch-lactose mixes in direct compression tabletting II: Application in the formulation of ascorbic acid and hydrochlorothiazide tablets.	Suitable for tabletting but optimum starch-lactose concentration levels for each formulation should be determined	Onyechi, 1989
15.	Cissus gum in co-processed ascorbic acid granules for direct compression tabletting.	Cissus gum can be used in ascorbic acid formulations	Onyechi, 1990
16.	Use of Nigerian ball clay in tabletting: Effect of EJF/A of paracetamol tablets.	Process ball clay properly to remove minerals and use at 2-5% concentration level	Onyechi, 1990

2.4 Airways Delivery of Medicines

Aerosol is a dispersion of a solid or a liquid in a gas. The therapeutic aerosol generators currently in commercial use are: pressurised inhalation aerosols or metered dose inhalers (MDIs), dry powder inhalers (DPIs) and nebulisers.

Aerosolised drugs are divisible into two groups:

- Agents acting locally on the lung, and
- Agents intended for systemic effects

The therapeutic objectives of aerosolised drug delivery include:

- Bronchodilatation

- Prevention of bronchospasm
- Inhibition of bronchial hyperactivity
- Suppression of airway inflammation, and
- Increased mucocilliary clearance

The medical use of inhalation aerosols are in:

A. Chronic obstructive pulmonary diseases (COPD)

- Asthma
- Bronchitis
- Emphysema
- Result of microbial infection
- Result of carcinoma

B. Restrictive Disease

- Fibrosing alveolitis
- Asbestosis

Advatages of inhalation therapy include:

- Non-invasive delivery of drugs to airways, a direct delivery to site of action
- Lower dose required for optimal effect
- Rapid onset of action
- Fewer side effects

Disadvantages of inhalation delivery

- Low efficiency of delivery
- Difficulty in breath co-ordination
- Corticosteroid-use can suppress immune response
- Throat irritation possible

A research opportunity opened up to me at Kingôs College, London (KCL) when my wife joined the Department of Nutrition and Dietetics there as a Commonwealth scholar for her PhD programme. I visited KCL on a six-month study leave and the Head of the Department of Pharmacy offered me a position in the

Aerosol Research Group when he learnt I was into powder technology research.
The aerosol research group at KCL was working on a British Technology Grant on the development of dry powder inhalers (DPIs).

The development of dry powder inhalers involves powder recrystallization, formulation, dispersion, delivery, and deposition of the therapeutic agent in different regions of the airways in prophylaxis/treatment/diagnosis of pulmonary and systemic disorders.

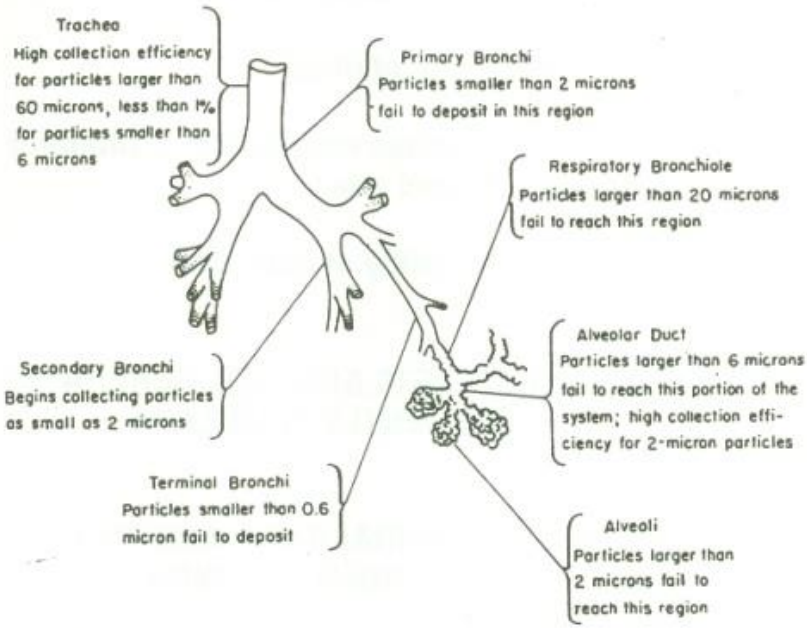

Fig. 45: Aerosol disposition in the lungs

Vice-Chancellor Sir, I stated at the start of this lecture that the regulatory control culture of the drug development environment is pervasive. The quality of pharmaceutical products in the market is

rigidly regulated to assess compliance with Good Manufacturing Practice (GMP) and regulatory authoritiesô guidelines.

At the time I joined the aerosols research group at Kingôs College London, the quality control methods for pharmaceutical aerosols were still being determined. The factors influencing the performance of equipment in use were still being investigated.

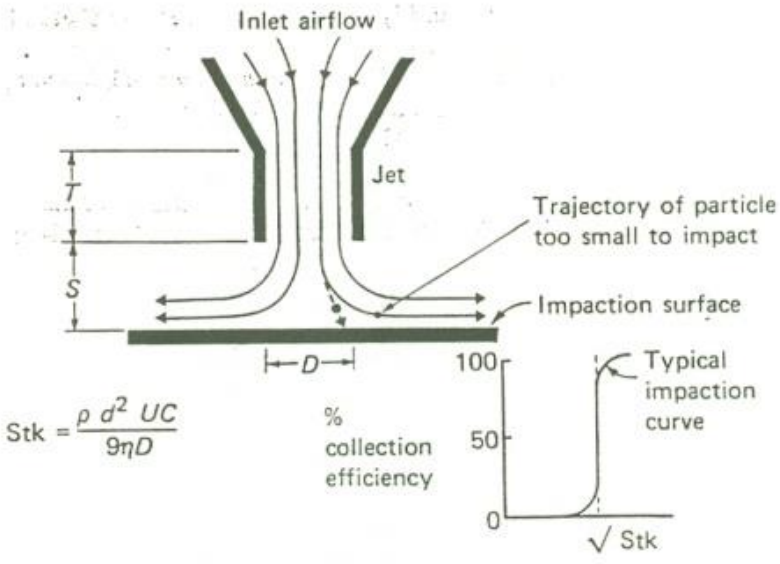

Fig. 9.15 — Principle of inertial impactor.

Fig. 46: Aerosol evaluation by inertial impactor method

In this regard, my first assignment at Kingôs was the generation of aerosols for use in the calibration of the Twin Impinger and the Andersen Cascade Impactor, both pharmacopoeal equipment used to characterize aerosol clouds.

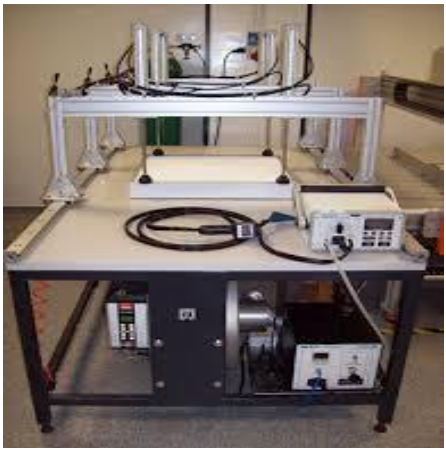

Fig. 47: The monodisperse aerosol generator, MAGE

We were able to use the monodisperse aerosol generator, MAGE to generate stearic acid and carnauba wax aerosols with which we calibrated the Twin Impinger and the Andersen Cascade Impactor.

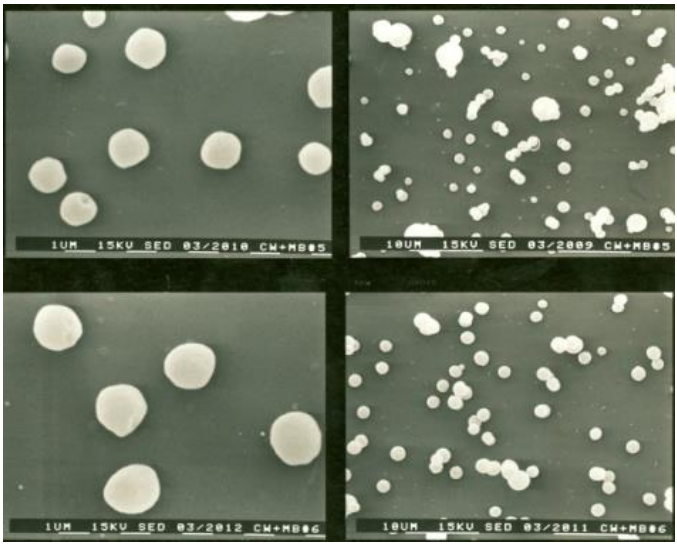

Fig. 48: Monodisperse aerosols of carnauba was generated with the MAGE

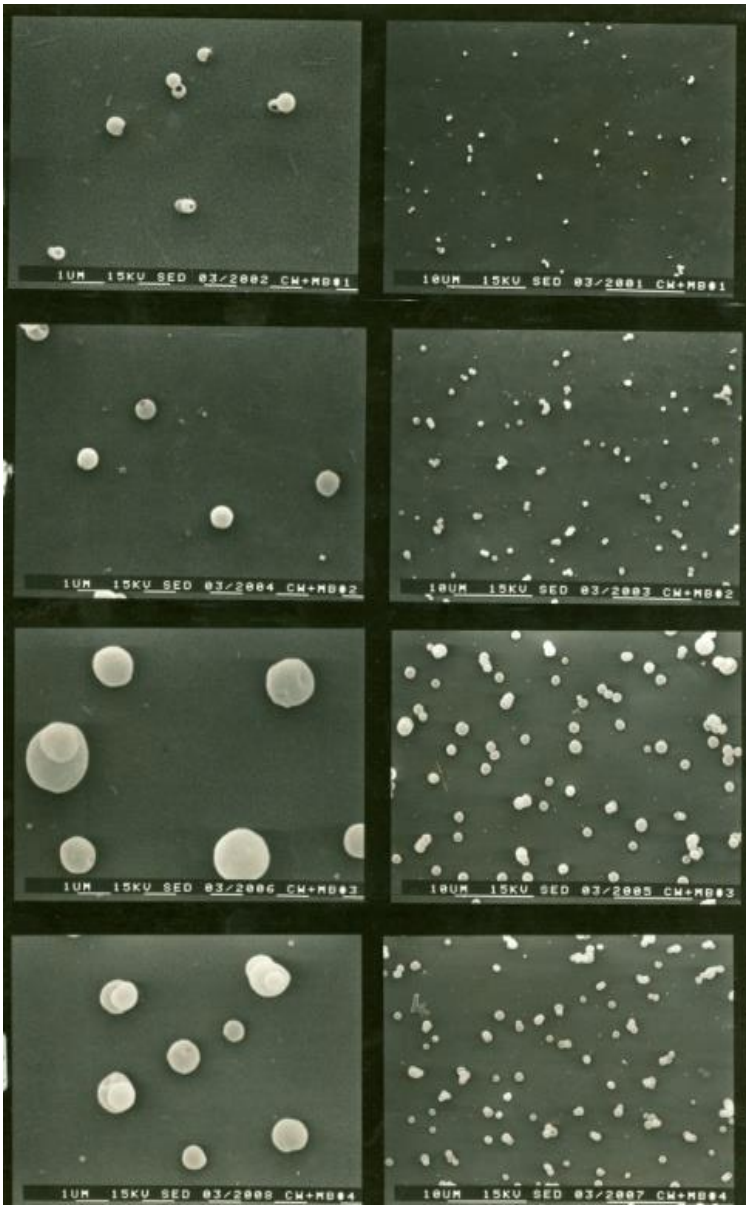

Fig. 49: Monodisperse aerosols of carnauba was generated with the MAGE

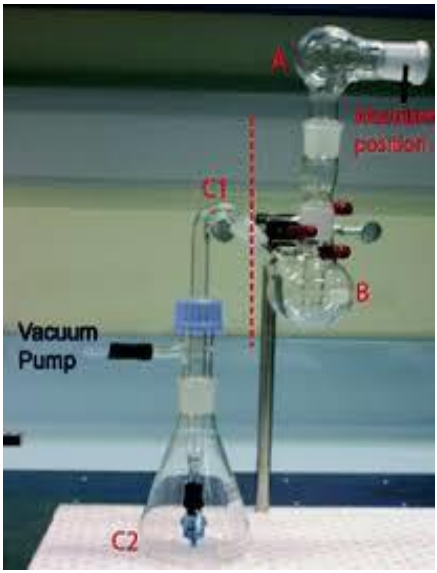

Fig. 49: The Twin Impinger BP

Fig. 50: The Andersen cascade impactor (glass)

