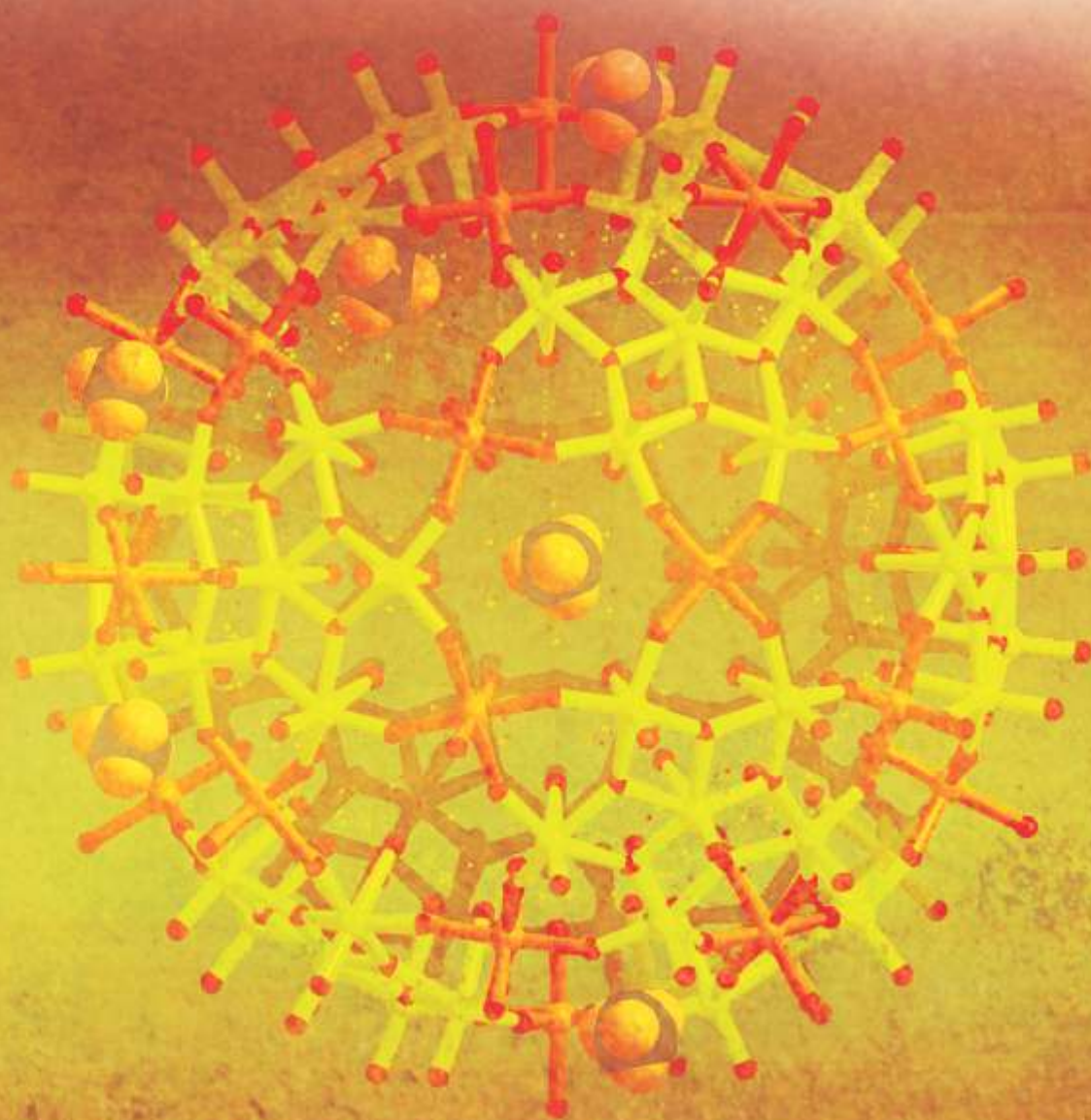


CHEMISTRY

IN SRI LANKA



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The Tri-Annual Publication of the Institute of Chemistry Ceylon

Founded in 1971, Incorporated by Act of Parliament No. 15 of 1972

Successor to the Chemical Society of Ceylon, founded on 25th January 1941

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"Begining of a New Era: Challenges and Opportunities for Chemists in National Development"

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Outline of our Institute

The Institute of Chemistry Ceylon is a professional body and a learned society founded in 1971 and incorporated by act of Parliament No. 15 of 1972. It is the successor to the Chemical Society of Ceylon which was founded in 1941. Over 50 years of existence in Sri Lanka makes it the oldest scientific body in the country.

The Institute has been established for the general advancement of the science and practice of Chemistry and for the enhancement of the status of the profession of Chemistry in Sri Lanka. The Institute represents all branches of the profession and its membership is accepted by the government of Sri Lanka (by establishment circular 234 of 9-3-77) for purposes of recruitment and promotion of chemists.

Corporate Membership

Full membership is referred to as corporate membership and consists of two grades: **Fellow (F.I.Chem.C.)** and **Member (M.I.Chem.C.)**

Application for non-corporate membership is entertained for four grades: **Associate (former Graduate) (A.I.Chem.C.)**, **Licentiate (L.I.Chem.C.)**, **Technician (Tech.I.Chem.C.)** and **Affiliate Member**.

Revision of Membership Regulation

All Special Degree Chemists can now apply directly to obtain **Associate (Graduate) Membership**. Three year B. Sc. Graduates (with an acceptable standard of Chemistry) can

- directly become **Licentiate**
- obtain corporate membership in a lesser number of years.

Tech.I.Chem.C.

Those who have passed the DLTC examination or LTCC examination or have obtained equivalent qualification and are engaged in the practice of Chemistry (or chemical sciences) acceptable to the Council are entitled to the designation Tech.I.Chem.C.

Members/Fellows are entitled to the designation of **Chartered Chemist (C.Chem.)** on establishment of a high level of competence and professionalism in the practice of chemistry and showing their commitment to maintain their expertise.

All corporate members (Members / Fellows) are entitled to vote and become Council/ Committee members whether Chartered Chemists or not.

Membership Applications

Any application for admission to the appropriate class of membership or for transfer should be made on the prescribed form available from the Institute Office.

Current Subscription Rates

Fees should be paid on 1st of July every year and will be in respect of the year commencing from 1st July to 30th June

Fellow	Rs. 750
Member	Rs. 750
Associate	Rs. 600
Licentiate	Rs. 500
Technician	Rs. 400
Membership for Life	Rs. 7500

Entrance Fee

All the grades	Rs. 500
Processing Fees*	Rs. 200
Processing Fee for Chartered Chemist designation	Rs. 1000
Institutional Members	Rs. 2500

*per application for admission/transfer to any grade

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CHEMISTRY IN SRI LANKA

Chemistry in Sri Lanka is a tri-annual publication of the Institute of Chemistry Ceylon and is published in January, May and September of each year. It is circulated among the members of the Institute of Chemistry and students of the Graduateship/DLTC course and libraries. The publication has a wide circulation and more than 1500 copies are published. Award winning lectures, abstracts of communications to be presented at the annual sessions, review papers, activities of the institute, membership news are some of the items included in the magazine.

The editor invites from the membership the following items for publication in the next issue of the Chemistry in Sri Lanka which is due to be released in May 2010.

- Personal news of the members
- Brief articles of topical interests
- Forthcoming conferences, seminars and workshops
- Latest text books and monographs of interest to chemists

All publications will be subjected to approval of the 'Editorial and Publicity Committee' and the Council of the Institute of Chemistry Ceylon.

Further, prospective career opportunities for chemists, could be advertised in Chemistry in Sri Lanka at a nominal payment. The editor welcomes from the members suggestions for improvement of the publication.

Do our universities respond to needs of a knowledge economy?

Prof. Ranjith Senaratne

Senior Professor of Group Science and former Vice Chancellor University of Ruhuna.



Traditionally teaching and research have been the main missions of a university. This has gradually changed with the emergence of disciplines such as biotechnology, increased globalization, reduced basic funding and the new perspectives on the role of university in the system of knowledge production. As knowledge becomes an increasingly important part of innovation, the university as a knowledge-producing and disseminating institution plays a larger role in industrial innovation. Thus, in a knowledge-based economy, the university becomes a key element of the innovation system both as a provider of human capital and as a seed-bed of new firms. In addition, it provides much of the backbone of the knowledge economy, such as laboratories, libraries and computer networks.

In today's global landscape of relentless change and innovation, the mission of universities has thus become multi-faceted, and they must see themselves as part of the larger global enterprise of creating, imparting, applying and commercializing knowledge. Research universities around the world are increasingly embracing an entrepreneurial dimension. They exert leverage on the natural complementarity between creating, imparting and applying knowledge and create spin-off companies and produce licenses and patents.

Today, academics and politicians are beginning to see universities, not just as creators of knowledge, as developers of young minds, and as transmitters of culture, but also as major agents of economic growth of regions and the country. This change in their purpose and self-image has been driven by the concept of the Knowledge economy, in which as mentioned before ideas and the ability to manipulate them are of more importance than the traditional factors of production. In this context a world-class university is becoming increasingly an asset. It has also not escaped the notice of policy makers the world over that behind most of the successful high-tech clusters of industry whether it is Silicon Valley, the "research triangle" of North Carolina, or Cambridge or the Triple Helix of Gothenberg or Linköping in Sweden - lies a world-class university. Aachen in Germany and Oulu in Finland are similar examples.

With the emergence of new expectations, the universities must cater for new needs in education and training which stem from the knowledge-based economy and society. These include an increasing need for scientific and technical education, horizontal skills and opportunities for lifelong learning, which require greater permeability between the components and levels of education and training systems.

Universities in the USA have been trail blazers in the world in commercializing knowledge and technology generated from R & D. Premier entrepreneurial universities in the world such as Stanford, Berkeley, Pennsylvania and MIT learnt how to balance their academic and entrepreneurial roles and harvest the benefits well ahead of their counterparts in other countries. For instance, several decades ago, MIT saw the values of a science and technology-led university education with an enterprise dimension. A study conducted in 1997 revealed that if the companies founded by MIT graduates and faculty formed an independent nation, their revenues would make them the 24th largest economy in the world with annual sales of US\$ 232 billion, which is more than double the GDP of Singapore. Universities such as MIT and Stanford, which had been considered as anomalies within the US academic system in the past, now have become the models for other universities to emulate. We can learn a great deal from the above success stories as to how they transformed new ideas and knowledge into innovative products and services through commercialization of R & D.

In order to respond to this change in Europe, members of the European Union met in Lisbon in 2000 and formulated "Lisbon Strategy" in order to make the EU the most competitive and dynamic knowledge-based economy in the world by 2010. Since the birth and growth of the knowledge economy and society rely on the combination of four independent elements - the production of new knowledge, its transmission through education & training, its dissemination through ICTs, and its use through new services or industrial processes - the European universities have been obviously identified as the key players in achieving this goal. They are strongly committed to this goal and accordingly started a debate on the "Role of European Universities in the Knowledge Society and Economy". Consequently, a multitude of programmes and activities have been launched in strategic and high impact areas in member countries and the EU as a whole in this regard.

In order to benefit from this wave, the UK government has developed ambitious plans for the future. Development of a 10-year Science and Innovation Investment Framework for the country and the establishment of Science Enterprise Centres and Higher Education Innovation Funds are some examples. The British Universities have risen to the challenge and a vast improvement of working relationships between universities and industry has been observed, which is a major cultural change. Similar plans are afoot practically in all developed economies including Japan, the Republic of Korea, Taiwan, Canada, Australia, New Zealand etc.

If we turn to our region, the Prime Minister of India constituted a National Knowledge Commission on 13

June 2005 with the mandate of transforming India to a strong and vibrant knowledge economy. In this connection, NKC has identified several key areas namely, Education, Science & Technology, Agriculture, Health, Industry and governance, that can help India achieve this goal. The NKC will form working groups in each of those areas and make concrete proposals for reforms to the PM through a series of White Papers. This task involves working closely with Central and State Government, professionals, academics, scientists, regulatory bodies, industry representatives, national think-tanks, civil society organizations etc. The time-frame for these activities is three years, from October 2005 to October 2008. Through this India plans to become a leading global player in the creation, dissemination and application of knowledge, and this will increase its competitive advantage over other countries and make it a leading economic power-house in the world. Similarly ambitious programmes have been launched in other countries in our region including Singapore, Malaysia and Thailand.

When such drastic changes are taking place in the global landscape of higher education and universities in many parts of the world are becoming key partners in regional and national development, what has been our response here in Sri Lanka? Are we adequately alive to such changes and their attendant implications? Has there been any debate on the new role of universities in the knowledge economy and knowledge society at national level with the participation of key stakeholders? Have we changed our mind-set to recognize our employees as knowledge workers and made a paradigm shift in management to suit the knowledge economy? Have we formulated appropriate policies and put in place necessary institutional

structures, systems and processes to transform new ideas, knowledge and technology generated at universities to new products, processes or services? Or have we created enabling environment for valorization of knowledge? Do we have innovation systems at national, regional or sectoral level supported by a national innovation policy to promote knowledge-intensive industries? These are some pertinent questions to ask. According to Charles Darwin "It is not the strongest species that survive, nor the most intelligent, but the species most responsive to change". This is equally applicable to any institution, organization or country. So if our universities do not swiftly, adequately and appropriately respond to change, they will soon become as dead as the dinosaurs.

Hence if universities are to survive in this rapidly changing landscape, they need to be able to swiftly respond to change. They must be ready to cater to the emerging demand for higher education. The innate conservatism of the academic profession does not help the university to the face these changes. "Thirty years from now, the big university campuses will be relics" said Peter Drucker, a world-renowned management thinker. In the globalized environment of the new millennium, the survival of a nation will depend on how well and how fast its citizens acquire new knowledge, skills and competencies; they will demand these vitals from the nation's institutions of higher education. How well the universities respond to this demand, thus has a direct effect on the survival of a nation. Both the universities themselves and the Government of a nation should thus take the matter of the development of the universities seriously and make the appropriate interventions to ensure that the higher education sector is responsive and adaptive to change.