Fig. 51: The Andersen Cascade Impactor

Fig. 52: New Generation Impinger USP

This modest achievement of calibrating the impingers in 1994 contributed in no small measure to the new risk-based approach to pharmaceutical manufacturing. Our work, with regard to aerosols, was the precursor to the PAT initiatitive which gave birth to Process Analytical Technology (PAT), a framework for understanding and improving the processes involved in pharmaceutical development, manufacturing, and quality assurance. The guidelines were published in 2004. It also enabled us to predict future prospects for pulmonary delivery of drugs (Martin, Onyechi and Marriott, 1994).

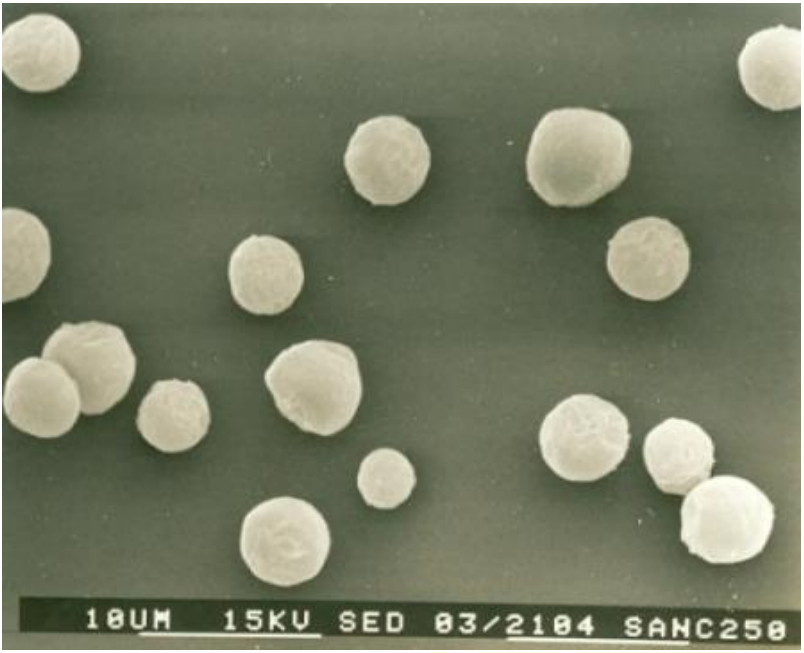

Fig. 53: Monodisperse aerosols of stearic acic generated at 250 ^{o}C

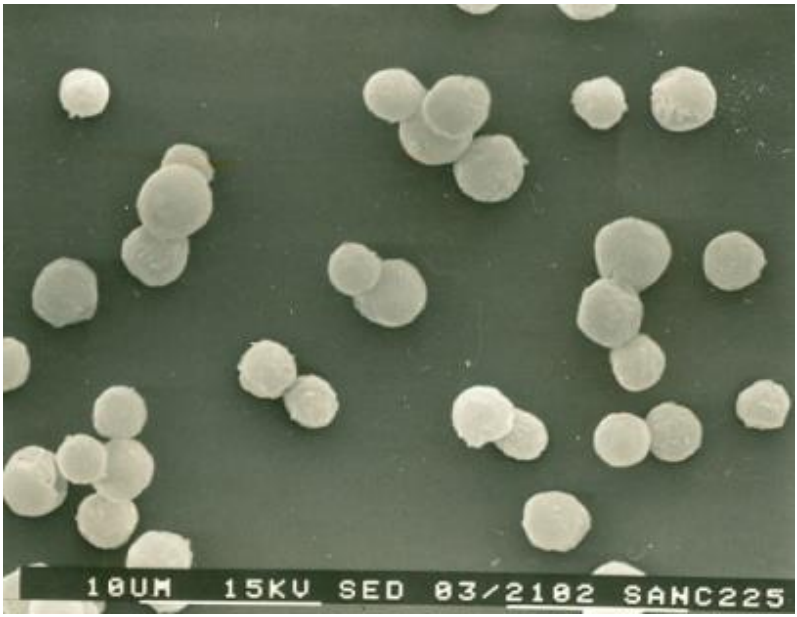

Fig. 54: Monodisperse aerosols of stearic acid generated at 225 ^{o}C

DPIs consist of the formulation mix (micronized drug and mix), carrier, and device. It is a requirement of the carrier that it is readily available in a suitable pharmaceutical grade, chemically and physically stable, inert to drug substance and physiologically acceptable.

VC Sir, our research involved identification of suitable aerosol carrier types to use in DPIs. We investigated the use of lactose as carrier.

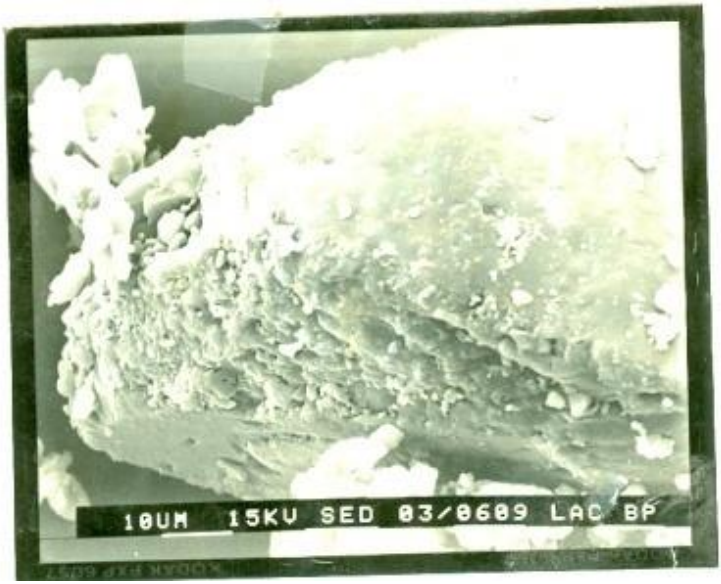

Fig. 54: SEM of Lactose BP

Fig. 55: SEM of Lactose BP (Recrystallized)

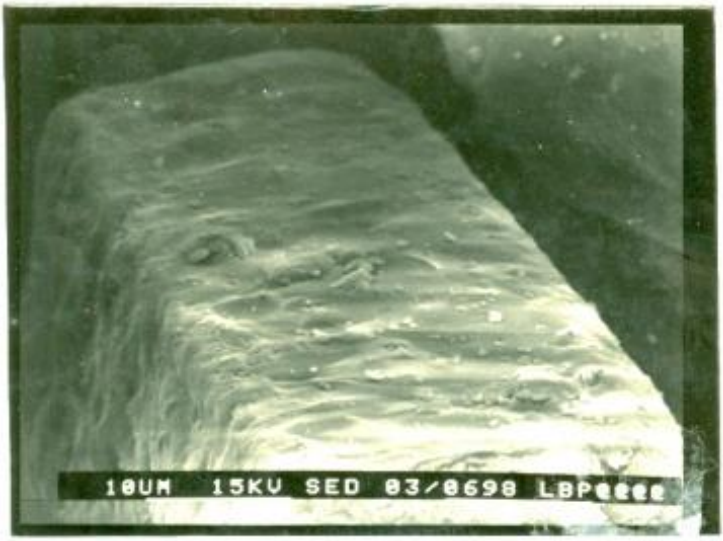

Fig. 56: SEM showing surface texture of Lactose BP

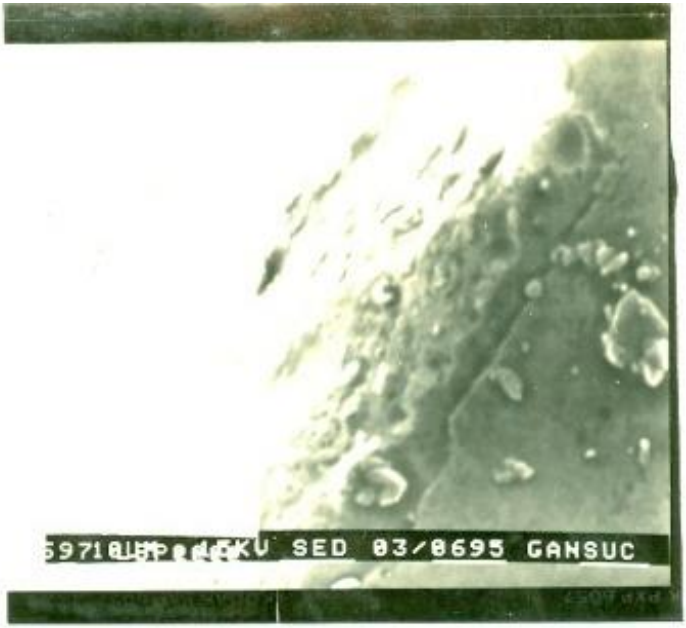

Fig. 57: SEM of surface texture of granulated sugar

We evaluated the respirable fraction of drug obtained between lactose BP, lactose EP, spray dried lactose, other forms of lactose and granulated sucrose. Other than using the scanning electron microscopy to examine the surface texture of the samples under investigation we used the TI apparatus we calibrated to determine the deposition patterns of aerosol formulations containing the drugs disodium cromoglycate, salbutamol, beclomethasonedipropionate and terbutaline sulphate. We chose the lactose BP sample to modify and after modification validated drug deposition patterns with the Twin impinger and the Andersen Impactor.

Our researches showed that using the TI and Andersen Impactor that the amount of respirable fraction of drug was in the order ML>spray dried lactose>lactose BP>lactose EP.

Conventional powder production by crystallization and milling has many limitations resulting in the development of alternative techniques to overcome the problems.

In the last few decades, many patents have been filed claiming improvement of aerosol performance of dry powder inhalers through use of

- incorporation of fines of carrier particles to occupy active sites on the surface and use of hydrophobic carriers to facilitate deaggregation through reduced surface energy and particle interaction;
- reducing aerodynamic diameter through particle engineering and incorporating drug into porous or low particle density; and/or
- preparing less cohesive and adhesive particles through corrugated surfaces, low bulk density, reduced surface energy and particle interaction and hydrophobic additives.

In this regard, we opted for the use of particle engineering methods and modified the surface texture of lactose BP. The modification

involved controlled recrystallization of lactose. A proprietary method for this controlled mass recrystallization to smoothen the texture of lactose has been described. The surface rugosity or surface roughness of the modified lactose was determined and compared with that of other lactose samples. Rugosity is given by the equation: Rs = So/Sd where Rs is rugosity or surface roughness, So is specific surface area obtained by air permeatry, and Sd is theoritical surface area obtained by projected particle diameter measurement. Scanning electron micrographs of samples of the modified lactose are shown in Figs. 58-61.

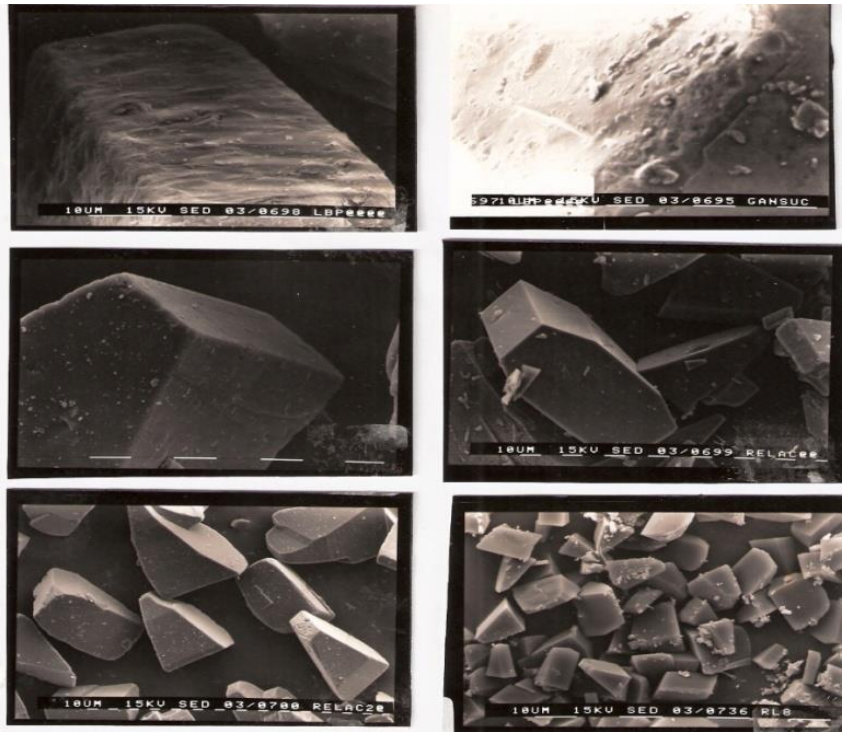

Fig. 58: SEM of carrier samples investigated

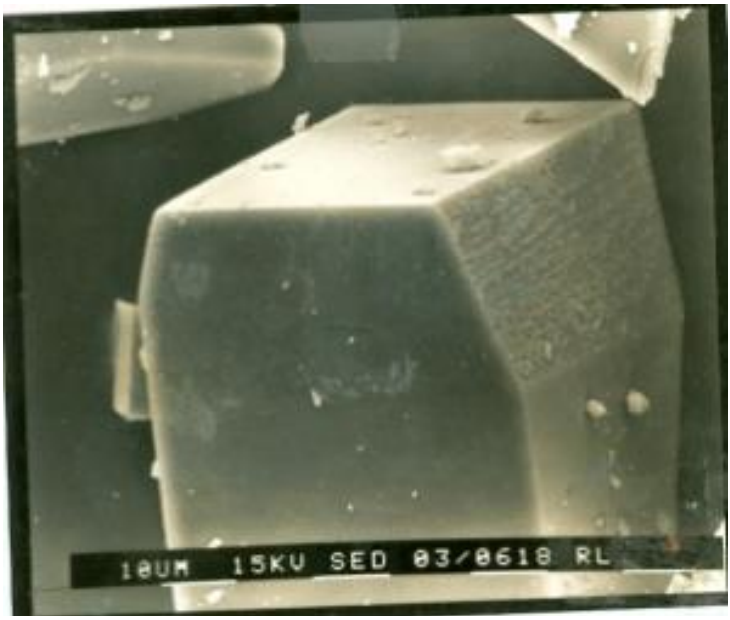

Fig. 59: SEM of surface texture of modified lactose

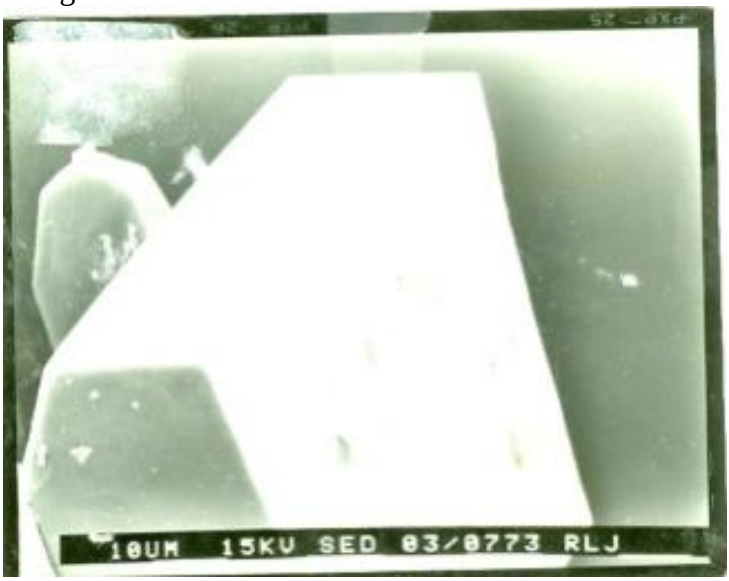

Fig. 60: Recrystallized lactose BP

Fig. 61: Recrystallized lactose crystals

One problem of aerosol delivery is the cohesive forces acting on the very small micronized drugs for aerosolized delivery. The drugs in the size range 2-5 microns and form lumps which must be deaggregated to be successfully delivered. Also, it is important that the drug-carrier complex formed should be deaggregated by the inpiratory effort of the patient. One way of ensuring this is by ensuring smooth carrier surface for the drug. We have shown a visualisation of the balling of some micronized drugs.