Cover Page

The cover page shows an example of host-guest chemistry at the surface of a sphere. For more details on host-guest chemistry see pages 12-15.

Deans Emergency Fund

The Deans Emergency Fund was established to provide financial relief to G I C students in case of emergency. The Institute of Chemistry Ceylon welcomes donations to this fund from members, students and well wishers.

I.Chem. C Benevolent Fund - Benefits

Beneficiaries comprise Institute Members who have paid membership fees for Life as well as Graduateship Course Lecturers/ Teaching Assistants, who contribute regularly towards the Fund.

Benefits are given below:

1. Death Donation of Rs 15,000 to next of kin for funeral expenses **or** Rs 10,000 donation after reaching 75 years, at the specific request of the member
2. Medical Expense for critical illness / accidents involving heavy expenditure (Max-Rs 25,000)
3. Contribution toward 50% of international travel expense of young Chemists attending Conferences abroad (Max-Rs 25,000)
4. Such other benefits as may be determined by the Council from time to time

At 80, the most enduring chemistry educator calls it a day

Veranja Karunaratne, FRSC

Department of Chemistry, University of Peradeniya & Sri Lanka Institute for Nanotechnology



Professor G P Wannigama

Almost unknown to the outside world, Professor Gladwin Percy Wannigama, who had completed 57 years as a University teacher in Chemistry in 2009, hung up his gloves and moved into retirement. This might look like a sudden and rash act to the untrained eye, but in all probability it was many years in the making, for everything Professor Wannigama ever does is meticulously planned. In a world where genuine commitment to one's chosen profession is hard to find, accolades for a job well done being rare and sporadic, Professor Wannigama's amazing achievement is a benchmark which many a good teacher would dream to reach. To celebrate his longevity as a teacher par excellence, there is no better way than to chronicle snippets of his life, so that the younger generation of Sri Lankan chemists could borrow a page or two from his life immersed totally in teaching and research.

Professor Wannigama was born in 1929 when his father was working in the Government Clerical Service at Hambantota. After two short spells in schools at Matara and Baddegama, he continued his studies at Holy Cross College, Kalutara. There, he spent seven years, until entry to Royal College on a Governor's Scholarship. He took up the University Entrance Examination in 1946 with Chemistry, Physics and Mathematics as subjects and entered the University of Ceylon in 1947, just one year prior to independence.

Charitha de Silva and R.O.B. Wijesekera, who had been among his closest friends at Royal College, were his batch mates when following the Special Degree Course in Chemistry from 1948 to 1951. They were both well known as excellent raconteurs and were capable of spinning yarns with not a single betraying smile. Among Professor Wannigama's other colleagues in the Chemistry Special batch were Sirisoma de Silva, H. R. Kanagarajah, N. Battirunathan and Mailoo Jeyaratnam. Sirisoma preached that flasks for chemical reactions should be scrupulously cleaned both on the outside as well on the inside. In a lazy and naughty mood he would say that in conducting chemical preparations with liquids, when in doubt, the specific gravity of the liquid should be taken as one. Kanagarajah was an inveterate smoker, often sharing his Peacock cigarette (Peak) with his friends. Battirunathan had the ability to douse fires with a single gust of wind from his lungs. Mailoo could write fast and

was a boon to the entire batch when dealing with 'fast' lecturers.

When the final results came Professor Wannigama was the batch top with a First Class and upon graduation he was hired to the permanent staff at the Colombo University. He proceeded to the University of Cambridge in 1952, matriculating at Christ's College. The whole period of three years was spent in the Pembroke Street laboratory, under the watchful eyes of Sir Alexander Todd who paid regular visits to all researchers in the laboratories, not merely to those under his immediate supervision.

All three years at Cambridge were spent on synthetic work; the first year, under the immediate supervision of Dr. B. Lythgoe was on acetylenic compounds; the second and third years were in the field of alkaloids, under the supervision of Dr. J. Harley-Mason.

Professor Wannigama's three years at Cambridge, 1952-1955, witnessed many breakthroughs in the fields of Organic Chemistry and Biochemistry such as the determination of the structures of the nucleic acids and their roles in natural systems, and the structures of Vitamin B12 and insulin. He enjoyed the privilege of attending talks given by persons who had worked on such projects and attended celebrations of victories of science such as the one in the laboratory when a carboxylic acid degradation product of Vitamin B12, obtained by Jack Cannon had crystallised during the Christmas vacation. X-ray analysis of this product by Hodgkin at Oxford led to the structure of the vitamin.

Professor Wannigama resided at Christ's College for one year and then in approved lodgings for the remaining two years. The enduring friendships struck up at Cambridge have continued all these years.

During his three years in England, young Wannigama (the eligible bachelor) joined the Youth Hostels' Association and used his holidays to see interesting parts of the United Kingdom and a few countries of Europe. With a borrowed rucksack on his back, sometimes hitch hiking and braving the rough life in Hostels, he journeyed to picturesque places from Cork in Eire to Venice, Kiruna in the Swedish Arctic (in summer!) to Rome. Although funds were hard to come by, he rarely came to grief. At the end of a particularly difficult day in Northern England, he had to use the shelter of a public telephone box to keep put out the April weather.

On his return to the Department of Chemistry in Colombo in 1955, he was steeped in the day to day run of lectures and practical work. Moreover, he was persuaded into accepting honorary posts, such as Secretary of the University Teachers' Association of Colombo and Secretary of the Chemical Society.

The home front was full of ups and downs for him during the late fifties. With two sisters still at school money was not in abundance at home. In 1956, Professor

Wannigama married Nandawali Hemalatha Paranagama from Kalutara. The period following his marriage was beset with many problems. However, interest in continuing research and the birth of their daughter Tilani Premila made all of them happy.

During his days at the University of Colombo he had talks with Drs. Bibile, Kottegoda, Abeywickrema, Dassanayake and a few others who foresaw a future in natural products research. He began by reading on the subject. Two books, one by Professor Chandrasena and the other by Kirtikar and Basu specially engaged his attention. The second book, which listed plant families in alphabetical order, led him to the Apocynaceae and he chose the plant, *Holarrhena mitis* in that family, endemic to Sri Lanka, as his first plant for study.

Professor Wannigama spent his first sabbatical year in Norman, Oklahoma, working not on this plant but on a problem chosen by his sponsoring University in the USA. Due to financial problems, he had to travel with his wife and daughter in a freighter, embarking from the port of Galle, disembarking at Staten Island, New York and travelling by train through Chicago to Norman.

After his return to Sri Lanka from sabbatical leave, he faced an even greater load of work, due to the opening of a Faculty of Science at Peradeniya, coupled with the requirement of gaining proficiency in the Swabasha. He was transferred to Peradeniya in 1966, after Vajit Nandaka, his son was born, and conducted part of his quota of lectures in Sinhalese. While teaching organic chemistry in Sinhala he wrote the "Kabanika Rasayanaya" for the G.C.E. (AL) students. It immediately became a great success. It is hardly an exaggeration to say that all who have done AL Chemistry have been nurtured by its remarkable clarity. It continues to be a hit even today.

Whether his transfer to Peradeniya, one year ahead of Professor Sultanbawa taking his sabbatical leave, was completely his own making or not, I have no doubt looking back at his 44 years at Peradeniya he would have no regrets that fate brought him to the new University. During the 1966/67 Professor Wannigama was Head of the Department. History would record that he did his utmost to keep young Assistant Lecturer J. N. O. Fernando in Peradeniya during this year, but again as fate would have it he was adamant that he wanted to be in the capital city, perhaps harbouring early visions of what he was going to achieve in Colombo. In 1967, Professor Sultanbawa, upon his return from his sabbatical leave, initiated a programme of research on Sri Lankan plants, which marked a new era in natural products research in Sri Lanka.

Chemists in France and elsewhere were striving, in the sixties, to find economically viable routes for the synthesis of medicinally active steroids from steroidal alkaloids (aminosteroids), the process consisting of replacement of functionalised nitrogen in the alkaloid by functionalised oxygen. Studies on African species of *Holarrhena* were promising and led French chemists to commence the investigation of Sri Lankan *Holarrhena*. This led to Professor Wannigama's success in obtaining funds from the French Government and French Industry (Roussel-Uclaf) to spend a sabbatical

year (1970). This was undoubtedly a very productive year in his research.

On his return from France, he joined the research group of Professor Sultanbawa on plant natural products and made several contributions to the project. Several other permanent staff had then joined the group after their PhDs. The research atmosphere in the Department was truly invigorating and they made good progress thanks to a grant from the United States Department of Agriculture. Later, Professor Sultanbawa's research team comprising of Professors Wannigama, Leslie Gunatilaka, Savitri and Vijaya Kumar, Sotheeswaran, including Balasubramaniam from the Department of Botany, were honored as joint winners of the President's award for research.

Eight years after his first year in France, using his contacts with French chemists, Professor Wannigama obtained a grant from the French Government to work in the laboratory of Ourisson at Strasbourg for the first six months of his third sabbatical period (1978/1979). He was back in synthesis, this time on a product of diagenesis of a sediment from the Rhine valley. The remainder of his sabbatical period was spent in Australia, where he worked on a study of the diagenesis of the constituents of the leaves of a mangrove from Southern Victoria.

Back at Peradeniya, Professor Wannigama was elected Head of the Department in 1980 after the resignation of Professor Sultanbawa. Relieved of that responsibility in 1984, he had time to be involved in the UNESCO sponsored South and Central Asian Medicinal and Aromatic Plants (SCAMAP) Network. Professor Wannigama became the country representative, Secretary and then the Chairman of the Network. He was thus able to continue with his research and had the opportunity of interacting with natural products chemists from the whole region. On a personal note, it was during this period that I returned to Peradeniya after my Ph.D. I still remember vividly, Professor Wannigama, standing on the corridor outside the General Degree Laboratory, updating me of the news of the Department during my absence. He told me sternly, "I am an old man who will leave the Department within a few years, but people like you must take ownership of this place." Little did I know at that time that he would guide and work with us for the next twenty five years. My Ph.D. training was in Synthetic Organic Chemistry. Professor Wannigama, however, invited me to join the Natural Products group and in the ensuing years we jointly published several papers.

His next sabbatical period was of six months' duration and was once again in France, where he worked on the isolation and identification of the quaternary alkaloids of a South American plant. His final period of sabbatical leave was also of six month's duration. He took up the analysis of the products of diagenesis of an Antarctic sediment, the project involving the "latest" technology.

Professor Wannigama brought back the 'hands on' experiences to the Department during all his periods of sabbatical leave. In his whole period of service to the University, both in Colombo and Peradeniya, the work which he enjoyed most was attending to the students'

problems in the practical classes, including research.

His wife passed on in 2003. I have no doubt that he remembers with gratitude how well she looked after both their children, and gave him all the time and encouragement necessary to proceed with his academic work. Both his children are now domiciled in Australia.

When I became the Head of the Department in May 2005, I felt honored more because I was taking his advice twenty years after it was given. During the first week in office, I phoned Professor Wannigama to inform him that I was going to nominate him for a D.Sc. When he finally spoke I was struck by a sense of awe I had not felt for a long time. The tone in his voice was resonant of the high mountain of stature he had climbed up to: I had a vivid feeling that he was beyond all accolades but was more than willing to make a junior colleague feel pleasantly humbled by accepting the honour.

Students will describe Professor Wannigama as a great teacher because he was always looking for the good in the student and loved chemistry. His sound academic judgment of students and their work was among the best I have seen. Giving new meaning to the word integrity, he would rarely pass judgment on issues, but when he did we knew that we could trust

them and that he would stand by his words for eternity. Ever the meticulous planner he believed that a teacher should never cancel a lecture at the last moment. Many a young staff member in our Department, ignorant of this great quality of Professor Wannigama, have been shocked and surprised when they wanted to exchange lectures with him without giving at least one week's notice. Year after year he religiously repeated his courses which produced a rich harvest of new students every time. Thus, he showed the world the profound power of persevering unyieldingly regardless of how many times a course is taught. At 80 years of age, he may have brought to a close his lectures for good, but his presence and his voice will echo down the halls of the Department for many years to come. Finally, in saluting the work of this great teacher may I wish that he continues learning every day in his retirement, the way he had all his working life.

Author wishes to thank Professor Wannigama for endless exchange of emails during the preparation of this manuscript. Professors J.N.O. Fernando, Vijaya Kumar, Savitri Kumar, Ratnayake Bandara, S. Sotheeswaran, Anura Wickramasinghe & Dr. Nedra Karunaratne are thanked for valuable input.