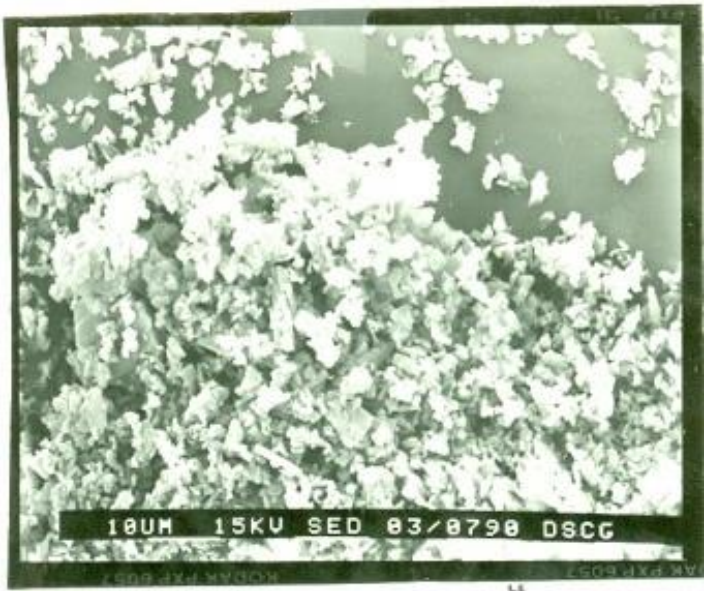

Fig. 62: SEM of micronized disodiumcromoglycate

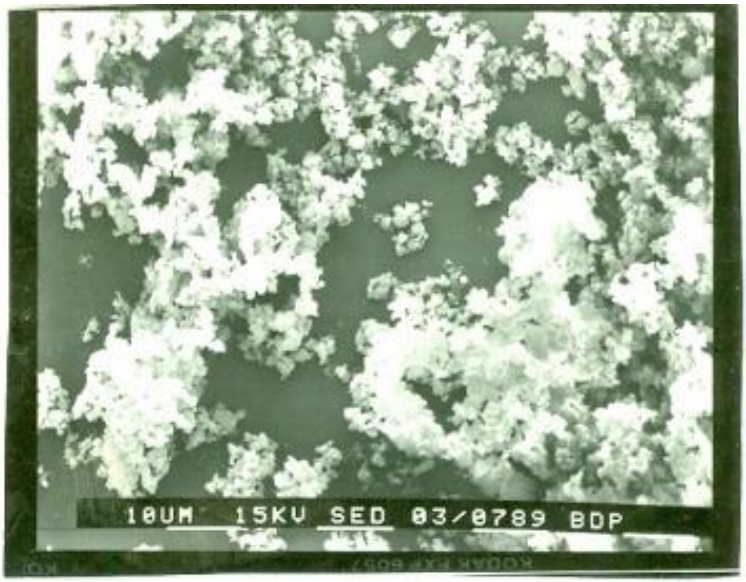

Fig. 63: SEM of micronized beclomethasone dipropionate

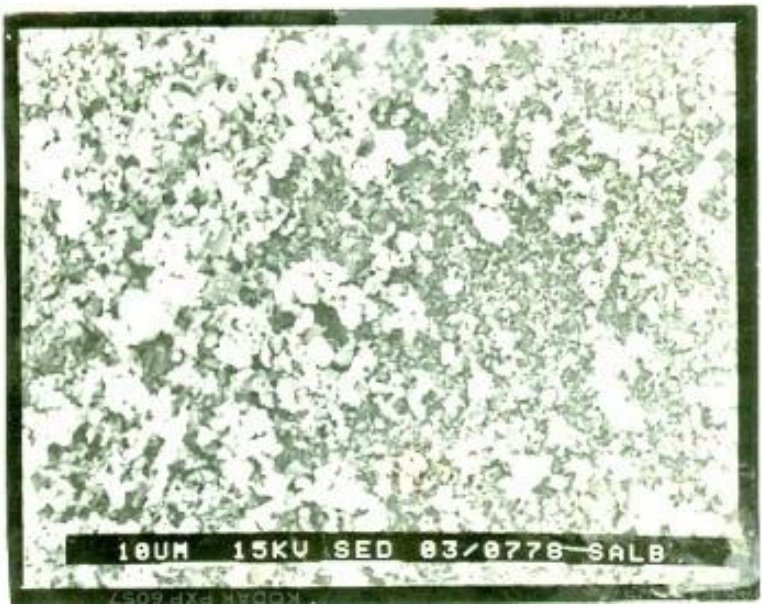

Fig. 64: SEM of micronized salbutamol sulphate

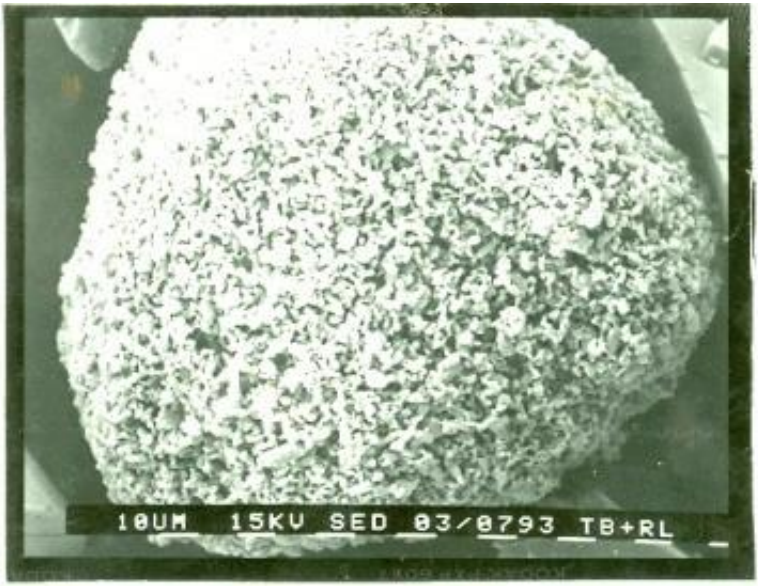

Fig. 65: SEM of micronized terbutaline sulphate

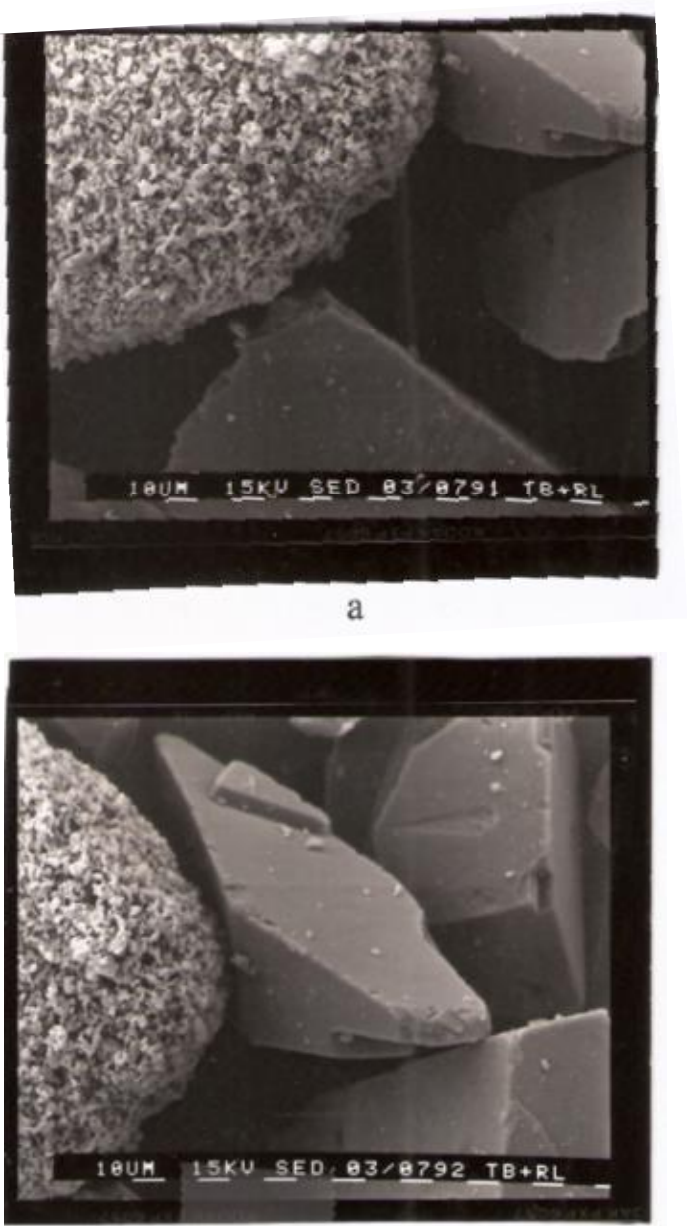

Fig. 66: SEM showing formulation problems with terbutaline sulphate and modified lactose.

The respirable fraction of drug obtained with modified lactose BP of size faction 90/63nm in formulation mixtures containing Salbutamol, BMDP, and terbutaline sulphate was greater than that obtained with Lactose BP using the Twin Impinger. (Onyechi, Martin, Marriott, 2010).

The DPI formulation aims at pulmonary drug delivery having uniform distribution, small dose variation, good flowability, adequate physical stability in the device before use and good performance in terms of emitted dose and fine particle fraction. Our reaearch showed that use of modified lactose BP, in the size range 69/53nm, in dry powder inhaler formulations containing the drugs salbutamol, terbutaline, BMDP and DSCG, gave better deposition patterns using the Twin Impinger for the evaluation, compared to lactose BP.

The performance of The DPI system depends not only on the powder formulation but also on the inhaler device. Devices are much less explored than powder formulations. The high point of our aerosol research activity at Kingôs was the development of the KCHaler device. The KCHaler device was a joint effort between the Department of Pharmacy and the Department of Mechanical Engineering at Kingôs.

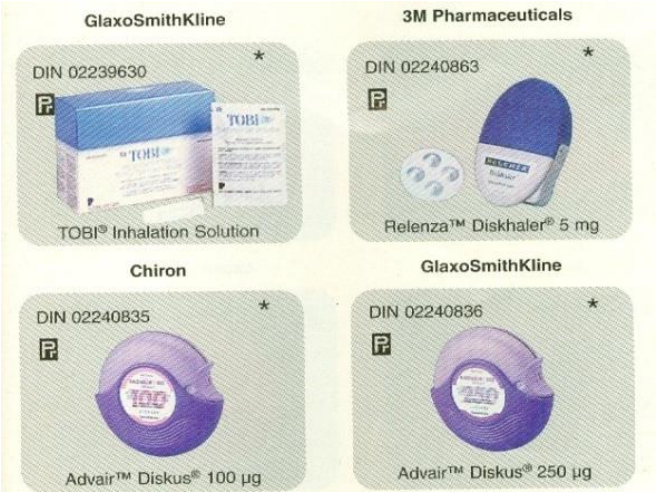

Fig. 67: Some commercially available dry powder inhalers (DPIs)

The KCHaler device has a similar design and dose-delivery mechanism to the metered dose inhaler.

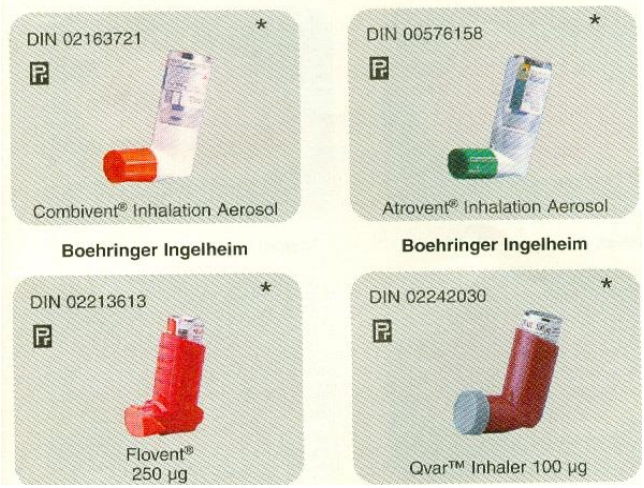

Fig. 68: Some metered dose inhalers (MDIs) available in the market

The main feature of the KCHaler device is a plastic transparent reservoir that can easily be dismantled and filled with powder mix for inhalation by gravity. On actuation, a dose of powder is delivered to a chamber from which contained drug is delivered to the lungs by the patientôs inspiratory flow.
The KCHaler device is a passive breath actuated multiple dose DPI device. Today there is a wide range of passive (breath driven) and active (power driven) single or multiple dose DPI devices in the market. The KCHaler device is patented to Kingôs College.
In several investigations involving the KCHaler device, we reported the deposition pattern of aerosol formulations containing salbutamol and DSCG inhalation mixtures. We also reported the effect of type of mouthpiece attached to the KCHaler device, angle of attachment of the mouthpiece on respirable fraction obtained with Twin Impinger BP. The characteristics of the KCHaler device were well established with powder formulations containing salbutamol sulphate, terbutaline sulphate, disodium chromoglycate, and beclomethasone dipropionate.

Table 5: Other Studies on Airway Delivery of Medicines

S/No.	**Nature of investigation**	**Result**	**Reference**
1.	Calibration of the twin impinger at different flow rates.	The deposition pattern obtained with Twin Impinger Apparatus BP depends on flow rate of operation	Onyechi *et al*, 1993
2.	Deposition of dry powder aerosols in cascade impactors at different flow	Particle deposition and cut-off is also flow rate dependent. The plates may need to be coated	Onyechi *et al*, 1993

	rates.		
3.	Calibration of the twin impinger at different flow rates	The respirable fraction obtained will depend on volume of the sampling liquid and time of sampling	Onyechi *et al*, 1993
4.	Formulation variables affecting deposition with the KCHaler device, a novel multiple dose dry powder inhaler device	Surface characteristics of carrier particles, carrier particle size distribution, mouthpiece and angle of presentation of the mouthpiece will affect KCHaler deposition pattern	Onyechi *et al*, 2010
5.	The formulation and evaluation of terbutaline sulphate dry powder inhalation mixtures with the Rotahaler device	Modified lactose gave up to 20-22% respirable fraction with the Rotahaler device, rather high for terbutaline inhalers	Onyechi *et al*, 2010
6.	Deposition of beclomethasone and and salbutamol from a multidose dry powder inhaler	Modified lactose gave a poor 10% respirable fraction for BMDP mixtures and 18-20% for salbutamol	Onyechi *et al*, 2010

	device		
7.	Deposition of terbutaline sulphate and salbutamol sulphate from a multidose dry powder inhaler device	Modified lactose reached 32% respirable fraction for salbutamol	Onyechi *et al*, 2010
8.	Controlled crystallization method for lactose useful in dry powder inhalation formulation	Method feasible and yields crystals with smooth surface	Onyechi *et al,* 2010
9.	Deposition of disodium cromoglycate and salbutamol from a multidose dry powder inhaler device	Deposition with Modified lactose particles reached 18-25% respirable fraction	Onyechi *et al*, 2010

2.5 From Research to Clinical Trials and GMP Manufacturing Laboratories: The Story of MedPharm Ltd., UK

VC Sir, when I joined the Chelsea Department of Pharmacy in 1991, the Aerosol Group Research Laboratory was located in the basement of the departmental building. From this out of sight location, a lot of research activities were carried out. The research assignments were heightened with the British Technology Group aerosol grant. In addition to the aerosol work, a lot of consultancy work was done for many firms reformulating their medicines. It was a time of mergers, acquisitions, and aggressive takeovers in

the UK pharmaceutical industry. The smaller groups sought alliances with academic departments or whole institutions to survive the downturn in the economy. No wonder academic communities, like Kingôs, became much sought after. The services we offered at Kingôs for Central Research Division, Pfizer Ltd., Sandwich Kent, CIBA Pharmaceuticals Ltd, Wimble Hurst Road, Horsham, Warner Wellcome Consumer Healthcare, Dartfod, Kent; Parke Davies and Co. Ltd, Usk Road, Pontypool, Gwent and the investment of other private individuals became the seed for MedPharm Ltd., UK. MedParm became a spin out from the Department of Pharmacy Research Laboratory. In the words of a colleague of mine at Kings who became the Chief Scientific Officer of MedParm Ltd., ñUK-based MedPharm is one company that is looking to re-educate the pharma industry on the importance of formulation development in drug delivery using alternative routes. Established in 1999, the company employs 35 staff. The contract development services laboratories are based in London and the corporate head office is in Charlbury, Oxfordshire. MedPharm also has a good manufacturing practice facility in Livingston, Scotland where the manufacturing services division is located for the production of clinical trial supplies. MedPharm works on formulation projects across a wide range of disease areas with both large and small pharmaceutical companies based in Europe, Australia, Japan and the USAò.