Graduateship Examinations in Chemistry, 2009

LEVEL 1 – AWARDS LIST

First prize and Charles Jayaweera Memorial (Open) Scholarship	Ms. H C Weeraratna
Second prize and Nandawathie Jayaweera Memorial (Open) Scholarship	Ms. S S Egalahewa
Third Prize and Prof. R S Ramakrishna Scholarship	Mr. R D Senavirathna

MERIT BURSARIES (in order of merit)

Ms. M Y Abeywardana, Ms. L P Egodawatta, Mr. A S Ghouse and Mr. S D Gunasinghe

Second Nandawathie Jayaweera (Southern Province) Scholarship	Ms. H C Weeraratna
Second Charles Jayaweera (Southern Province) Scholarship	Ms. M Y Abeywardana

SUBJECT PRIZES

Graduate Chemist Alumni prize for General & Inorganic Chemistry	Mr. A K Abeysinghe
Emerine Fernando Memorial prize for Principles of Physical Chemistry	Ms. H C Weeraratna
Bennet prize for Mathematics for Chemists	Mr. K A V S Siriwardena
Somawathi Mathew Memorial prize for Biology for Chemists	Ms. M C D Cooray
Prof & Mrs S Sotheeswaran Prize for Principles of Organic Chemistry	Ms. M N T Dayarathne
Mr & Mrs J M Ranasinghe Banda for Application of Mathematics in Chemistry	Ms. H C Weeraratna
Henry Ashmore Pieris Memorial Prize for Management, Economics & Finance	Mr. P U A I Fernando

Concessions for Life Members :

The following clinics/Laboratories will provide concessions for Laboratory test Reports and OPD Examinations:-

- Medisense Laboratory, Malay Street, Colombo 2
- Ohlums clinic and Laboratories, 288, Galle Road, Colombo 4
- Medispot, Jayantha Weerasekera Mw., Colombo 10
- Asiri Surgical Hospitals, Kirimandala Mawatha, Colombo 5 for OPD Medical Test Reports, ECG and Xrays

This facility is currently confined only to Life members & their spouse, and children below 18 years. Members are requested to become Life Members and enjoy these concessions which provides a 10% discount on the normal clinic/hospital charges. Life Members also become automatically entitled to our Institute's Benevolent Fund benefits.

Eternal Quest to Learn From Nature It is now nanotechnology

A. Nadeesh Madusanka and Nilwala Kottegoda
Sri Lanka Institute of Nanotechnology

Observing nature led to new findings in history

There is a rich and long history of gaining inspiration from nature for the design of practical materials and systems. Traditionally, biomimeticists, inspired by biological structures and their functions, focused on copying, imitating or duplicating bio-systems using mostly synthetic components and following traditional approaches. Early humans learned hunting, shelter and survival techniques by observing animals as they interacted with their surroundings. While humans lacked the fierce claws and superior hunting instinct of bears, people could mimic their techniques. As humans began to design more complicated contraptions, they continued to look to nature's examples. For example, Leonardo da Vinci's 15th-century sketches of flying machines inspired the Wright brothers' to invent first successful prototype four centuries later, therefore, dreams of human flight centered on observing birds.

The date was 17th Dec 1903; Time: 10. 30 a.m.; Place: Kitty Hawk, North Carolina; The first airplane rose for a few seconds to make the first powered, heavier-than-air, controlled flight in history. Orville Wright piloted the historic flight while his brother, Wilbur, observed.



Fig: Human attempts to create effective flying machines often involved studying flight of birds.

Ref: Fabrice Coffrini/AFP/[Getty Images](#)

Nanotechnology today

Nanotechnology has become a big buzz word in the world of science today. It is going to impact just about everything in our day today life. If you ask the general public the question "what nanotechnology is"? For many scientists, it is nothing new; after all chemists have been working at the nanoscale or even below for decades, through manipulating nature's tool box of atoms and molecules. For most other groups, however, nanotechnology means something far more ambitious, miniature submarines in the bloodstream, little cogs and gears made out of atoms, space elevators made of nanotubes, and the colonization of space. It is no wonder people often muddle up nanotechnology with science fiction.

A nanometer (nm) is one-billionth of a meter, smaller than the wavelength of visible light and a hundred-thousandth the width of a human hair. In other words a nanometre is defined as the size of 10 hydrogen, or 5 silicon atoms in a line is within the power of the human mind to grasp.

"One nanometer is in fact a magical point on the dimensional scale. Nanostructures are at the confluence of the smallest of human made devices and the largest of the living things".

Mike Roco 2001

In the history of the present world, industrial revolution which ignited in 1780 accelerated across the world with five different types of revolutionary industrial waves up to date. The latest revolutionary wave sweeping the whole world is the nanotechnology, which is the nano scale assembly of building blocks in very small scale that is in the order of less than 100 nm. It is already well-known that matter made of nano-sized particles or in nano-thin films, can look and behave quite differently from the corresponding bulk material. One crucial difference is their large surface-area to volume ratio – which leads to significantly increased chemical reactivity.

The exciting and challenging aspects of the nanoscale is the role that quantum mechanics plays in it. The rules of quantum mechanics are very different from classical physics, which means that the behavior of substances at the nanoscale can sometimes contradict common sense by behaving erratically. You can't walk up to a wall and immediately teleport to the other side of it, but at the nanoscale an electron can -- it's called electron tunneling. Substances that are insulators, meaning they can't carry an electric charge, in bulk form might become semiconductors when reduced to the nanoscale. The beauty of nanoscience is that most of the laws and concepts related to your day today life are no longer valid at nanoscale and you have to reinvent the wheel from square one for the new scale.

However, nanotechnology is expected to re shape the world in a fundamental way, in other words as stated by the famous scientist Richard Smalley "shaping the world atom by atom". But do you think that big buzz on nano is new! NO, it is nothing new to our closest relative, mother nature although mankind realized it very recently.

Nanotechnology has been intricately linked with biological systems since its inception by Richard Feynman in his famous 1959 speech, "There's Plenty of Room at the Bottom." In reference to the complexity and smallness of the cell, Feynman challenged the scientific community to "make anything very small which does what we want". In 1981, Eric Drexler's landmark paper was for the first time ever in the history, published on molecular engineering and manipulation on the atomic scale. Drexler focused on protein synthesis as a pathway

for creating nanoscale devices. It comes as no surprise that cellular mechanisms are often cited as proof to the viability of nanotechnology devices with atomic precision. However until 1981 nano scale manipulation through bottom up approach was a conceptual science and the trend for it to become a real science was created by advancements in microscopy as illustrated through Don Eigler's revolutionary "stunt" at IBM. Here, he manipulated individual Xenon atoms on a Nickel surface to form the letters "IBM."

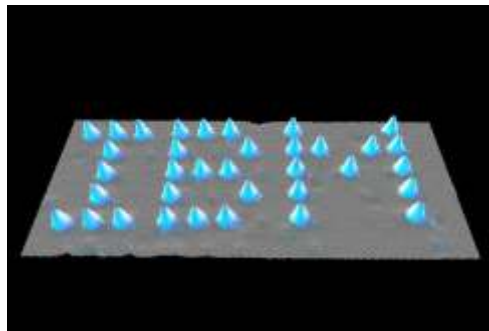


Fig: Man artificially assembles atoms for the first time in the history

"Nature has given us the tools... to play with the ultimate toy box of nature – atoms and molecules. Everything is made from it... The possibilities to create new things appear limitless." - Nobel Laureate Horst Stormer

As mentioned before, nanotechnology, like any other branch of science, is primarily concerned with understanding how nature works. However, copying nature may not be the most effective approach to modern nanotechnology. But nature and its trade secrets of manufacturing may be used as inspiration for modern discoveries. The major trade secrets of nature are life friendly manufacturing, ordered hierarchy, self assembly and templating of crystals.

If you look at history, in the early era, the materials used for manufacturing were solely supplied by the nature, e.g. wood, silk, and sand, clay. We are now at the brink of a materials revolution that will be on the par with the Iron Age and the industrial revolution. We are leaping forward into a new era of materials. With the recent developments of molecular and nanoscale engineering in physical sciences, and advances in molecular biology, biomimetics is now entering the molecular scale manufacturing. By combining nature's molecular tools with synthetic nanoscale constructions, molecular biomimetics is emerging as a hybrid technology.

The greatest advantage of biomimetic approach is that nature has already proven that it is possible to generate complex machines using nanotechnology. There is an existing framework of working components manufactured by nature that can be used as a guide to develop our own nanodevices. In biomimetic nanotechnology structures are manufactured in the way that animals and plants do, use sun light and simple compounds to produce complex structures and other materials such as fibers, ceramics and plastics. Nature can provide the models for solar cells copied from leaves, models for computers to store and read programs

similar to DNA and RNA, steely fibers woven from spider silk, shatter proof glass drawn from mother-of-pearl, cancer cures compliments from chimpanzzies, computers that signal like cells.

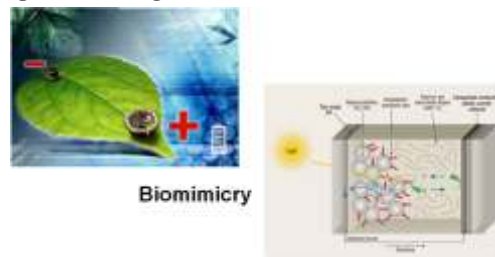


Fig: Future solar cells copied from leaves

On the other hand nature has the ability to design highly energy efficient systems that operate precisely without waste, fix only that which needs fixing, do only that which needs doing, and no more. Although currently we are not able to create these wonderful structures, one day our understanding of nanoscale phenomena may allow us to replicate at least part of what nature accomplishes with ease.



Fig. Surface of the Lotus leaf

Currently most of the high-tec materials are synthesized under high temperature, pressure and strong chemical environments. Though these artificial approaches are currently successful they do not have long term sustainability since according to the first principles of thermodynamics all the processes occur in order to minimize energy. As demonstrated by the nature, all complex natural molecules are synthesized under eco-friendly route where reactions are carried out in water, room temperature, atmospheric pressure with the aid of mild chemicals.

For example, spider silk, is five times stronger than steel, mussel adhesive functions under water and stick to any thing, Rhino horns though made from dead cells, are repairable, bone, wood, muscles, skin, all miracle materials. On the other hand, nature uses all its resources, particularly energy, in a very effective way and all the creations of nature are recyclable.

In addition, nature has assigned multifunctions to its materials and structures. For example human cells and bones are multi-functional and they control most of the body processes. The use of materials that perform multifunctions has allowed the nature to create creatures with lower body weight. The concepts of multi functional materials and structures have become the model for current nanocomposites. Currently scientist work on imitating the bone composition for artificial bones, tooth fillings, skin functions for artificial skins, with the aid of nanotechnology.

Another example for biomimicry is the spider web. Have you observed that the spider generates a very strong fiber at room temperature and pressure? The fibers generated by the spider are in different shapes and lengths and the other interesting feature is that spider web is a sticky material to catch its prey but the spider can move on it freely without sticking. The silk that is produced by the spider is far superior in its elasticity and toughness to Kevlar which one of the commonly used synthetic material in aircraft industry and manufacturing bullet proof costumes. Also, spider silk is much stronger than steel, where tensile strength of the two materials is 1154 MPa and 400 MPa respectively. Recent advances in nanotechnology also reveal the need for making elastic light weight fibers with superior strength.



Fig: Spider silk for aerospace applications

Self assembly or the derivation of higher order structures from lower order elements is the basis of the structure for most of the biological systems. This fabrication method also known as bottom up approach allows to create massive three dimensional structures with nanoscale precision. This approach is the key to most of current research advances in nanoscience. For example, the scientists have now succeeded in manufacturing micro-mechanical systems (MEMs) based repairable artificial cells by self assembling silicon circuits.

In nature, the viability of biological systems is sustained via specific interactions among the tens of thousands of proteins, the major building blocks of organisms from the simplest single-celled to the most complex multicellular species. Biomolecule-material interaction is accomplished with molecular specificity and efficiency leading to the formation of controlled structures and functions at all scales of dimensional hierarchy. Through evolution, Mother Nature developed molecular recognition by successive cycles of mutation and selection. Molecular specificity of probe-target interactions, e.g., ligand-receptor, antigen-antibody, is always based on specific peptide molecular recognition. This concept has become the key to most of the researches in nanotechnology based medical applications.

Modern day computers are machines that represent, store and manipulate information for us. The major focus of the fourth and the fifth industrial revolutions are basically focused on manufacturing

more and more advanced multi tasking artificial thinking machines through miniaturization which has come to a limit. Nanotechnology currently focuses on manufacture of superfast multi tasking computers. Mother Nature has created the best model computer for the man-kind and the engineers now have digital silicon computers which use zeros and ones. Nature equivalent of thinking machine has been wandering through the landscaping of computing for more than 3.8 billion years. The human being has not understood the nature's computing style yet. In the computers gifted by the nature, problem solving and data processing occur at a colossal scale. Out of the several tasks within the human life, embryonic cells convert to liver cells, liver cells release sugar, nerve cells command the muscle cells to be still or to fire, neurons weigh incoming signals and send the message 'buy low sell high'. "For a technology to succeed, reality must take precedence over public relations, for Nature cannot be fooled."- Richard Feynman

Although biomimetic nanotechnology is in its infancy, with no applications yet reaching commercialization, the barriers in some cases lie mainly in scaling up production processes to industrial levels.

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Artificial Receptors for Anion Binding

Dr. Chayanika Padumadasa

Department of Chemistry, University of Sri Jayewardenepura

Introduction

Supramolecular chemistry has been defined as 'chemistry beyond the molecule'. It involves the synthesis and study of molecular systems in which the components are held together reversibly by non-covalent intermolecular forces.¹ This is in contrast to traditional synthesis in which covalent bonds are used to synthesise molecules.

Supramolecular chemistry is a multidisciplinary field covering the chemical, physical and biological features of components held together and organised by non-covalent interactions. The importance of this field was recognised in 1987 with the award of the Nobel Prize in Chemistry to Donald J. Cram, Jean-Marie Lehn and Charles J. Pedersen, for their pioneering studies in cation binding.²⁻⁴

Supramolecular chemistry is often divided into host-guest chemistry and self-assembly (**figure 1**).

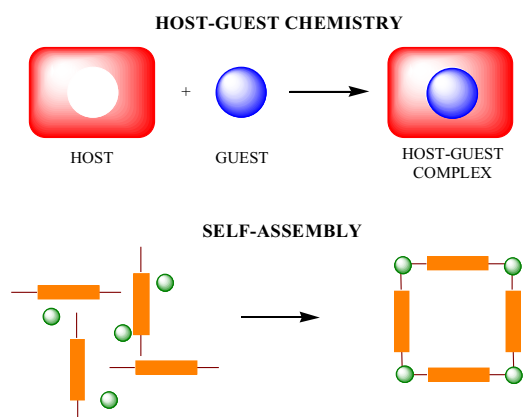


Figure 1 Concepts of host-guest chemistry and self-assembly.