The idea of MedPharm Ltd. was practised here at UNN long before I went to the UK. We operated the Pilot Production Unit in the Faculty of Pharmaceutical Sciences. We offered consultancy services to establishments, manufactured pharmaceuticals which were much sought after. Our only mistake was that we paid money we generated into the bursary and were unable to sustain our efforts. I saw the picture following somewhere and it tells the story of the PPU visually. The picture is a section of the production room of the defunct PPU. The persons in the photograph include Prof. O.K. Udeala, Prof. Amarauche Chukwu and my humble self,

if we are permitted to name names. We are proud to mention it that Juhel Manufacturing Pharmacy debuted here at the PPU UNN.

Table 6: List of Formulation Studies for MedPharm Ltd at King's College London, University of London

S/No.	Nature of investigation	Result	Reference
1.	Generation of aerosols and calibration of aerosol qc equipment	Calibration of the TI at different flow rates	Onyechi *et al*,1994
2.	Modification of lactose for aerosol delivery	Recrystallization and surface treatment of lactose as carrier for DPIs	Onyechi *et al*,1994

3.	Generation and properties of solid stearic acid aerosols I	Calibration of Andersen Impactor at different flow rates	Onyechi *et al*,1994
4.	Generation and properties of solid carnauba wax aerosols II	Calibration of Andersen Impactor at different flow rates	Onyechi *et al*,1994
5.	Deposition of dry powder aerosols in cascade impactors at different flow rates	Aerosol quality control standardization	Onyechi *et al*,1994
6.	Adhesion studies on Anusol Formulations 3:Water uptake pattern of suppositories at RT and 37^{o}C	Bioadhesive dosage formulation	Onyechi *et al*,1994
7.	Adhesion studies on Anusol Formulations 4: Effect of Methocel on the MP range of the suppositories	Bioadhesive dosage formulation	Onyechi *et al*,1994
8.	Adhesion studies on Anusol Formulations 5:	Bioadhesive dosage formulation	Onyechi *et al*,1994
9.	Adhesion studies on Anusol Formulations 6: Characterisation	Bioadhesive dosage formulation	Onyechi *et al*,1994

	of Lambda 2903 suppository base		
10	Adhesion studies on Anusol Formulations 9: The formulation and tensile strength of Anusol creams containing varying concentration of Methocel	Bioadhesive dosage formulation	Onyehi *et al*,1996
11	Adhesion studies on Anusol Formulations 10: An assessment of suppository formulations containing Suppocire M suppository base	Bioadhesive dosage formulation	Onyechi *et al*,1996
12	Adhesion studies on Anusol Formulations 11: Stability of Anusol cream formulations conataining Methocel and effectof propylene glycol on Anusol suppositories containing Methocel	Suitability of Methocel for bioadhesive cream formulation	Onyechi *et al*,1996

13	Adhesion studies on Anusol Formulations 12: Bioadhesive properties of Anusol ointment formulations containing Methocel	Choice of range of polymers potentially useful for bioadhesive Anusol dosage formulation	Onyechi *et al*,1996
14	Evaluation of the bioadhesive properties of some liquid Fluconazole preparations 1	Screening of different polymers for bioadhesive Fluconazole dosage formulation	Onyechi *et al*,1997
15	Evaluation of the bioadhesive properties of some liquid Fluconazole preparations 2	Choice of polymers for bioadhesive dosage formulation	Onyechi *et al*,1997
16	Development of an antibody formulation for ‘a proof of conceptô study for the treatment of ulcerative colitis I, II, III, IV and A Project Report	Simple solution formulation, choice of excipients, compatibility screening, solid dosage formulation for clinical trials	Onyechi *et al*, 2001, 2002, 2003.

2.7 Formulating Medicines for Extemporaneous Dispensing

A final leg of my odyssey around the world formulating medicines took me to the Kingdom of Saudi Arabia from my London base. I had read about an opening to lecture Pharmacy and I attended an interview at the Saudi Embassy in London. I was Saudi bound in

two days to Hofuf, Al Ahsa, and the headquarters of the Eastern Region of the kingdom. I was to report to a new school for the training of health technicians. My brief was to help train pharmacy technicians and help formulate medicines to be given to patients who attend the primary healthcare centres dotted all over the region. During my tour of duty in the Kingdom of Saudi Arabia, it was unlawful to write out of stock for prescribed medication; it was not permitted for those attending primary healthcare centres. The pharmacist was obliged to provide prescribed medication to patients.

The consequence of this directive was the preparation of medicines for extemporaneous dispensing.

We used branded drugs from reputable manufacturers to formulate different dosage forms to ensure the sick received prescribed medication. The medicines included syrups, granules for reconstitution, suspensions, creams, ointments, pastes, etc. The results of the assignment is published in a journal which I cherish so much and will be a parting gift to any public health establishment devoted to providing prescribed medication to our teeming population of poor, hard pressed populace attending clinics in primary healthcare centres locally.

Having performed such remarkable and enjoyable odyssey round the world, formulating medicines, and solving problems in other climes, I thank God I have returned to base, back to where it all began, UNN. I know there are silent demands to know how the body of knowledge I possess can help the Nigerian situation. Surely, I have suggestions to make to my countrymen.

2.8 Recommendations

Vice-Chancellor Sir, based on my experiences around the globe formulating medicines, the following recommendations should benefit Nigeria.

Government

A new government will be inaugurated tomorrow. We wish it well. This APC government must exorcise the demons militating against progress by past administrations. It must fund education at all levels of our society, as well as fund infrastructural development. It must find and decapitate all the vandals sabotaging our energy endeavours

The Nigerian Pharmaceutical Industry

The Nigerian pharmaceutical industry must adopt a professional management approach to its business activities. There is need for both short-term and long-term development plans, not the current ad hoc approach to planning. There is an urgent need for injection of finances into the pharmaceutical industry by both the government and the private sector. There is need for alliances between the Nigerian pharmaceutical industry and academia. This alliance is imperative for growth in the industry. The primary motivation for a company to seek an alliance with an academic department or an entire institution is to expand the companyôs internal research capacity particularly in an area where experience is lacking. The several advantages of a company-academia alliance include, for the academic institution, financial grant to the institution, ability to recruit additional faculty and expand scientific base of the institution, ability to develop new research area or expand existing one, possibility of having new or improved facilities paid for by the industrial partner. For the company, the advantages are increased research capacity in areas important to the company, development of research capacity in new science areas of importance to the company, increased professional interaction for companyôs senior scientists at the frontiers of research.

Those issues that must be discussed prior to forming alliances include: academic freedom, confidentiality of data, IPRs, transferring discoveries from academia to industry and the stability of long-term corporate financing.

University of Nigeria Nsukka
The Pilot Production Unit in the Faculty of Pharmaceutical Sciences should be revitalized for research, training, consultancy and manufacturing. It will serve as a veritable source of IGR for the University. It should be modelled after the UNNMFB Ltd, one of the rare success stories of UNN investments.

2.9 ACKNOWLEDGEMENTS

I start by acknowledging the Lord God Almighty, the Sovereign One who rules and reigns. He has been faithful and gracious to me. He has endowed me graciously and is ever alongside me in these modest achievements that span the various vistas of my life, which I share with you today.

My precious family: I first want to thank my wife, Uche, for her care, concern and love for me. I am not sure I would have survived to deliver this lecture today without her care. She has a way of sorting me out and making sure I survive the many things I get myself into. This is a good opportunity to tell you how much I love you and to thank you for all you have been to me. Thank you for your ceaseless prayers, your support, the care and concern. You have been a wonderful wife. My sincere love and appreciation to Uche, and our three lovely children, Afomachukwuebuka, Okwuchukwudinma and Ifunanyachukwu. They have been wonderful children who have flavoured my life. They have let us be ourselves. I also salute our fourth child, Kene, who is married to our Afoma. We love you.

I must thank members of my family here. My Chairman, Venerable Chijioke Onyechi, and Hon Kay, who sheltered me at the very start of this odyssey. I thank you for the very supportive beginnings. I want to thank my brother, friend and professional colleague, Ike Onyechi and his wife, Chinee, and the entire Onyechi family: Harold Onyechi, Deboy, and Ngozi for your support. I must also thank my in laws- the Okafors- Nne, Vicky. Obi, Zo, Patty and wife, your family accepted me warts and all as

a brother. And my co in-laws Dr Mbanefo, Dr Chinwuba, Engr. Ben Iloabachie, Ben Okafor and many; I cannot name here because of time constraints

My parents are in the bosom of the Lord. Sure they are in the place of eternal rest, a better place by all accounts.

I deeply appreciate the Vice-Chancellor, Professor Benjamin Chukwuma Ozumba. I adopt the title my professional colleagues have used to address him, an Associate of Pharmacy. He has shown determined, purposeful, committed and exemplary leadership of his charge, UNN. I thank you for the support and the opportunity to present this inaugural lecture.

My Supervisor, Professor OK Udeala, deserves special mention. He came to UNTH Enugu where I was an intern and invited me back to the Faculty for postgraduate work. He showed supreme patience with me. I am sure he found out early in our studies that I didnôt root for theoretical research without tools. He did not spare cash, his cash, to help me out. When I first went to Chelsea he paid my bench fee but what I didnôt tell him to date was that the money he provided for my bench fee, was first used to cater for the West African Cricket Conference team on tour of the Midlands, UK at the time. We sourced funds to survive till our team finances arrived from Nigeria and I was able to begin my laboratory work.

My colleagues in the Department then, Professor Amarauche Chukwu, Dr Ahly, Ms Stella Megwa, Ogbonna Okorie were good company and I thank them.

Thanks are due in a large measure to my teachers and colleagues in the Department of Pharm. Tech. and Ind. Pharmacy, Faculty of Pharmaceutical Sciences. Prof. O.K. Udeala, who reengineered our Department to suit us all deserves all the mention. I cannot thank you enough, Sir. I thank Prof PI Akubue, he sent me to Pfizer Products as a second year pharmacy student. I thank

Professor Nze Aguwa; he sought me out to England and arranged my passage back to UNN. I thank Prof Mosto Onuoha and his wife Ola. Mosto made sure I came back. His home was available to my family when we came back. He has remained a staunch supporter. I thank Prof Achunike Akah, Dean of Students Affairs. He has fond memories of our times working day and night in the past. He has remained a staunch supporter and friend. There are others who have been our students and now bosses. They have remained respectful and I thank you all. God will continue to enlarge your coasts. I refer to Prof S.I. Ofoefule, Prof G.C. Onunkwo and Prof. E.C. Ibezim, current Dean of Faculty of Pharm Sciences. Also, thanks is due Prof. Ken Ofokansi; Prof. V. C. Okore, a former Dean of Faculty; Dr. Nick Obitte, Prof. C. O. Esimone, the current DVC (Academic) of NAU, Awka;. I thank all the non-academic staff of the Department past and present, for their support.

I have fond memories of my collaborators abroad. I am not sure who are still on this side of eternity and those who are not. I would they were all still around. I remember Professor David Ganderton, Professor Chris Marriot, Prof Gary Martin; Drs Taz, Donaldson, Mark Brown all of MedPharm. And Johnny, Steve, and all our Nigerian crowd at Chelsea.

At Maryland, I remember Late Professor Ralph Shangraw, Professor Larry Augsburger, and David. Professor Modilim Achufusi, a past DVC (Admin) here at UNN will always be on my mind. He welcomed me to Maryland, took me to a bank and at a time no one used the ATM here in Nigeria, drew cash by one of those Oyibo tricks sorted me out on my first day in the USA. Thank you uncle as you age graciously.

My graduated masters degree studentsï and current ones, I thank you.

My undergraduate students too numerous to mention here, I extend my regards to all of you.

The following companies have been of immense help.
Alpha Pharmacy and Stores Nig. Ltd. The CEO, my dear brother, Ike Onyechi always looked in on us in the UK when he visited. He kept me registered and practising all the odd years I was on this odyssey. Thank you Ike and Chinee, for your continuing support even in my ministry. The CEOs of Juhel Pharmacy and Stores Ltd., Ceenek Pharmaceuticals Ltd., Impact Pharmaceuticals Ltd., Zevis Pharmaceuticals Ltd., Kingsize Pharmaceuticals Ltd., Ogidi and Emzor Pharmaceuticals Ltd., Lagos, made their establishments willing training ground for all we know today. I sincerely thank you all.

I wish to commend the efforts of the Chairman, Senate Ceremonials Committee, Prof. Malachy Okwueze and members of that committee. May you be strengthened and empowered to continue the Inaugural Lecture Series.

I reserve the last acknowledgement to three groups: my school mates, all who attended GSSA, ọ́pleasesô to my seniors. They left a tradition that taught us to be what we are today. I salute all of you. Please continue to *Fear God and Honour the King*. Jookwanu. I doff my hat to all my friends in the Cricketing arena. Knowing you and associating with you was worth it.
And lastly to a group I tangled with playing squash, Dan, Eddy, Sylva, The Zel, and Ikeoha 1. Before the odyssey began, we kept faith with one another and helped one another survive living in Nigeria. I thank God for all of you.

And to you my wonderful audience, I say thank you and God bless all of us.

2.10 REFERENCES

Abundance of the Heart, Ifeyinwa Nebo, Emeka Otagburuagu, JO Onyechi

Dika Fat: Tabletting Applications.

Dr M. Brown, Professor Gary Martin, Dr M Donaldson and Dr J.O. Onyechi, *Development of an antibody formulation for 'a proof of concept' study for the treatment of ulcerative colitis I.* An Interim Technical Report for KS Biomedix Ltd, 7 Romans Business Park, East Street, Farnham, Surrey, August 2001.

Dr M. Brown, Professor Gary Martin, Dr M Donaldson and Dr J.O. Onyechi, *Development of an antibody formulation for 'a proof of concept' study for the treatment of ulcerative colitis* II. An Interim Technical Report for KS Biomedix Ltd, 7 Romans Business Park, East Street, Farnham, Surrey, December 2001.

Dr M. Brown, Professor Gary Martin, Dr M Donaldson and Dr J.O. Onyechi, *Development of an antibody formulation for 'a proof of concept' study for the treatment of ulcerative colitis III*. An Interim Technical Report for KS Biomedix Ltd, 7 Romans Business park, East Street, Farnham, Surrey, May 2002.

Dr M. Brown, Professor Gary Martin, Dr M Donaldson and Dr J.O. Onyechi, *Development of an antibody formulation for 'a proof of concept' study for the treatment of ulcerative colitis*. A Project Report for KS Biomedix Ltd, 7 Romans Business Park, East Street, Farnham, Surrey, January 2003.

From Vision to Mission, EJ Otagburuagu, JO Onyechi, G Nwokenna and T Tivde.

G.P.Martin, J.O. Onyechi and C. Marriot (1993), *Future prospects of pulmonary drug delivery*, STP Pharma Sciences 4(10): 5-10.

Generation and Properties of Solid Monodisperse Aerosols of Stearic Acid and Carnauba Wax and the Deposition of Dry Powder in the Andersen Mark II Cascade Impactor at Different Flow Rates.

Handbook of Pharmaceutical Facility Auditing and Validation Practice by Jacob Onyechi and Jasper Onyeka.

Introductory Formulation Science 1, 1st Edition, Edited by Dr JO Onyechi.

Introductory Formulation Science 2, 1st Edition, Edited by Dr JO Onyechi.

Introductory Formulation Science 3, 1st Edition, Edited by Dr JO Onyechi.

J.O Onyechi (1983), ***Studies on the flow of erythromycin granules***. **M. Pharm. Thesis**, School of Postgraduate Studies, University of Nigeria, Nsukka.

J.O Onyechi (1987), ***Physico-chemical properties of dika fat and its application in tabletting***. **Ph D Thesis**, School of Postgraduate studies, University of Nigeria.

J.O Onyechi and C.U. Emenike, *Co-processed paracetamol and ascorbic acid granules for tabletting*. Proceedings of the 61st Annual Conference of the Pharmaceutical Society of Nigeria, Abuja, November 8-12, 1988.

J.O Onyechi and J.C. Maduka, *Vitacel, a new direct compression excipient for vitamin tablets.* Proceedings of the 61st Annual Conference of the Pharmaceutical Society of Nigeria, Abuja, November 8-12, 1988.

J.O Onyechi and O.K. Udeala (1988), *Evaluation of sodium stearoyl-2-lactylate in the formulation of sustained release tablets.* Nig J Pharm 32:6-9.

J.O Onyechi and O.K. Udeala (1990), *Tabletting properties of dika fat lubricant*. Drug Dev and Ind Pharm 16(7): 1203-1216.

J.O Onyechi and O.K. Udeala, *Dika fat a potential prolonged release tablet excipient*. Proceedings of the 9th Pharmaceutical Technology Conference, Veldhoven, Holland, April 4-6, 1990.

J.O Onyechi and O.K. Udeala, *Preformulation drug/excipient compatibility testing: Application of differential scanning calorimetry and isothermal stress tests in the evaluation of dika fat-drug/excipient compatibility*. Proceedings of the 59th Annual Conference of the Pharmaceutical Society of Nigeria, Bauchi, November 1986.

J.O Onyechi, *Evaluation of Nigeria ball clay in tabletting*. Proceedings 56th Annual Conference of the Pharmaceutical Society of Nigeria, Owerri, Nov 22-26, 1983.

J.O Onyechi, *Pregelatinisation of starches for direct compression tabletting*. Proceedings of the 61st Annual Conference of the Pharmaceutical Society of Nigeria, Abuja, November 8-12, 1988.

J.O. Onyechi and D. Ganderton, Modification of lactose for use as a carrier in dry powder inhalers. A Technical Report for British Technology Group, October 1992.

J.O. Onyechi and G.P. Martin (2010), The bioadhesive and rheological properties of some Fluconazole gels. JOPHAS 7(1):626-638.

J.O. Onyechi and G.P. Martin, *A method to determine adhesion of suppository mass to excised intestinal tissue.* A Technical Report for Parke Davies and Co Ltd, Usk Road, Pontypool, Gwent, November 1993.

J.O. Onyechi and G.P. Martin, *Adhesion Studies on Anusol Formulations: Summary report.* A Technical Report for Parke Davies and Co Ltd, Usk Road, Pontypool, Gwent, October 1995.

J.O. Onyechi and G.P. Martin, *An assessment of suppository formulations containing Suppocire AM suppository base.* A Technical Report for Warner Wellcome Consumer Healthcare, Dartford, Kent, May 1996.

J.O. Onyechi and G.P. Martin, An improved method to *determine adhesion of suppository mass to excised intestinal tissue* A Technical Report for Parke Davies and Co Ltd, Usk Road, Pontypool, Gwent, December 1993.

J.O. Onyechi and G.P. Martin, *Bioadhesive properties of Anusol ointment formulations containing Methocel.* A Technical Report for Warner Wellcome Consumer Healthcare, Dartford, Kent, November 1996.

J.O. Onyechi and G.P. Martin, *Characterization of Lambda 2904 suppository base.* A Technical Report for Parke Davies and Co Ltd, Usk Road, Pontypool, Gwent, January 1995.

J.O. Onyechi and G.P. Martin, *Effect of Methocel on the melting point range of the suppositories*. A Technical Report for Parke Davies and Co Ltd, Usk Road, Pontypool, Gwent, March 1994.

J.O. Onyechi and G.P. Martin, *Stability of Anusol cream formulations containing Methocel and effect of propylene glycol on Anusol suppositories containing Methocel.* A Technical Report for Warner Wellcome Consumer Healthcare, Dartford, Kent, September 1996.

J.O. Onyechi and G.P. Martin, *Supplementary data on suppository and ointment formulations containing 1% and 2% Methocel.* A Technical Report for Parke Davies and Co Ltd, Usk Road, Pontypool, Gwent, April 1995.

J.O. Onyechi and G.P. Martin, *The formulation and tensile strength of Anusol creams containing varying concentration of Methocel.* A Technical Report for Warner Welcome Consumer Healthcare, Dartford, Kent, November 1996.

J.O. Onyechi and G.P. Martin, *Water uptake pattern and bioadhesion of Anusol cream and ointment formulations*. A Technical Report for Parke Davies and Co Ltd, Usk Road, Pontypool, Gwent, October 1994.

J.O. Onyechi and G.P. Martin, *Water uptake pattern of Anusol suppositores at room temperature and* 37^0C. A Technical Report for Parke Davies and Co Ltd, Usk, Pontypool, Gwent, July 1994.

J.O. Onyechi G.P. Martin and C. Marriott, *Generation and properties of solid monodisperse aerosols of stearic acid and carnauba wax (1)*. A Technical Report for CIBA

Pharmaceuticals Ltd, Wimble Hurst Road, Horsham, January 1993.