In host-guest chemistry, the host spatially accommodates the guest (cationic, anionic or neutral) within a binding domain, the nature of which determines the strength and selectivity of guest complexation.⁵ Self-assembly refers to the reversible assembly of molecular building blocks into supramolecular architectures commonly with the help of a templating agent.⁶ Both of these fields rely on reversible non-covalent intermolecular forces to construct the supermolecules.⁶ These include; electrostatic interactions, hydrogen bonding, π -stacking interactions, van der Waals forces and hydrophobic interactions. Although these interactions are individually much weaker than covalent bonds, collectively, they can be remarkably strong.

As mentioned above, host-guest chemistry covers a broad area of interests such as anion, cation and neutral guest binding. The theme of this article is concerned with anion binding and a brief review of this field will be discussed in the following section.

Anion Binding

Biological Anion Receptors

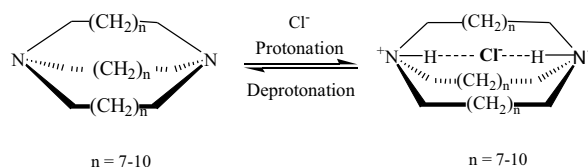
Nature has provided us with many examples of anion receptors which include the sulphate and phosphate binding proteins, chloride cross-membrane transport channels and enzymes such as DNA helicase RepA which binds SO_4^{2-} anions. These receptors operate through a combination of hydrogen bonding and electrostatic interactions.⁷

Artificial Anion Receptors

A wide variety of artificial anion receptors have been reported to date and they can be classified into three main classes depending on the type of non-covalent interaction(s) that is being used to mediate the anion recognition event.

(1) Positively Charged Anion Receptors

The most obvious way of binding an anion is to use a positively charged receptor that would bind the anion via strong electrostatic interactions. Simmons and Park exploited this phenomenon to synthesise a series of polyammonium cryptands in the late 1960s which were the first artificial anion receptors to be synthesised.⁸⁻¹⁰ These receptors upon protonation of the bridgehead nitrogen atoms bind halide ions in aqueous medium within their macrobicyclic cavity using electrostatic interactions and hydrogen bonding (**scheme 1**).



Scheme 1 Park and Simmons polyammonium cryptands for chloride binding.

Inspired by this pioneering work, Lehn and co-workers have developed a range of nitrogen and oxygen containing macrocyclic, macrobicyclic receptors. They have also synthesised a highly preorganised macrotricyclic receptor (**figure 2**).¹¹⁻¹³ This receptor, when neutral binds metal cations and an ammonium ion, while in its diprotonated state binds neutral molecules such as H_2O , and upon tetraprotonation binds anions such as Cl^- .

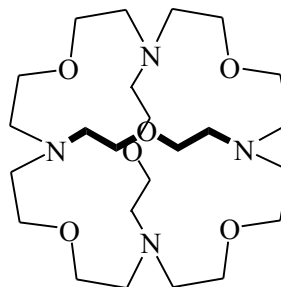


Figure 2 Lehn's macrotricyclic receptor.

Guanidinium-based receptors have also been used for anion recognition. This is because the guanidinium ion with a pK_a of 13.5 remains protonated over a wide pH range. Anslyn and co-workers constructed a receptor (**figure 3**) which contains three guanidinium moieties that selectively binds citrate in water ($K = 6.910^3 M^{-1}$). This receptor was also able to complex citrate from beverages.¹⁴

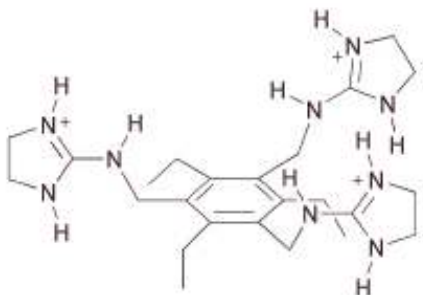


Figure 3 Anslyn's guanidinium-based receptor.

In more recent years, the imidazolium moiety has been shown to be an effective motif for complexing anions through electrostatic interactions and hydrogen bonding. The tetrakis-imidazolium macrocycle (**figure 4**) produced by Kim *et al.* exhibited strong binding of F^- in a 1:1 stoichiometry in $DMSO-d_6$ ($K = 2.8910^4 M^{-1}$).¹⁵

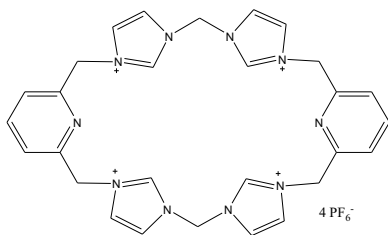


Figure 4 Kim's tetrakis-imidazolium macrocycle.

Positively charged metal-containing receptors have also been used for anion binding. One such example is shown in **figure 5**, where a coordinated platinum(II) metal centre and urea hydrogen bond donors are arranged in close proximity to provide an anion binding cleft. This has shown to bind SO_4^{2-} and HPO_4^{2-} with $K > 10^5$ in $DMSO$.¹⁶

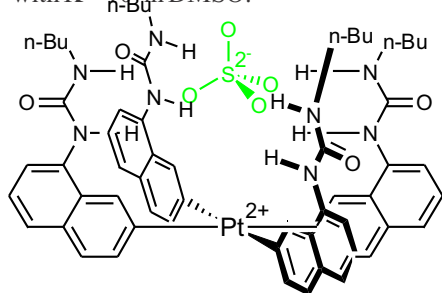


Figure 5 An anion binding metal-containing receptor.

(2) Neutral Anion Receptors

In contrast to positively charged anion receptors, neutral anion receptors bind anions in a wide range of organic solvents via hydrogen bonding interactions.

decades leading to a plethora of neutral receptors containing a variety of functional groups such as amides, thioamides, ureas, thioureas and pyrroles.⁶

Crabtree has demonstrated that simple acyclic isophthalamide derivatives such as the receptor shown in **figure 6** binds Cl^- strongly in CD_2Cl_2 ($K = 6.1 \times 10^4 M^{-1}$) due to a complementary size match with the binding cavity.^{17,18}

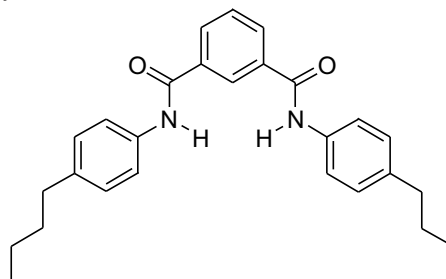
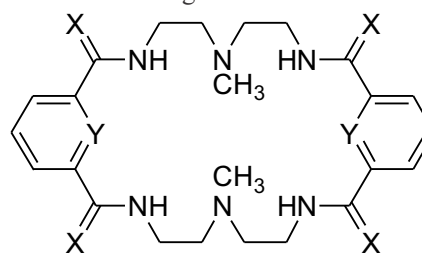


Figure 6 Crabtree's amide based anion receptor.

Bowman-James *et al.* have synthesised a variety of amide and thioamide based macrocyclic anion receptors (**figure 7**) that exhibit higher affinities for oxoanions such as $H_2PO_4^-$ and HSO_4^- in $DMSO-d_6$. The thioamide systems, however, were superior in binding the two oxoanions which maybe linked to the acid-base properties of both the ligand and anion.¹⁹



$X = O \text{ or } S$

$Y = CH \text{ or } N$

Figure 7 Bowman-James' amide and thioamide macrocycles.

The urea moiety, which contains two potential hydrogen bond donor groups, has been interestingly exploited in the construction of many different anion receptors. Valiyaveetil and co-workers synthesised the tris-urea receptors (**figure 8**) with differing tripodal scaffolds which exhibited binding affinities for carboxylate anions in 1:1 stoichiometry in $DMSO-d_6$.²⁰

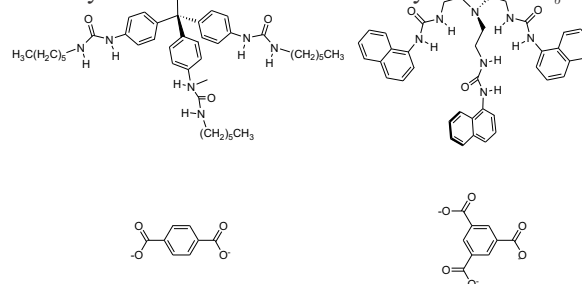


Figure 8 Tris-urea receptors selective for the aromatic

Although the calixpyrroles have been known for a very long time, it was only in the 1990s that Sessler and co-workers first reported their use as neutral receptors for anions. They have synthesised a range of receptors based on the calix[4]pyrrole framework that are effective and selective anion binding agents due to the convergent array of pyrrole N-H moieties. The parent receptor (**figure 9**), selectively binds F^- over other anions in CD_2Cl_2 due to its small and rigid binding cavity.²¹ The receptor based on the calix[6]pyrrole framework (**figure 9**), however, has a preference for I^- in $CDCl_3:CD_3CN$ (9:1, v/v) as a result of the much larger binding cavity.²²

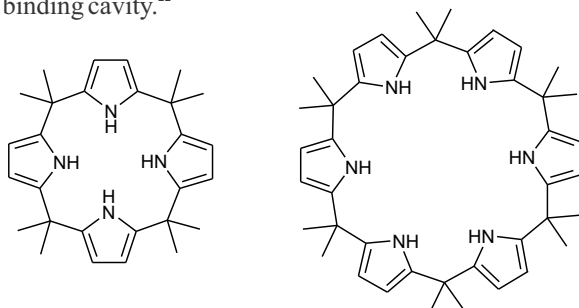


Figure 9 Calix[n]pyrrole based receptors.

Recently, Jeong and co-workers reported the preorganised, conjugated indolocarbazole macrocycle (**figure 10**) with an internal cavity surrounded by four indole N-H hydrogen atoms. This receptor displayed a strong selectivity for F^- in CD_3CN due to the size complementarities of the guest and the internal cavity.²³

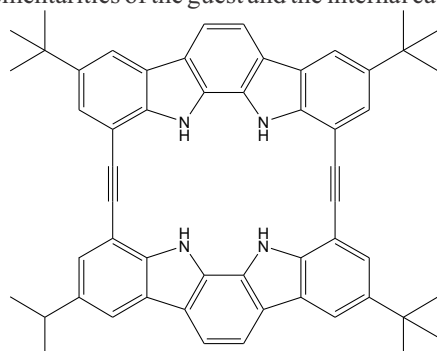


Figure 10 Jeong's indolocarbazole macrocycle.

(3) Lewis Acid Receptors

Electron-deficient Lewis acidic receptors are able to bind anions by an orbital overlap that causes a non-covalent bonding interaction. This phenomenon led to the production of many chelating and macrocyclic neutral receptors containing boron, silicon, germanium, tin and mercury atoms for anion binding and several examples are given in this section.⁶

One of the first examples was the boron containing receptor (**figure 11**) reported by Katz in 1985. This is capable of abstracting H from many hydride sources in THF by virtue of its chelating ability.²⁴

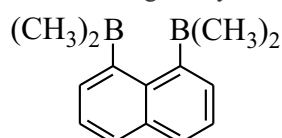


Figure 11 The boron receptor.

Hawthorne *et al.* synthesised a class of carborane-based mercury-containing macrocycles and receptor shown in **figure 12** is one such example.²⁵ This is related to the well known [12]crown-4 macrocycle and is therefore named [12]mercuracarborand-4.

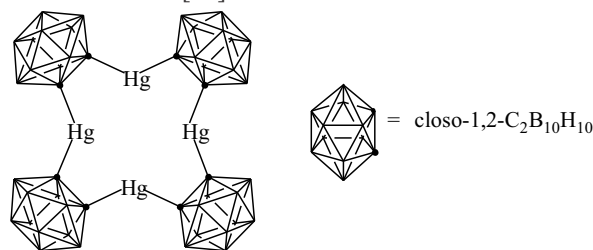


Figure 12 Carborane-based mercury-containing macrocycle.

Crystallography showed that the Cl^- anion binds in the plane of the four mercury atoms, interacting equally with all four mercury centres. The I^- anion, however, is too large to fit into the cavity and therefore, a 1:2 complex is formed between the receptor and I^- , one located above and one below the tetramer plane of the four mercury atoms.

Mercury based receptors have been synthesised by Shur and co-workers.²⁶ The receptor given in **figure 13** binds halide anions via mercury-halide bonds and the crystal structures show polydecker sandwiches where each halide anion is coordinated with six mercury atoms from two neighbouring receptor molecules. However, with equimolar amounts of SCN^- , an infinite helical structure is obtained with alternating receptor molecules and SCN^- anions where each anion is bonded to two neighbouring molecules of **receptor** through the sulphur atom.

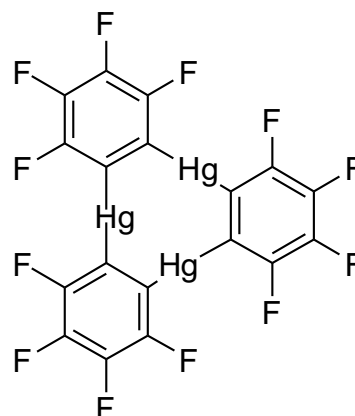


Figure 13 Shur's trimeric perfluoro-o-phenylenemercury macrocycle.

Conclusion

Anions are ubiquitous in nature. They play essential roles in numerous natural and man-made processes. Therefore, their strong and selective recognition is an area of intense current interest. Already, a wide variety of anion receptors have been synthesised by supramolecular chemists to yield strong and sometimes selective recognition of anions. In recent years, a considerable amount of attention has been focused on the development of anion sensors due to their potential

medical and environmental applications and hopefully this will be the future of anion binding.