J.O. Onyechi, *Cissus gum in co-processed ascorbic acid granules for direct compression tabletting.* Poster 30, 9th Pharmaceutical Technology Conference, Veldhoven, Holland April 4-6 1990.

J.O. Onyechi, Cissus gum in wet granulating tabletting: *Effect of granulating agent on binding properties.* Proceedings of the Pharmaceutical Society of Nigeria, Lagos, November 1990.

J.O. Onyechi, D. Ganderton, G.P. Martin and C. Marriott Evaluation of KCHALER Device, a novel multiple-dose dry powder inhaler device. A Technical Report for Kingôs College Enterprises Ltd, Kingôs College London, University of London, December 1992.

J.O. Onyechi, *Difference in the release characteristics of generic calcium supplement tablets.* Proceedings of the 61st Annual Conference of the Pharmaceutical Society of Nigeria, Abuja, November 8-12, 1988.

J.O. Onyechi, *Evaluation of starch-lactose mixes in direct compression tabletting I: Granule and tablet properties.* Proceedings of the 62nd Annual Conference of the Pharmaceutical Society of Nigeria, Abeokuta, November 1989.

J.O. Onyechi, *Evaluation of starch-lactose mixes in direct compression tabletting II: Application in the formulation of ascorbic acid and hydrochlorothiazide tablets.* Proceedings of the 62nd Annual Conference of the Pharmaceutical Society of Nigeria, Abeokuta, November 1989.

J.O. Onyechi, G.P. Martin and C. Marriot, *Deposition of dry powder aerosols in cascade impactors at different flow rates.* A Technical Report for CIBA Pharmaceuticals Ltd, Wimble Hurst Road, Horsham August 1993.

J.O. Onyechi, G.P. Martin and C. Marriott, *Evaluation of the bioadhesive properties of some Liquid Fluconazole preparations 2*. A Technical Report for Central Research Division, Pfizer Ltd., Sandwich, Kent CT13 9NJ, United Kingdom, September 1997.

J.O. Onyechi, G.P. Martin and C. Marriott, *Generation and properties of solid monodisperse aerosols of stearic acid and carnauba wax (2)*. A Technical Report for CIBA Pharmaceuticals Ltd, Wimble Hurst Road, Horsham, April 1993.

J.O. Onyechi, G.P. Martin, C. Marriot, *Evaluation of the bioadhesive properties of some liquid Fluconazole preparations I.* A Technical Report for Central Research Division Pfizer Ltd, Sandwich, Kent CT13 9NJ United Kingdom. July 1997.

J.O. Onyechi, G.P. Martin, C. Marriott and L. Murphy (1994), *Deposition of dry powder aerosols in cascade impactors at different flow rates*. J. of Aerosol Sc., 7(2); 181-184.

J.O. Onyechi, G.P. Martin, C. Marriott and L. Murphy, *Deposition of dry powder aerosols in cascade impactors at different flow rates*. Conference on drug delivery to the lungs IV. The Aerosol Society, London, December 1993.

J.O. Onyechi, G.P. Martin, L. Murphy, D. Ganderton and C. Marriott, *Calibration of the twin impinger at different flow rates*. Proceedings of the 8th Annual Conference of the Aerosol Society, March 1994.

J.O. Onyechi, S.O. Abali and O. Okorie (2014), Formulation developmentof Eudragit coated polymeric matrices for targeted and controlled delivery to the colon, IJPRS 3(1-2): 475-478.

J.O. Onyechi, *Use of Nigerian ball clay in tabletting: Effect of EJF/A of paracetamol tablets*. Proceedings of the 63rd Annual Conference of the Pharmaceutical Society of Nigeria, Lagos, November 1990.

J.O.Onyechi, C.Marriott and D.Ganderton (2010), Controlled crystallization method for lactose useful in dry powder inhalation formulation JOPHAS 7 (1): 801-814.

J.O.Onyechi, C.Marriott and D.Ganderton (2010), Deposition of beclomethasone and salbutamol from a multidose dry powder inhaler device JOPHAS 7 (2): 926-944.

J.O.Onyechi, C.Marriott and D.Ganderton (2010), Deposition of disodium cromoglycate and salbutamol from a multidose dry powder inhaler device JOPHAS 7 (1): 826-843.

J.O.Onyechi, C.Marriott and D.Ganderton (2010), Deposition of disodium cromoglycate dry powder inhaler mixtures using the Rotahaler device JOPHAS 7 (3): 1008-1022.

J.O.Onyechi, C.Marriott and D.Ganderton (2010), Deposition of terbutaline sulphate and salbutamol sulphate from a multidose dry powder inhaler device JOPHAS 7 (3): 1087-1103.

J.O.Onyechi, C.Marriott and D.Ganderton (2010), Formulation variables affecting deposition with the KCHaler device, a novel multiple dose dry powder inhaler device, JOPHAS 7 (2): 956-972.

J.O.Onyechi, C.Marriott and D.Ganderton (2010), The formulation and evaluation of terbutaline sulphate dry powder inhalation mixtures with the Rotahaler device JOPHAS 7 (3): 1037-1048.

Modification of Lactose for Use in Dry Powder Inhalers and the Evaluation of a Novel Multiple Dose Dry Powder Inhaler Device.

O.K. Udeala, J.O Onyechi and S.I. Agu (1980), *Preliminary evaluation of dika fat, a new tablet lubricant.* J Pharm Pharmacol 32:6-9.

Perkin-Elmer Model DSC-4 Instruction Manual (1983) Rev Oct 1982, Perkin-Elmer Corp., Connecticut, p5-5.

Salpekar AM and Augsburger LL (1974) J Pharm Sci 63: 289-293
Strickland WA (1959) Drug Cos Ind 85: 318-319; 406-409.

Vincent JG, Nyack W and Wray PE (1968) US Patent 3,388,424.

Watson EG, OôNeill MJ, Justin S, Brenmer SN (1964) Anal Chem 36:1233.

Wray PE, Vincent JG, Molle, FW and Jackson CJ (1966) Paper presented at APhA meeting Dallas, Texas.

INAUGURAL LECTURES
OF THE UNIVERSITY OF NIGERIA, NSUKKA

1. **Prof. K. Nzimir O – 1976**
   Title: The Crisis in the Social Sciences: The Nigerian Situation

2. **Prof. Chika Okonjo – 1976**
   Title: Economic Science, Imperialism and Nigerian Development.

3. **Prof. K. S. Hegde, Vet. Medicine – 1977**
   Title:

4. **Prof. D. I. Nwoga – 1977**
   Title: Visions Alternatives: Literary Studies in a Transitional Culture.

5. **Prof. J. A. Umeh – 1977**
   Title: Land Policies and Compulsory Acquisition of Private Land for Public Purposes in Nigeria.

6. **Prof. D. C. Nwafo – 1984**
   Title: The Surgeon as an Academic

7. **Prof. G. E. K. Ofomata – 1985**
   Title: Soil Erosion in Nigeria: The views of a Geomorphologist.

8. **Prof. E. U. Odigboh – 1985**
   Title: Mechanization of cassava production and processing: A Decade of Design and Development.

9. **Prof. R. O. Ohuche – 1986**
   Title: Discovering what Learners have attained in Mathematics.

10. **Prof. S. C. Ohaegbulam – 1986**
Title: Brain Surgery: A Luxury in a Developing Country like Nigeria.

11. **Prof. I. C. Ononogbu – 1998**
Title: Lipids: Your Friend or Foe.

12. **Prof. V. E. Harbor-Peters – 2001**
Title: Unmasking some Aversive Aspects of Schools Mathematics and Strategies for averting them.

13. **Prof. P. O. Esedebe – 2003**
Title: Reflections on History, Nation Building and the University of Nigeria.

14. **Prof. E. P. Nwabueze – 2005**
Title: In the Spirit of Thespis: The Theatre Arts and National Integration.

15. **Prof. I. U. Obi – 2006**
Title: What have I done as an Agricultural Scientist? (Achievements, Problems and Solution Proposals).

16. **Prof. P. A. Nwachukwu – 2006**
Title: A Journey through the Uncharted Terrain of Igbo Linguistics.

17. **Rev. Fr. Prof. A. N. Akwanya – 2007**
Title: English Language learning in Nigeria: In Search of an Enabling Principle.

18. **Prof. T. UzodinmaNwala – 2007**
Title: The OtontiNduka Mandate: From Tradition to Modernity.

19. **Prof. J. A. Ibemesi – June 2007**
Title: From studies in Polymers and Vegetable oils to Sanitization of the Academic System.

20. **Prof. Obi U. Njoku – June 2007**
Title: Lipid Biochemistry: Providing New Insights in our Environment.

21. **Prof. Humphrey Assisi Asobie – July 2007**
Title: Re-inventing the Study of International Relations: From State and State Power to Man and Social Forces.

22. **Prof. Aloy Emeka Aghaji – July 2007**
Title: Prostate Cancer: Coping with the Monster in a Third World Setting.

23. **Prof. Eunice A. C. Okeke – August 2007**
Title: Making Science Education Accessible to All.

24. **Prof. Chibuike U. Uche – August 2007**
Title: The Future of the Past in Banking

25. **Prof. Ossie O. Enekwe – September 2007**
Title: Beyond Entertainment: A Reflection on Drama and Theatre.

26. **Prof. Onyechi Obidoa – September 2007**
Title: Life Does not Depend on The Liver: Some Retrospectives, Perspectives, and Relevance in Xenobiosis, Chemoprevention and Capacity Building.

27. **Prof. Okechukwu Ibeanu – 2008**
Title: Affluence and Affliction: The Niger Delta as a Critique of Political Science in Nigeria.

28. Prof. Damian Ugwutikiri Opata – 2008
Title: Delay and Justice in the Lore and Literature of Igbo Extraction.

29. Rev. Fr. Prof. Elobuike Malachy Nwabuisi – 2008
Title: Education for What?

30. Prof. Michael C. Madukwe – 2008
Title: Practice Without Policy: The Nigerian Agricultural Extension Service.

31. Prof. Anthony N. Eke – 2008
Title: Delay and Control in Differential Equations: Apogee of Development.

32. Prof. Joe Sonne Chinyere Mbagwu – 2008
Title: From Paradox to Reality: Unfolding the Discipline of Soil Physics in Soil Science.

33. Prof. Inno Uzoma Nwadike – 2008
Title: Igbo Studies: From the Plantation of West Indies to the Forest lands of West Africa, 1766 ï 2008.

34. Prof. Benjamin Chukwuma Ozumba – 2008
Title: Improving Maternal Health in Developing Countries: The Nigerian Experience.

35. Prof. Henrietta Nkechi Ene-Obong – 2008
Title: Nutrition Science and Practice: Emerging Issues and Problems in Food Consumption, Diet Quality and Health.

36. Prof. Amarauche Chukwu – 2008
Title: Using Neglected Local Raw Materials in Developing High Level International Health Manpower.

37. **Prof. Samuel Ogbonna Enibe – 2008**
Title: Engineering Systems Analysis and Optimization.

38. **Prof. Michael Ifeanyi Uguru – 2008**
Title: Crop Genetics and Food Security.

39. **Prof. Alex I. Ikeme (KSM) – 2008**
Title: Poly-Functional Egg: How can it be Replaced?

40. **Prof. Chukwuma C. Soludo – 2008**
Title: Financial Globalization and Domestic Monetary Policy: Whither the Economics of the 21st Century.

41. **Prof. Josephine Ifeyinwa Okafor (Mrs) – 2008**
Title: Fungal Diseases: A Serious Threat to Human Existence in Recent Times.

42. **Prof. C. C. Agu – 2008**
Title: Understanding the ABC of the Financial System.

43. **Prof. Polycarp E. Chigbu – 2009**
Title: Semi-Latin Squares and Related ñObjectsò: Statistics and Combinatorics Aspects.

44. **Prof. Reuben U. Okafor – 2009**
Title: 4-circle Base Triangular Model in Ageing and Death Education.

45. **Prof. Francisca Nneka Okeke – 2009**
Title: Geomagnetic Research in Physics: The Journey So Far.

46. **Prof. Clara Ikekeonwu – 2009**
Title: Language and Gender in Nigeria: Perception, Pattern and Prospects.

47. Prof. Fabian C. Okafor – 2009
Title: The Varied Roles of Snails (Gastropod Molluscs) in the Dynamics of Human Existence.

48. Prof. Denchris Nnabuike Onah – 2009
Title: The Elegance and Success of Trypanosomes as Parasites: Immunological Perspective.

49. Prof. Grace Chibiko Offorma – 2009
Title: Curriculum across Languages.

50. Prof. Doris Ukanwamaka Egonu – 2010
Title: Illiteracy in a Century-Old Education System: The Challenge of Adult Education in Nigeria.

51. Prof. Uchenna Mariestella Nzewi – 2010
Title: Itôs all in the Brain: Of Gender and Achievement in Science and Technology Education.

52. Prof. Beatrice A. Okeke-Oti – 2010
Title: They have Dignity and Worth and Therefore Need Restoration.

53. Prof. Ernest Onwasigwe – 2010
Title: Paediatric Ophthalmology: Past, Present and Future.

54. Prof. Chika Onwasigwe – 2010
Title: Disease Transition in Sub-Saharan Africa: The Case of Non-Communicable Diseases in Nigeria.

55. Prof. Rich Enujioke Umeh – 2010
Title: River Blindness: An Insight into Community Directed Management of Endemic Diseases.

56. Prof. Eric C. Eboh – 2011
Title: Agricultural Economy of Nigeria: Paradoxes and Crossroads of Multimodal Nature.

57. Prof. George O. S. Amadi – 2011
Title: Political Jaywalking and Legal Jiggery-Pokery in the Governance of Nigeria: Wherein Lies the Rule of Law?

58. Prof. Ola Oloidi – 2011
Title: The Rejected Stone: Visual Arts in an Artistically Uninformed Nigerian Society.

59. Prof. Felicia N. Monye (Mrs) – 2011
Title: The Consumer and Consumer Protection in Nigeria: Struggles, Burdens and Hopes.

60. Prof. Goddy Chuba Okoye – 2011
Title: Enhancing Healthy Human Life Through Bioengineering and Rehabilitation Medicine.

61. Prof. James C. Ogbonna – 2011
Title: Biotechnology and the Future of Human Existence.

62. Prof. Ngozi M. Nnam – 2011
Title: Adequate Nutrition for Good Health: Is Our Environment Nutrition Friendly?

63. Prof. Joseph C. Okeibunor – 2011
Title: Health Services for the Poor by the Poor: Lessons for Addressing the Diverse Social Problems in Nigeria.

64. Prof. Okwesili Fred C. Nwodo- 2012
Title: From Water Beyond Wine to Longevity.

65. Prof. Fab Obeta Onah- 2012
Title: Engaging the Challenges of Human Resource Management in Public Organisations in Nigeria.

66. Prof. Emmanuel Onyebuchi Ezeani- 2012
Title: Delivering the Goods: Repositioning Local Governments in Nigeria to Achieve the Millenium Development Goals (MDGs).

67. Prof. Malachy Ikechukwu Okwueze - 2012
Title: Religion: Indeed the óOpiumôof Life?

68. Prof. Emmanuel Chinedum Ibezim- 2012
Title: Exploring the Exciting World of the Wonder Agents called Drugs.

69. Prof. Patience Ogoamaka Osadebe - 2012
Title: From the Lab. Bench Through the Gardens to the Apothecary: Journey So Far.

70. Prof. Ifeoma Maureen Ezeonu – 2012
Title: People vs Bacteria: Bacteria Innocent Until Proven Guilty.

71. Prof. Chika Njideka Oguonu-2012
Title: Fiscal Management And Grassroots Development: Issues And Concerns In The Nigerian Context.

72. Prof. Gabriella I. Nwaozuzu -2013
Title: The Babelist Theory of Meaning.

73. **Prof. Basden Jones C. Onwubere – 2013**
Title: High Blood Pressure - The Silent Killer On The Prowl: Combating The Albatross.

74. Prof. Obina Onwujekwe – 2013
Title: Moving Nigeria From Low Coverage to Universal health Coverage: Health System Challenges, Equity and the Evidence.

75. Prof. David N. Ezeh -2013
Title: Science Without Women: A Paradox.

76. Prof. Elizabeth Ugonwa Anyakoha - 2013
Title: Advancing A Framework For Showcasing Family Concerns: Challenging The Challenges.

77. Prof. Micah Okwuchukwu Osilike – 2013
Title: Fixed Point Theory and Applications: Contributions from Behind Closed Doors.

78. Prof. Augustine A. Ubachukwu – 2014
Title: Physics in Life and the end of all Things.

79. Engr. Prof. Daniel Oraeguna N. Obikwelu -2014
Title: Metallic Materials: Challenges in the 21st Century Nigeria and Didactic Lessons from the 18th Century Industrial Revolution.

80. Prof. (Mrs.) Catherine Ikodiya Oreh – 2014
Title: Igbo Cultural Widowhood Practices: Reflections On Inadvertent Weapons of Retrogression in Community Development.

81. Prof. Charles Livinus Anija Asadu– 2014
Title: The Soil We Do Not Know.

82. Prof. Basil Chukwuemeka Ezeanolue - 2014
Title: Hear the Voice

83. Prof. Ifeoma Pamela Enemo – 2014
Title: Dangerous Families In Nigerian Law: A National Albatross?

84. Prof. Christopher Okeke Tagbo Ugwu – 2014
Title: The Demise of the African God/s: Fallacy or Reality

85. Prof. Bernard Obialo Mgbenka - 2014
Title: Clariid Catfish Aquaculture: a Panacea for Quality Animal Protein Security

86. Prof. Benjamin Sunday Chudi Uzochukwu - 2014
Title: Accelerating the Achievements of Health-Related Millennium Development Goals: Social Determinants of Health approach and Mainstreaming Health in All Policies

87. Venerable Prof. Samuel Obiajulu Ike - 2014
Title: The Matter of the Heart

88. Prof. Chimdi Memnofu Chuka-Okosa - 2014
Title: Beyond Vision

89. Prof. John Chika Mbah - 2014
Title: "The Control of Impurities In The Quality Control of Pharmaceutical Dosage Formsò.

90. Prof. Emmanuel Rapuluchukwu Ezeome - 2015
Title: Cancer in Nigeria: Surviving the Emerging Epidemic

91. Prof. Anthony Amaechi Attama - 2015
Title: The Road to Nanomedicines

92. Prof. Aloysisu-Michaels Okolie - 2015
Title: Global Political Economy and Development of Underdevelopment: Different People, Same Market and Glorification of Poverty

FORMULATING MEDICINES ROUND THE GLOBE: LESSONS FOR THE GROWTH OF THE PHARMACEUTICAL INDUSTRY IN NIGERIA

By
Rev. Canon Professor Jacob Okwuchukwu Onyechi
B. Pharm., M. Pharm. Ph.D, MPSN
Professor of Pharmaceutical Technology and
Industrial Pharmacy
University of Nigeria, Nsukka

Quick Summary of Lecture

Formulation of medicines round the globe: Lessons for the growth of the pharmaceutical industry in Nigeria describes an odyssey by the author through four of the seven continents of the world formulating medicines. The odyssey began in Nigeria, Africa where the lecturer describes research work designing tabletting excipients. Detailed work done with a tablet lubricant, dika fat, extracted from the kernels of *Irvingia gabonensis* var *gabonensis* and var *excelsia* was narrated. The dika fat was processed to pharmaceutical grade and the compatibility of dika fat with classes of drugs and excipients were copiously illustrated with thermograms generated by differential scanning calorimetry (DSC). The use of instrumented tablet machines (ITMs) to evaluate the effect of dika fat on hardness, friability, disintegration and dissolution of tablets containing aspirin, paracetamol and ascorbic acid are also shown graphically. Both the DSC and ITMs were determined at the University of Maryland at Baltimore, USA. The lecture also describes work done developing and optimizing a solid dosage form of an antibody Kab104M, potentially useful for the treatment of ulcerative colitis. The solid formulation of Kab104M was prepared by freeze drying and/or sprays drying. Data on the stability profile of the solid formulation was also generated. A list of other drug development activities involving

bioadhesive suppositories, creams, ointments formulations are provided in the lecture booklet.

The odyssey next shifted to London, Europe, where the lecturer describes the most productive period of the journey. The odyssey anchored at the Department of Pharmacy, Kingôs College London, developing dry powder inhalers (DPIs). The development of DPIs involved generation of monodisperse aerosols used in calibrating the Twin Impinger BP and the Andersen Cascade Impactor USP. Both are equipment used in quality control of aerosol fine fraction. The development of DPIs included the recrystallization of lactose BP to yield low rugosity lactose used in formulation of powders for inhalation. The design of a multi-dose dry powder inhaler device, KCHaler (KCL Enterprises, UK) a collaborative research between the Department of Pharmacy and Department of Mechanical Engineering, Kingôs College, London was part of the development of DPIs. The performance characteristics of the KChaler device were evaluated for patenting purposes.

The odyssey stopped over briefly in the Kingdom of Saudi Arabia where the lecturer was engaged in training pharmacy technicians and formulating medicines for use in the primary health care centres in the eastern region of the kingdom at a place known as Hofuf, Al Ahsa. The course of the odyssey returned to Europe where the lecturer joined MedPharm Ltd, UK. The research laboratory at Kingôs College London had transformed into a clinical trials manufacturing laboratory.

The lecture ends with acknowledgement and gratitude to all those who made the odyssey possible and recommendations by the lecturer from the wealth of experience garnered from the odyssey, that government must address and resolve the infrastructural, energy and financial problems hindering the growth of the pharmaceutical industry. The lecturer commends to his professional colleagues, industry-academia alliance. He is also of the opinion that both short-term and long-term development plans rather than the ad hoc development plans currently being practiced

as well as the principle of management by objectives are the *sine qua non* for the growth of the pharmaceutical industry in Nigeria.