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Graduateship Examinations in Chemistry, 2009

Level 2 Award List

First Prize & W F Pieris Memorial Trust Scholarship

Second Prize & Professor W Pearlyn D Pereira Scholarship

Third Prize & Professor G C N Jayasuriya Scholarship

Fourth Prize & Family Leelarathna Scholarship

Level 2 A (2009)

Ms. U D Hewagamage

Ms. P A M K Erangi

Mr. R M J S Hunukumbura

Mr. U L A S Perera

Level 2B (2008/9)

Ms. G Mayooringi

Mr. K A D S Ravinatha

Ms. G D S Dassanayake

Ms. T G Vithanage

Subject Prizes for Best Performances

Yogarani & Family Prize for Analytical & Instrumentation Analysis

Mr. U D Hewagamage

Ms.

G D S Dassanayake

Prize for Biochemistry I

Ms. B G N D K Somatilaka

Ms. F N Jamal

Rex Jayasinghe Memorial Prize for Electronics & Instrumentation

Ms. P A M K Erangi

Ms. F N Jamal

Prof. J N Oleap Fernando Prize for Physical Chemistry

Ms. U D Hewagamage

Ms.

G D S Dassanayake

Merit Bursaries (in order of merit)

Level 2 B

Ms. M R M Perera, Ms. F N Jama, Ms. D C Wimalasiri, Mr. R J M K Jayasundara, Ms. M A Wickramasinghe, Mr. J H S C Tissera

Level 2 A

Ms. K A De Silva, Ms. B G N D K Somathilaka & Ms. J M H R S Peiris, Ms. T D Abeyasuriya, Ms. P M D Amarawardena & Mr. D C Senevirathna

Analysis of Atmospheric Aerosol

Sameera Ranmal Gunatilake, Graduate Chemist (2007)
Ph.D. Student, Mississippi State University, USA

1. INTRODUCTION

Aerosols are solid or liquid particles suspended in a gaseous medium. Aerosols which are suspended in the atmosphere are called atmospheric aerosols. Formation of aerosols can occur by quite a few mechanisms such as chemical reactions of gasses which generate low pressure vapors followed by single or multi-component nucleation or condensation onto surfaces of existing particles of those low vapor pressure products, reactions of gasses at surfaces of pre existing particles and reactions which take place within particles.

1.1 Size and Chemical Composition

The diameters of these particles range from few nanometers to few hundred micrometers. Sampled aerosol particles are also called particulate matter (PM). PM₁₀ denotes all aerosol particles with an aerodynamic particle diameter $d \leq 10 \mu\text{m}$. In atmospheric research the term "fine air particulate matter" is usually restricted to particles with aerodynamic diameters PM₁ or PM_{2.5}. In air pollution control it sometimes also includes larger particles up to PM₁₀.

Chemical composition of aerosols can vary significantly. They can be composed of inorganic ions, organic compounds, black carbon, soil derived compounds, trace elements and water. There can be sulfate, nitrate, chloride, ammonium, sodium, calcium, potassium and magnesium ions present in these particles as inorganic ions. Soil-derived compounds are mainly oxides of silicon, aluminum, iron, calcium, potassium and magnesium.⁴ Composition of organic compounds in aerosols is very wide. There are hundreds of organic compounds have been detected in air particulate matter.¹⁻⁴ Following table discusses the organic compounds present in the atmospheric aerosols and their sources.

Table 1: Organic compounds present in the atmospheric aerosols and their sources.³ Taken from Poschl, 2005.

Substance	Sources
aliphatic hydrocarbons	biomass, fossil-fuel combustion
aliphatic alcohols and carbonyls	biomass, SOA/aging
levoglucosan	biomass burning
fatty acids and other alkanolic acids	biomass, SOA/aging
aliphatic dicarboxylic acids	SOA/aging
aromatic (poly-)carboxylic acids	SOA/aging, soil/dust
multifunctional aliphatic and aromatic compounds	SOA/aging, soil/dust
polycyclic aromatic hydrocarbons (PAHs)	fossil-fuel combustion, biomass burning
nitro- and oxy-PAHs	fossil-fuel combustion, biomass burning, SOA/aging
proteins and other amino compounds	biomass
cellulose and other carbohydrates	biomass
secondary organic oligomers and polymers	SOA/aging, soil/dust

1.2 Primary and Secondary Organic Aerosol components

Primary organic aerosols (POA) are directly emitted in the condensed phase as liquid or solid particles or as semi volatile vapors and they are condensable under atmospheric conditions whereas Secondary organic aerosols (SOA) are formed by chemical reaction and gas-to-particle conversion of volatile organic compounds in the atmosphere, which can happen through three major pathways; New particle formation, Gas-Particle partitioning and heterogeneous or multiphase reactions.

1.3 Natural and Anthropogenic Aerosols

Some of aerosols occur naturally while the other type of aerosols comes from human activities. Natural aerosols originate from volcanoes, dust storms, forest and grassland fires, living vegetation, and sea spray. Volcanic aerosols are created by major volcanic eruptions. They are found in the stratosphere (the second major layer of Earth's atmosphere, above the troposphere and below the mesosphere). The main volcanic aerosol layer is created by sulfur dioxide which is converted to droplets of sulfuric acid. Once formed, these aerosols stay in the stratosphere for about two years and also they spread to a large volume by wind. Desert dust originates from dust storms. Most of them start off from deserts of the Asian and African continents. Other types of natural aerosols are sulfate particles and biogenic particles. Sulfate aerosols are formed by the oxidation of Dimethyl sulphide (DMS) emitted by the sea surface and the oxidation of SO₂ emitted by volcanoes. Sources of biogenic aerosols are oxidation of monoterpenes emitted by trees and vegetation.

Human activities, such as the smoke from burning of fossil fuels and burning tropical forests, also generate aerosols and those are called anthropogenic aerosols. Anthropogenic sulfate aerosols are created by the burning of coal and oil. This human made sulfate aerosol in the atmosphere has grown rapidly since the start of the industrial revolution.

1.4 Effects of Atmospheric Aerosols

Atmospheric aerosols are of interest mainly because of their effects on health and climate. Health effects are mainly due to their adverse effects on the respiratory function, and some also act as irritants for the eyes. Small particles can enter deep into the lungs, reaching the alveoli. They also cause covalent modifications of key intercellular proteins and adjuvant effects in the immune system. Many epidemiological studies have shown a link between increased mortality or morbidity and increased PM₁₀ or PM_{2.5}. Through their acid composition, aerosol particles also contribute to acidification of ecosystems.

Climate effects of aerosols can be categorized as primary and secondary effects. They absorb and scatter light. Most aerosols reflect sunlight back into space. Therefore they tend to cause cooling of the Earth's surface immediately below them. This direct cooling effect by reducing the amount of solar radiation that reaches the surface is known as the primary effect on climate.

Moreover, atmospheric aerosols can contribute to climate change indirectly by changing the radiative properties and lifetime of clouds. They act as seeds to start the formation of cloud droplets. However as the concentration at aerosols increases within a cloud, the water in the cloud gets spread over more and more. Since these are smaller than frozen crystals or little drops of water in the cloud, they fall more slowly in the atmosphere and lower the amount of precipitation. Therefore the atmospheric aerosols have an effect on frequency of cloud occurrence, cloud thickness and rainfall amounts which is known as the secondary effect on climate. Short uncertain lifetime of aerosols cause their concentration to be highly variable in time and space. This is another important reason for the unexpected changes of the climate.

2. ANALYSIS OF ATMOSPHERIC AEROSOLS

Due to above discussed health and environmental effects, analysis of atmospheric aerosols has become a popular research area among analytical and environmental chemists. Field measurements, Laboratory experiments and modeling analysis are done to study the behavior and properties of atmospheric aerosols.

The goal of atmospheric studies is to quantitatively identify all species within individual particles rapidly to examine real time changes of particulate matter. This is really challenging since these aerosols are different in sizes and shapes. Also they are quite small and the compositions are complicated.^{5,6} Various analytical techniques are used for the chemical and physical analysis of aerosol particles. In most cases a combination of methods are used.

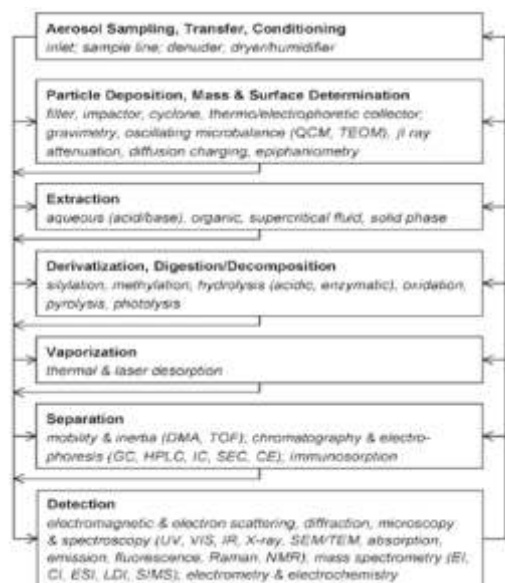


Figure 1: Common analytical procedures and techniques for aerosol analysis.³ Taken from Poschl, 2005.

2.1 Classical off-line methods

Offline methods are filter based techniques which involve the collection of particles on solid deposition substrates such as fiber filters, membranes, inertial impaction plates etc. or in liquids such as wetted wall cyclone, impinger or wash bottles and subsequent analysis. In most cases samples are collected for periods of hours to weeks. Sample storage, transport and sample preparation steps are done prior to the analysis. One disadvantage to this approach is sampling artifacts caused by adsorption and absorption of additional gas phase components, evaporation of particle components, and chemical changes caused by reactions during sample collection.^{3, 6} The other major disadvantage is that no information can be obtained on the extent of internal or external chemical mixing since this is a bulk analysis.⁷

2.2 In situ Atmospheric Chemistry

Due to the low concentrations, short flight durations and variable environment conditions, particulate matter should be analyzed within a short period of time in order to obtain a better chemical composition measurement.⁸ Hence various in situ analytical techniques are being developed to overcome above problem. However the molecular identification is limited and detailed molecular composition measurements are obscure.⁸ Modifying an instrument from laboratory version to a field version is challenging since smaller instruments which work with lower power supplies are needed for the in situ analysis.⁶

2.3 On-line analytical methods

Single particle in-situ analysis which continuously separates and monitors inhalable, thoracic and alveolar fractions of aerosol particles is called on-line analysis. This approach has become the preference for many aerosol studies as a result of above discussed disadvantages of classical off-line analytical methods.^{9,10}

2.4 Real time analysis

Measurements are done at a rate similar to the rate of expected sample variations. Detection scheme is used for the simultaneous detection with an aerosol sampling system and an external particle generator.^{10,11} Need of a real time analysis came up as characterization of aerosol particles by traditional sample collection and treatment techniques caused to be invalid because of contamination and interference effects.

3. INSTRUMENTATION

3.1 Chromatographic methods coupled with Mass spectrometry

A variety of chromatographic techniques have been used since early stages of aerosol analysis. Until recently, traditional offline analysis which includes filtration or impaction followed by extraction with subsequent LC or GC analysis is used to analyze major components in atmospheric aerosols.^{5,6,12} Many research projects have been done on polycyclic aromatic hydrocarbons (PAHs) due to their carcinogenic and mutagenic effects.¹²⁻¹⁴ Techniques such as flash chromatography fractionation, GC/FID and GC/MS are used for the off-line analysis of PAHs. Thermal decomposition (TD) methods coupled with GC/MS came up to overcome drawbacks of off-line analysis.¹³ Several approaches came using different TD

devices. One approach was by using a desorption oven with an association to a GC via short transfer line and a cryogenic trap where aerosols are positioned in a stainless steel deposition liner flanked by two glass wool plugs.¹⁴ Then direct sample introduction (DSI) methods appeared to reduce the difficulties with sample introduction by eliminating the transfer line and the oven. Sample was placed inside a glass micro valve and heated inside the GC injector for TD.¹⁵ TD/GC/MS apparatus with TD auto samplers were discovered very recently and this process allows the analysis of volatile organic compounds exclusive of modifications.¹³

Moreover, two dimensional thermal decomposition aerosol gas chromatography (2D-TAG) systems are also used for the in-situ analysis of organic aerosols.⁵ The ability to distinguish between more polar compounds is enhanced by GC x GC approach. Two columns in series connection are used with a rapid scanning FID.

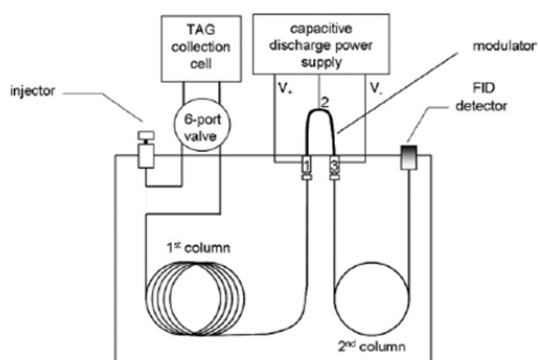


Figure 2: Schematic diagram of 2D-TAG instrument.⁵ Taken from Goldstein et al., 2008.

Ideal approach for screening polar compounds in atmospheric aerosols is liquid chromatographic schemes since, most of the gas chromatographic approaches for the analysis of polar compounds such as carboxylic acids, ketocarboxylic acids, hydroxyketones, diols etc. included one or more time consuming derivation steps.¹⁶ They may also entail intrinsic technical problems with reproducibility, yields, residual reactants in the final extracts and high chemical interference levels. Moreover, derivatisation is intended towards compounds such as carbonyls, acids or alcohols; no information is obtained for other classes of compounds.¹⁶

On-line supercritical fluid extraction–liquid chromatography–gas chromatography–mass spectrometry (SFE–LC–GC–MS) system was developed specially for the analysis of PAHs by combining both GC and LC systems. Samples are analyzed in a closed system without manual sample pretreatment which can be considered as an advantage in this system.¹⁷

Until recently, chromatographic methods coupled with ordinary mass spectrometric systems are used but routine analyses by these systems are failed because of the insufficient sensitivity and robustness. Direct MS systems are failed since aerosol particles are too large for conventional mass spectrometers. Hence more advanced MS systems appeared to deal with these obstacles.

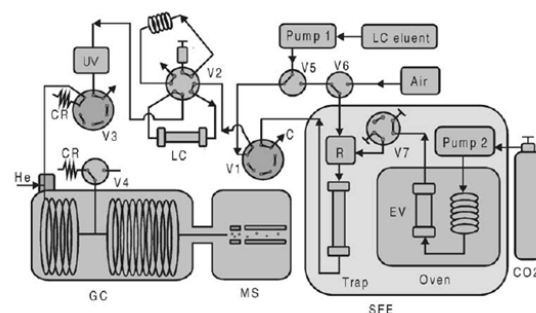


Figure 3: Schematic diagram of SFE–LC–GC–MS instrument. Taken from Masahiko et al., 2002.

3.2 Improved MS systems for the aerosol analysis

A number of alternative methods such as electro spray ionization (ESI), desorption electro spray ionization (DESI) and atmospheric pressure chemical ionization (APCI) were developed for better sensitivity and robustness. ESI is used in mass spectrometry to generate ions. This technique is efficient in producing ions from aerosol particles because it overcomes the tendency of these molecules to fragment when ionized. DESI is an atmospheric pressure ion source that ionizes particulate matter in open air under ambient conditions.

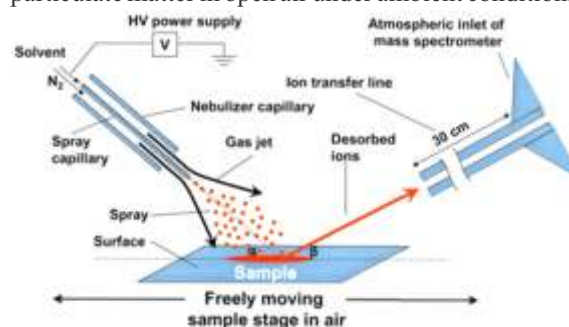


Figure 4: Schematic diagram of DESI source.¹⁸ Taken from Takats et al., 2004

Ionization of light molecules is done by a charge transfer mechanism while ionization of heavy molecules is done by multiple charged ion formation. When charged droplets colloid with the sample it spreads over a diameter greater than its original diameter dissolving sample particles.¹⁸

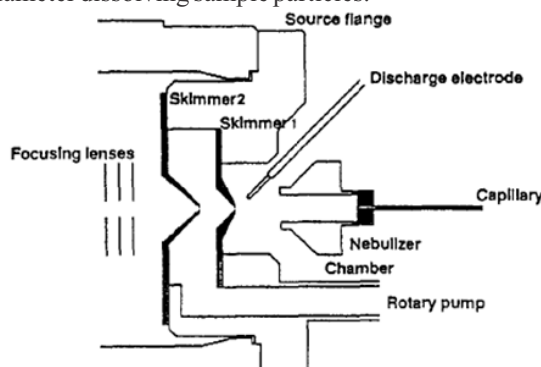


Figure 5: Schematic diagram of APCI source.¹⁹ Taken from Nojima et al., 1995

In APCI, usually the mobile phase containing is heated to relatively elevated temperatures and sprayed with high flow rates of nitrogen and the entire aerosol cloud.

This process is subjected to a corona discharge that creates ions.^{19,20,21}

Short analysis times can be obtained by using Rapid single particle mass spectrometry (RSMS) since particulate matter is sampled directly into the MS and the determination of chemical composition can be done approximately 1 ms after sample introduction to the inlet. The rate of analysis is about one particle per second. Laser microprobe mass spectrometry (LAMMS) was developed by performing RSMS by laser desorption or ionization. The ability to distinguish between surface and total volume composition of a particle is one of the major advantages of this method. Furthermore, PPT detection levels were obtained by LAMMS.

The aerosol mass spectrometer (AMS) is designed for three real time analysis of aerosols via efficient thermal vaporization.^{7,22}

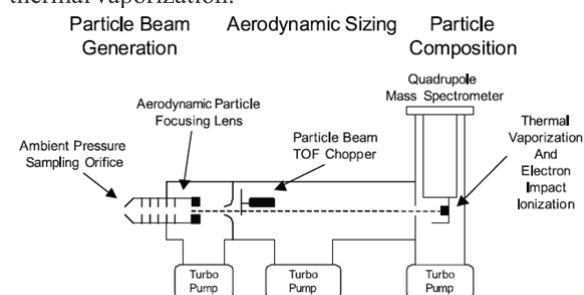


Figure 6: Schematic diagram of AMS.²² Taken from Jayne et al., 2000

In this approach, particles are focused into a tightly collimated beam and directed onto a resistively heated surface. Fast detection of aerosols is synchronized with a mechanical chopper beam allowing particle size determination by a time-of-flight (TOF) measurement.

3.3 X-ray methods

X-ray spectrometry can be used for the analysis of elemental composition of particulate matter. Particle-Induced X-ray Emission (PIXE) is a non-destructive method used in the determination of the elemental make-up of an aerosol sample. When the sample is exposed to an ion beam, X-ray radiation is produced by atomic interactions.²³

Energy Dispersive X-ray Fluorescence (EDXRF) is a common type X-ray Fluorescence technique which can be used for elemental analysis applications of atmospheric aerosols. Simultaneous excitation of all the elements of the sample is done and an energy dispersive detector in combination with a multi-channel analyzer is used to gather fluorescence radiation. Different sample elements are separated based on the energy difference of the characteristic radiation. Instrumentation is enhanced by using X-ray optics.²⁴

3.4 Other Spectrometric methods

Techniques such as atomic emission spectrometry (AES) and atomic absorption spectrometry (AAS) can be used for the heavy metal analysis of particulate matter even though its applications are rare in aerosol chemistry. Electro thermal atomic absorption spectrometry is used for the slurry sample introduction methods with less sample preparation. Ability to take

measurements of several replicates from single slurry which improves the reproducibility of the analysis is an important advantage over solid sampling methods.²⁵ Particulate matter can be sampled by an electrical by an electrical discharge technique with subsequent AAS analysis. Atomic emission spectroscopy is also used for same kind of analysis especially when the heavy metals in the sample are qualitatively unknown. Since it does not require a hollow cathode lamp, easy analysis can be done compared with AAS. Electrical discharge sampling coupled with AES is a modern approach in heavy metal analysis of aerosols since it allows the simultaneous determination of multiple elements in one sample.²⁶

3.5 Neutron activation analysis of atmospheric aerosols

Neutron Activation Analysis (NAA) is a nuclear process which allows isolated analysis of elements as it disregards the chemical form of a sample, and focuses only on its nucleus. NAA is used to determine elemental abundance in the filters which are prepared by passing high volume air samples containing aerosols on Whatman-41 filter papers.²⁷

3.6 Electron beam techniques

Compositional information of aerosol samples can be obtained by nondestructive micro analytical methods such as electron probe X-ray microanalysis (EPXMA) and Scanning electrochemical microscopy (SEM). Wavelength dispersive spectrometers (WDX) or energy dispersive spectrometers (EDX) are used to determine the energies of emitted X-rays. Rutherford backscattering spectra can be used to visualize aerosol particles and determine particle diameters and elemental correlations.²⁸ These techniques became very popular since they are computerized automated systems, however these methods need to operate under vacuumed conditions and there are some problems with quantization. Lots of new research projects are being done to overcome these drawbacks.⁹

Transmission electron microscopy (TEM) and scanning transmission electron microscopy (STEM) are also useful in micro analysis of aerosols. In TEM, electron beam is transmitted through an ultra thin specimen. An image is formed from the interaction of the electrons transmitted through the specimen; the image is magnified and detected by a sensor such as a CCD camera. STEM uses the same technique but the electron probe is focused to a narrow spot and scanned over the specimen.⁹ In both techniques, transmitted electrons are recorded as bright and dark field images.

3.7 Satellite methods to monitor aerosols

Satellites can observe atmospheric aerosols by measuring wavelengths, angular and polarization properties of radiant energy reflected and emitted by earth carriers. Instruments such as Polarization and Directionality of the Earth's Reflectances (POLDER), Moderate-resolution Imaging Spectroradiometer (MODIS) and Multi-angle Imaging Spectroradiometer (MISR) are used to generate satellite images. Sea surface temperature (SST) is a popular indicator for satellite imagery. Huge amount information on aerosol distribution can be obtained from SST charts generated by satellite images.^{29,30}

CONCLUDING REMARKS

Even though various analytical techniques are being appeared to analyze and monitor atmospheric aerosols, still the chemistry of it is relatively unknown. Aerosols are increasingly generating and spreading in atmosphere and can cause a lot of environmental changes and health effects. Hence this area of scientific research is significantly important and more attention should be taken to prevent hazardous activities of particulate matter.

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Answers to study questions appeared in the previous issue on the topic Hydrogen Bonding (October 2009 vol 26 No 3)

- (i) $\text{CH}_3\text{OCH}_3, \text{F}^-, \text{HCOOH}$
- (ii) CH_3OH can form hydrogen bonding but not CH_3F
- (iii) CH_4 – London forces
 CHCl_3 – dipole – dipole (hydrogen bonding), London forces
 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ – hydrogen bonding, London forces
- (iv) $\text{OHCH}_2\text{CH}_2\text{OH} < \text{FCH}_2\text{CH}_2\text{OH} < \text{FCH}_2\text{CH}_2\text{F}$

27th Batch of 92 Graduate Chemists Pass out

(under new structure)

First Class Honours (12)

Ms. G D M R Dabera, Ms. V G Thangavadivale, Mr N M S D Perera, Ms. H D M Sriyathne, Ms. N M R Shashikala, Ms T S N Peiris, Ms. D Attanayake, Ms. S Princy, Mr T A N Peiris, Mr. K R S Thenna Hewa, Ms D H K Amarasekara, Mr. J N Dias

Second Class Honours (Upper Division) (14)

Ms. S D Hettiarachchi, Ms. S M J Hettiarachchi, Ms. J Mariyathas, Mr. S Vaseetharan, Mr. P T Wansapura, Ms. L H S M De Silva, Ms. H M K C Herath, Ms. G G E H De Silva, Ms. C D Devasinghe, Mr. D S Ranasinghe, Ms. P G P S D Panangala, Ms. D P W Jayatunga, Ms. N A S Karunarathne, Ms. P N N Paranawithana

Second Class Honours (Lower Division) (12)

Ms. E W M P W N U Ellepola, Ms. W A C L Jayasekara, Ms. D S R Perera, Ms. K S U Rathnayake, Ms. M D W Samaranayake, Ms. I Fhazi, Ms. S Yasodharshini, Ms. L G H I Guruge, Ms. G I D S D Malawana, Ms. A W Kalubowila, Ms. S Karunamoorthi, Ms. K S P Lokuge

Third Class Honours (15)

Ms. G L M L A De Silva, Mr. P P G P Panduka, Ms. M C R Peris, Ms. S P I U Hewage, Ms. V Vigneshwaran, Ms. D M I Y Dissanayake, Ms. N S Jayawardana, Ms. S D A Wickramasinghe, Mr. K W S C P S Wijesinghe, Ms. M D L M Mahawatta, Ms. I C Dissanayake, Ms. R A D T Dharshani, Ms. B A H E Balachandra, Ms. H M Ramanayake, Ms. I Lewkebandara

Pass (01)

Ms. G D Wijesuriya

(under old structure)

Second Class Honours (Upper Division) (01)

Ms. M A D D Nimmi

Third Class Honours (02)

Ms. W D C S Abeywickrama, Mr. D S P Warnakula

Pass (35)

Mr. K N Amarasinghe, Ms. W A N Wickrama Arachchi, Ms. M R C K Mallawa, Ms. R N De A Dissanayake, Ms. H D H K De Alwis, Ms. J H P D S Tissera, Ms. S S S Dayarathna, Ms. H L T H De Silva, Mr. N D Hapukotuwa, Mr. J A M A Karunathilaka, Ms. P C Kathriarachchi, Ms. A Mahalingam, Ms. J P S L Perera, Ms. K W V P Ranasinghe, Mr. R H P K Senadeera, Mr. A T U Somapala, Ms. S Thenuka, Ms. K Vararatharajaperumal, Mr. W V P A Chinthaka, Mr. A S B Rajapakse, Mr. H G A Jinadasa, Mr. G K R P Gajanayake, Ms. R P D Y D Chandrasena, Mrs. S K M Kuruppu, Mr. W R S De Silva, Ms. J A LaBrooy, Ms. T N Meegahawatta, Mr. H P N D P Pushper Sri, Ms. A R Rajamanthre, Mr. W A I Wickramasinghe, Ms. C N De Silva, Ms. E M A R Edirisinghe, Mr. A R Adhikari, Ms. W W V T Mendis, Ms. P P K Karunaratne

Convocation Awards & Prizes 2009 (under New Structure)

Overall Examination Awards -2009

1 st	Shireen Jayasuriya Memorial Gold Medal	Ms. G D M R Dabera
2 nd	Graduateship Silver Jubilee Award	Ms. V G Thangavadivale
3 rd	Graduate Chemist (25 th Batch Passing out) Silver Jubilee Award	Mr. N M S D Perera & Ms. H D M Sriyathne

Overall Excellence Awards covering all levels

Prof. Leslie Gunatilake Award for Organic Chemistry	Ms. V G Thangavadivale
Haniffa Award for Physical Chemistry	Ms. G D M R Dabera
Prof. J K P Ariyaratne Award for Inorganic Chemistry	Ms. G D M R Dabera

Levels 3 & 4 Overall (Theory) Awards

First	RSC (SL Section) Award	Ms. G D M R Dabera	
Second	Ms. H D M Sriyathne	Third	Ms. V G Thangavadivale

Overall Best Performer Prizes for Practical

Professor R S Ramakrishna Memorial Prize	Mr. K R S Tennahewa
Mr. & Mrs. K Sivarajah and Family Prize	Mr. P T Wansapura
B A Jayasinghe Memorial Prize	Ms. G D M R Dabera
College of Chemical Sciences Prize	Ms. S M J Hettiarachchi
College of Chemical Sciences Prize	Mr. D S Ranasinghe

Levels 3 & 4 Subject Prizes

P Rohan K Fernando Prize for Special Topics in Chemistry	Ms. G D M R Dabera & Ms. V G Thangavadivale
W R O Fernando Memorial Prize for Energetics & Kinetics	Ms. G D M R Dabera
Dr Sudath Kumarasinghe Memorial Prize for Selected Topics in Physical Chemistry	Ms. G D M R Dabera
Dr. Lakshman Ponnampere Memorial Prize for Special Topics in Inorganic Chemistry	Ms. V G Thangavadivale
Professor P. P. G. L. Siriwardane Memorial Prize for Further Topics in Inorganic Chemistry	Ms. G D M R Dabera & Ms. V G Thangavadivale
Mr. & Mrs. N I N S Nadarasa Prize for Special Topics in Organic Chemistry	Ms. V G Thangavadivale
Prof. Eugene de Silva Prize for Industrial Chemistry & Technology	Ms. V G Thangavadivale
Mevan Pieris Prize for Polymer Chemistry & Technology	Ms. N M R Shashikala
MicroChem Laboratories Pvt (Ltd.) Prize for Environmental Chemistry	Ms. V G Thangavadivale
Batch 2005 Prize for Information Technology	Ms. H D M Sriyathna
Vasanthan & Menaka Prize for Further Management, Economics & Marketing (Course provided by Unilever)	Ms. G D M R Dabera
Prize for Food Chemistry & Technology (donor awaited)	Ms. G D M R Dabera & Ms. H D M Sriyathna
Susila Jayaweera Memorial Prize for Biochemistry II	Ms. G L M L A De Silva
Careen Manel Abeywardene Memorial Prize for Natural Products	Ms. T S N Peiris

Level 3 Award List

Level 3 - Overall Award List

First Prize and Mandrupa & Oleap Fernando Hall Opening Scholarship	Ms. D L Basnayake
Second Prize and Susila Jayaweera Memorial Scholarship	Mr. R Loorthuraja
Third Prize and Graduateship Silver Jubilee Scholarship	Mr. H A G S Perera

Merit Bursaries (in order of merit)

Mr. Y M N D Y Bandara, Ms. B I Karawdeniya, Ms. C H Narangoda, Ms. H S M Fernando, Ms. L R S Jayasinghe, Ms. M L C Cooray, Mr. S C D Fernando

Subject Prizes (Second Semester)

Dr Sudath Kumarasinghe Memorial Prize for Physical Chemistry	Mr R Loorthuraja
Susila Jayaweera Memorial Prize for Biochemistry II	Ms D L Basnayake
Careen Manel Abeywardene Memorial Prize for Natural Products	Mr H A G S Perera
Mevan Pieris Prize for Polymer Chemistry & Technology	Ms R A D U Ranawaka
Vasanthan & Menaka Prize for Further Management, Economics and Marketing	Ms H S M Fernando & Ms P A N K P Jayawardena
Batch 2005 Prize for Information Technology	Ms M L C Cooray
Mr N M S Hettigedara Family Prize for Pharmaceutical & Medicinal Chemistry	M s B I

Diploma in Laboratory Technology in Chemistry, 37th Batch (2007/09)

Honours Pass (4)

Mr M R L Fernando, Ms R P N Priyanthi, Mr S J Kolambage, Ms A M D M Priyangika

Merit Pass (11)

Mr A V C Rodrigo, Mr L J P R R Perera, Ms S Thanusiya, Ms F S Mufthi, Mr A J S Kurera, Ms D Y Y W Dasanayaka, Ms G N L Y Senathilake, Ms H P W T Pathirana, Ms L B W D T Madushani, Mr D S Amarasekera, Ms D W R D Harischandra

Ordinary pass (16)

Ms P K W Ruwani, Mr S P K W K Senadeera, Mr Mirunda Perera, Ms S M S G Perera, Mr J A S Ravindrajith, Ms W M Kusumalatha, Ms M S S Minsa, Mr R M K M Rathnayake, Mr H M P D Herath, Mr S P S T

DLTC Examination Awards List-2009

First Prize	G C N Jayasuriya Award for the Best Performance	Mr M R L Fernando
Second Prize	Ms R P N Priyanthi	Third Prize
		Mr S J Kolambage

Sixth Convocation of the College of Chemical Sciences

Convocation Address

Two Chemists who enlarged the bound of society

Dr. R.O.B.Wijesekera, *C.Chem.*

*Hony. DSc (Hull & Peradeniya); PhD (Hull); BSc (Ceylon); FRSC; F.I.Chem.C.; FNASSL
Senior Chemist & Director/Consultant, Link Natural Products (Pvt) Ltd*



PROLOGUE

Science and particularly chemistry has interested me ever since I first entered a laboratory way back in my school days at Royal College. We were in war time then – the World War II. Our school buildings were commandeered and being used for a military hospital. We were housed in buildings in Turret Road, and we used the University Laboratories at Thurstan Road. So it became a fascinating journey for us to cycle from Turret Road to Thurstan Road once or twice a week for an afternoon session in the laboratory. My love affair with science and chemistry began there. It was supplemented by another fact. Mr Edward Lawrence Bradby, our Principal, was quick to notice that we in the science streams were not really interested in History. Our marks and especially mine in that subject were appalling. So he substituted a subject: History of Science instead of European History. In this class, which Mr Bradby himself conducted, we studied the lives of a number of great scientists, as chosen by him. I recall, Michael Faraday, Humphrey Davy, Isaac Newton, William Hershel and others whose life and work was our theme. Mr. Bradby was a perceptive young man then in his thirties, and I owe it to him to realize that the lives of scientists not only gave us knowledge of what they did, but how they did it. Now an octogenarian, this remained as one of my interests throughout these last six and a half decades of my life. I believe a proper study of science must include the stories of the lives of those who made science what it is today – the most dominant social factor of mankind.

In keeping with this I have chosen to discuss today, albeit very briefly, the lives and scientific work of two of the world's greatest scientists, who are alive today. I have chosen chemists for obvious reasons, not only because I am a chemist, and I am addressing the College of Chemical Sciences of the Institute of Chemistry, but also because of the fact that I have had the privilege of knowing both of these great scientists personally, over a long period of time. These two great chemists enlarged the bounds of society.

Their work over half a century have displayed a momentous social impact and it shows what science can achieve what benefits mankind derives and also what dangers are possible by the abuse and misuse of the scientific results. It also exemplifies that one learns science from the lives of those who make it possible, those who use it are not scientists alone but the society at large and this spells the importance of the ethical dimension in science. All this and more I shall hope to illustrate by a discussion on the lives of the works of the

two great chemists I have chosen. They are both contrasting, and in their devotion to science and society similar. The first of these is Frederick Sanger, FRS, and an Englishman who has won two Nobel Prizes – the only one living scientist to have this honour. The second is Carl Djerassi, an American, a Jewish emigrant from Bulgaria, a winner of the Priestley Award, - America's highest award for chemistry, - and arguably the greatest scientist never to win a Nobel Prize. Sanger has been named the "Father of the Genome" and Djerassi is often referred to as the "Father of the Birth Control Pill" So these two chemists, very different from one another, have had a remarkable impact on society by their work.

FREDERICK SANGER.

Frederick Sanger, born in 1918, was the son of a General Physician by the name of Frederick Sanger. His mother came from wealthy stock which helped him in later life to go on his own pathway as a researcher at Cambridge University doing what he immensely enjoyed doing. By his own admission he decided before entering St John's College Cambridge, that he would be better suited to a career in which he could concentrate his activities and interests more on a single goal, than appeared to be possible in his father's profession. He became intensely interested in Biochemistry at the University because as he said: "it seemed to me that here was a way to really understand living matter and to develop a more scientific basis to many medical problems".



**Frederick SANGER
FATHER OF THE GENOME**

A man known for his extreme modesty he thought he was a better than average student, and states that he surprised his teachers and himself by netting a first class degree. He was a conscientious objector during the war and was permitted to do a Ph.D degree under A. Neuberger. He generously credits Neuberger the one who first taught him how to do research both technically and as a way of life.

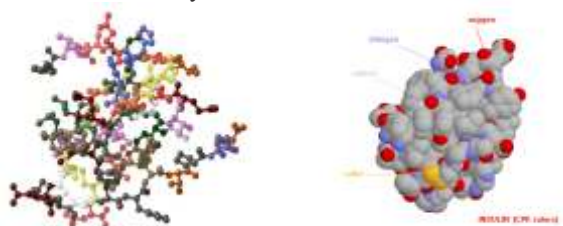
In 1943 he joined the group of A.C.Chibnall and commenced studies at Cambridge, on the chemistry of the protein insulin, about which very little was known at the time. This was a particularly exiting time in protein chemistry and Sanger recalls the new developments of the time in the separation methods of paper chromatography which had been just developed by

A.J.P. Martin and his colleagues for which they were to receive the Nobel Prize. Sanger at the time saw the real possibility of determining the exact composition of insulin. Insulin was a protein and was therefore built up of a number of amino acids, which were like the building blocks that formed the structural whole. Proteins were known to function as building blocks, as enzymes that trigger and control chemical reactions, but nevertheless they were known to be composed of the same building blocks namely twenty different kinds of amino acids strung together like pearls on a string. The connection between the amino acids was known as the peptide link, a very stable connection. Every protein chain could consist of tens to thousands of amino acids strung together. Insulin was one of the simpler ones and Sanger was to find methods to determine the order in which each amino acid in the molecule of insulin was strung together. Thus, Sanger painstakingly succeeded in developing new methods for amino acid sequencing, for which he was awarded the Nobel Prize for Chemistry in 1958. Sanger and his colleagues had broken through a difficult barrier to determine the order, i.e. the sequence, of the various building blocks of the protein insulin and thus paved the way for studying the chemistry of proteins the basic building blocks of nature.

Sanger visited Sri Lanka in 1963 as the Chief Guest at the Annual Sessions of the then CAAS (now SLAAS). I was the General Secretary at the time and Dr Noel G. Baptist a Cambridge contemporary of Fred Sanger was the General President.

He proved to all the great break-through he achieved in a brilliant lecture he gave to Section E on the Chemistry of Insulin.

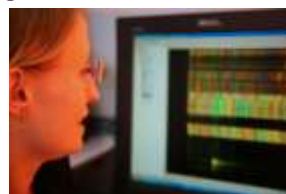
In a lighter vein permit me to recall that Fred Sanger was very keen on seeing more of our country but time was short as he had planned to return by ship. He had barely four days after the sessions and although we took him to the southern beaches for two days he was keen to see more. Mr. L.A.D.I. Ekanayake who as the Director of Meteorology happened to overhear his expressed wish to me, and offered to fly him over the island in a private plane which he would hire. When I drove the Sangers, (Mrs. Sanger was with us too), to the Ratmalana airport it transpired that the plane hired by Mr. Ekanayake (Laddy), was a two-seater Tiger Moth Trainer aircraft and was to be piloted by himself, as he was a licensed pilot. To be honest I was most apprehensive, and so was Mrs. Sanger. Both of us waited anxiously at the airport for a good couple of hours and were relieved when the plane finally landed and a beaming Laddy and Fred emerged. I was worried that we may not have a Chief Guest for our Annual Dinner later that day.



Models of the Molecule of Insulin

After winning the Nobel Prize for his work on the sequencing of proteins he was to move over to the new Laboratory of Molecular Biology set up by the UK Medical Research Council. He had assumed work there when he came to Sri Lanka. There he was to develop further methods for studying proteins and the active centres of some enzymes. It was then that he turned his attention to the nucleic acids RNA and DNA. In the same manner as proteins the DNA molecule, isolated by a Swiss scientist in 1871 from the cell nucleus consists of a string of pearls of smaller molecules. DNA consists of only four different pearls called nucleotides. Sanger's work culminated in the development of the technique known as: the "dideoxy technique" for DNA sequencing around 1975. Sanger's driving force was the challenge of determining the order of the bases in DNA - (DNA sequencing). The method he and his group had developed was a relatively rapid one, and he successfully used it to determine the DNA sequence in several of the bacteriophages, and of human mitochondrial DNA (48500 nucleotides). Since then his method has been automated with the intervention of improved instrumentation and computer technology, to enable the study of the human genome (3 billion nucleotides) He has earned for himself the epithet of FATHER OF THE GENOME. - The Genome being all the information encoded within the DNA which is the carrier of genetic information.

By this time much was known of both DNA and its cousin RNA and Watson and Crick with the X-ray work of the late Rosalind Franklin had made the epoch making discover of the double helix. Thus in 1960, one hundred years after Darwin elaborated the Theory of evolution, scientists had identified DNA as the molecule that carried the hereditary traits. The sequence of the nucleotides, control the sequence of amino acids in proteins.



Sequencing at the SANGER Centre



Fred Sanger at the Sanger Centre

Sanger was personally well endowed, and he collected from his research much credit and a second Nobel Prize for this work, but characteristically little wealth, except enhanced sponsorship of his research. The naming of his laboratory complex as the Sanger Centre in Cambridge was a logical tribute to this great scientist whose work will revolutionise the course of future medicine and also crime detection. This unbelievably humble man lives a simple life, enjoying retirement and gardening.

CARL DJERASSI

Carl Djerassi is as different to Frederick Sanger as the proverbial Chalk and Cheese. He won no Nobel Awards but this is a travesty of justice, as he has done sufficient for Science, as well as for Society to merit two awards. His career spans so many things. He has been described as the Father of the Birth Control Pill, a title he

shares with the other collaborators: Gregory Pincus and John Rock, who performed the biological and clinical studies to confirm the efficacy and safety of the pill in humans.



Carl DJERASSI
FATHER OF THE
BIRTH-CONTROL PILL

He was a brilliant chemical researcher giving to organic chemistry many techniques for elevating its use, such as what is called Optical Rotatory Dispersion or to chemists ORD. Besides, he was also the developer of antihistamines, the founder of biomedical companies, the inspiring teacher of world class chemists, and even a novelist, a poet and a playwright, whose plays have been performed on the stage in Broadway and London. He won besides the Priestley Medal (1992), the National Award for Science (1973), and the National Award for Technology (1991), the only one to get both. All this happened in a single lifetime, with plenty of time to reflect upon the social consequences and outcome of it all.

Carl Djerassi was born the son of a Bulgarian father and a Viennese mother, both of whom were clever physicians. He was educated in Vienna a City which became his home. For him it was always “*Wien, wien nur du allein...*” as the song goes. The 4th of July figures to him as the day when as a European Jew he migrated with his mother in 1938 to the USA to escape the Nazis. When he left Vienna barely fifteen years of age he confesses, that he had never received grades any higher than “satisfactory” having attended the same school as Sigmund Freud.

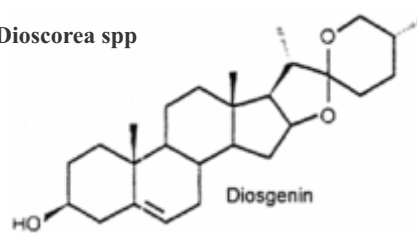
He was a man in a hurry, and was quick to do his degree and even completed a Ph.D in two years working with the aid of a Research Fellowship, on steroid synthesis at the University of Wisconsin. Then sponsored by the firm of CIBA he researched on anti-histamines, at the same time continuing his individual interests on steroids. By this short time Djerassi had acquired a reputation in academic chemistry. It was then that he took an intuitive decision to accept an offer to lead a research group in Mexico. George Rosenkranz, a thirty two year old Director of the small company Syntex in Mexico, had absolutely won him. Rosenkranz himself a refugee from Hitler's Europe, a Hungarian and a brilliant steroid chemist “absolutely charmed me”, he was to say later. Rosenkranz had obtained his Ph.D., working with the Nobel Laureate Leopold Ruzicka in Switzerland, who was regarded then as the doyen of chemists. Djerassi accepted the position; and saw it as a means to establish a rapid scientific reputation. He developed a partnership with Rosenkranz, in which the two scientists called the shots in respect of publications, and not the patent lawyers. This way was the reverse of the ordinary in the case of companies in the USA. They had a common goal and that was to develop a new and

more productive synthesis of then all important drug, cortisone, beginning with a plant-derived product.

As a result of this policy he and Rosenkranz published their work and he reveals that their publications outnumbered those from the academia or industry or elsewhere. So in assessment Syntex's research department had within ten years of its founding, published more work on Steroids than any other department – academic or industrial. This assessment was made by Harvard's celebrated Louis F. Fieser and reported at the international steroid conference. Djerassi and his Mexican team had made the grade. They had also studied the monumental work of an American chemist R.E. Marker on a group of steroids called “sapogenins”. They were so called because they possessed a soapy nature and Mexican villagers used them as soap. Marker concentrated on the steroidal saponin Diosgenin extracted from the rhizomes of plants of the *Dioscorea species*, used in Mexican traditional medicine. Marker realized the synthetic potential of Diosgenin, which he found was also contained in abundance in several inedible yams found in Mexico. In 1944, Marker had left the company he had helped to found. It was after that Djerassi and Rosenkranz took over. They had a legacy of work and were soon into the literature. They were helped by Gilbert Stork another brilliant contemporary scientist who was also an emigrant and who worked at Harvard. Stork kept them posted with all the current literature then not available in Mexico. Rosenkranz had already used this compound to commercially make both the male and female hormones, and was with Djerassi's active participation working on the synthesis of cortisone. Cortisone at the time was the wonder drug for arthritis but it was prohibitively costly. Eventually the Syntex team led by Djerassi and now with Stork's assistance was able to synthesize cortisone beating other more famous names in the USA in the race. They had achieved what the media described as: SYNTHETIC CORTISONE FROM GIANT YAM. They had found a means of synthesis to achieve the steroidal framework in ample yield. A substantial yield was a prerequisite to use on a large scale of any compound.



Dioscorea spp



By this time it was known that the female sex hormone, Progesterone was virtually a contraceptive agent. Maintained in the female body system during pregnancy it impedes further impregnations, so it is virtually nature's contraceptive. The natural hormone though has weak activity and cannot be used orally or by injection in practical terms. Djerassi refers to the piece in Harper's magazine which goes thus:

“In perhaps no other recent development, it [the synthesis of cortisone], underscores a point often overlooked in a big money age. Big minds, rather than big research budgets, lead to big discoveries.....The leader

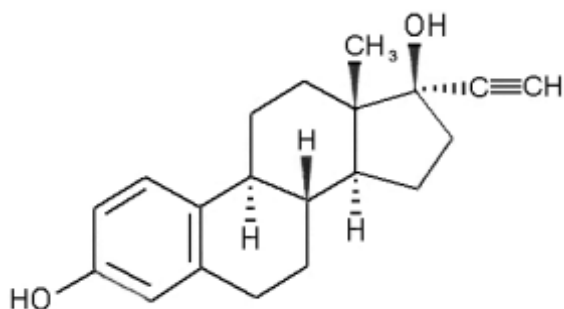
in the race was a chemical manufacturer in presumably backward Mexico."

The presence of technical support at the small company that was Syntex prompted Djerassi to use a plant derived substance as the starting material for further synthetic work. Diosgenin was available in ample quantities from *Dioscorea* yam. He attempted to synthesize Progesterone the female sex hormone naturally secreted by the *corpus luteum*.

Progesterone though it is nature's way of preventing pregnancy is only weakly effective orally and cannot be used as a contraceptive. The male sex hormone Testosterone was readily available. It was made in Europe from Cholesterol, but at Syntex they were able to make it from Diosgenin. Estradiol an estrogenic hormone then used clinically was isolated from enormous quantities of the urine of mares. Djerassi was successful in converting the male sex hormone testosterone to Estradiol by aromatizing the A-ring using the method adopted in another instance by the Australian chemist A.J.Birch. Finally with the introduction of an acetylenic group at C17 he was able to make **17- α -ethynylestradiol**, which displayed substantial oral estrogenic activity.

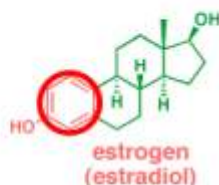
In science we build on the work of others and so it was in this case where the work of Birch, and also of Inhofen in Berlin helped as clues. It took a quarter of a century for this to be established as one of the main components of a safe and efficacious oral contraceptive. That is often the time taken to develop a drug from a discovery in science.

The chemical formula of the of the Pill first synthesized by Djerassi (17- α -ethynylestradiol)



?

whoever said that men are more stable than women never took organic chemistry



Q. which has the lower energy, less reactive more stable electrons, an alkene or an aromatic ring, and why?

A. six electrons in an aromatic ring such as that in the estrogen estradiol are stable as a consequence of the nature of molecular orbitals of cyclic systems, which is usually taught in second semester organic!

I have borrowed the above to explain the difference between the two hormones, and to remind us that Djerassi taught organic chemistry at Stanford University then, and until his retirement. He was known as an inspiring teacher at all levels from B.Sc. to Ph.D. and beyond.

Djerassi was often asked the question: Is he the father of the Oral Contraceptive Pill and he was to respond in this vein. If he was the father there has to be a mother and a midwife/obstetrician. He explains further. The organic chemist must first produce the substance. The biologist must then produce evidence of its efficacy and safety in animal models sufficient and necessary for a clinician to administer the substance in humans. Djerassi led the chemical team that produced the substance, the synthesis of the first orally active steroidal contraceptive, on 15th October 1951. Gregory Pincus of the Worcester Foundation for Experimental Biology, in Shrewsbury, Massachusetts, headed the biology group that reported the ovulation inhibiting properties of the synthetic substance, in animal models. The Harvard gynecologist John Rock and his team did the clinical trials to establish efficacy and safety in humans. So there was the story of the genesis of the pill.

After twenty years and then after forty years following the first use of the oral pill Djerassi was to write two essays namely: "The Pill at Twenty" followed by "The Pill at Forty", in which he reflected on the consequences and social impact of the pill.

He reflected that the advent of the pill changed R&D priorities of the international pharmaceutical industry, there being reflected a considerable decrease in interest as compared with 1960.

It was at this time that the WHO formed its Research Programme on Plants for Fertility Regulation with Carl Djerassi and Norman R.Farnsworth as principal actors. Both these scientists were members of the team led by Djerassi to Sri Lanka in 1975 for the US-Sri Lanka Workshop on Natural Products, at which I led the Sri Lankan team.



Carl Djerassi and R.O.B. Wijesekera Co-chairs at the 1975 US-Sri Lanka Workshop on Natural Products.



From the Djerassi collection of paintings by Swiss artist Paul Klee.

My own appointment as the Task Force Manager of this WHO Task Force for Research on Plants for Fertility Regulation, in an endeavor to discover new agents effective as oral contraceptives from plants used worldwide, was to bring me in contact once again with this redoubtable chemist at a personal level. One personal incident is worth recording:

Djerassi was at dinner in my home in Chambesey, near Geneva together with the Director of the WHO Special Programme for Fertility Regulation, Dr Alexander Kessler. He then presented Kessler with his new book "The Politics of Contraception." He was quite

well known to my wife, Marina, whom he had met in Colombo in 1975 and got quite friendly. Djerassi has a disability because of a stiff knee as a result of a skiing accident. He therefore, when crossing his feet while seated, cannot put the foot down. He challenged my younger children as to who could put up one foot and keep it up there for the longest time. The children took up the challenge and of course lost the battle, due to Djerassi's permanently stiff knee.

The contraceptive pill by no means represents Djerassi's best research. He has done outstanding work to be well recognized professionally although the coveted Nobel Award has still eluded his grasp. Perhaps in time the Nobel Committee which has its own criteria may well think differently. He is not the only example where the justice has obviously slipped by.

Among other things this amazing man has one of the world's best collections of the paintings of Paul Klee the best known Swiss artist. He is a sponsor of the Arts, a Playwright, a novelist, and a poet and today is interested in the arts in a big way and has found a new manner of exposition of science in literature.

EPILOGUE

What do we learn from the lives of great men like Sanger and Djerassi? They have differing characteristics; the one is unusually modest but not lacking in confidence to any extent. The other is brash and invasive, by his own admission, and not reticent, to advertise his views and performance. Yet the social concern in both, is pre-eminent and mostly in regard to

the abuse of science for malicious purposes. Sanger expressed his views on a rare occasion to condemn conflict and war. He was a conscientious objector in wartime. He would not like his painstaking efforts to end up in misuse such as the cloning of humans. Sanger was genuinely confident that his work will revolutionise medicine. The recent Nobel prize winning works of Kornberg, and then Ramakrishnan, Steitz and Yonath winners for 2009, amply accentuates that.

Carl Djerassi has amply reflected on the social aspects of the use and misuse of the pill. It revolutionized sexual behavior and encouraged promiscuity. It ushered in the permissive society and broke down the barriers of traditional relationships. Djerassi's purpose was to bring relief to the many women in the third world in particular who suffered as a result of being overly burdened with frequent child bearing. He was for management of populations to use in sustainable fashion the world's resources. He was no protagonist in the abuse of sex and the trail of diseases like AIDS.

Hard work towards a decided goal, within a team effort, and study of the knowledge before them, brought them their successes.

They were for the world at large and not only for the rapacious industries to conquer and dominate. They led the way towards achievement. It is a fact that any success big or small is at the mercy of society. But who controls the ethical dimension. Small wonder then that Bernard Shaw was to cynically remark the Science creates more problems than it solves. This is a point for reflection.

A/L 2010 CHEMISTRY

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උදේ 9.00 සිට සවස 4.30 දක්වා

රාජගිරිය Institute of Chemistry හිදී.

දිනය	මාතෘකා	දේශකවරු	මැයි 24	විද්‍යුත් රසායනය හා අයනික සමතුලිතතාව	මහාචාර්ය දයාල් ද.කොස්තා
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Continued Concrete Progress by the CCS in Human Resource Development



It is with an ever increasing sense of accomplishment, pride and satisfaction that I present to you this report of our work since the fifth convocation held on 30th January 2009 at Cinnamon Grand.

Graduateship Programme in Chemistry

The 27th batch of Graduate Chemists who are formally passing out today is unique for several reasons. They include the first batch who entered Adamantane House in their first year in October 2005. They include the first batch who coincidentally followed the present course structure and course content which represents a radical departure from the earlier Part I & II structures which existed from 1979. Consequent to the new structure, they include the first batch to have had examinations in all courses in each of the four years of study, in keeping with current developments in the educational sphere. They include the first batch to have all examination questions as compulsory under the new structure. They also include the first batch to have a whole range of optional/elective courses in their last two years of study. However, the most significant feature characteristic of this 27th batch is the largest output ever to be recorded in the 32 year history of our Graduateship Programme.

92 Graduate Chemists passing out this year exceeds the previous highests of 52 and 53 in 2007 & 2008 respectively and brings the total output of our Graduate Chemists from 27 batches to 663. Our total annual output is now approximately equal to the total output of Chemistry Special Graduates from all the six Sri Lankan Universities producing such Graduate Chemists. May I take this opportunity to thank all officers, officials and staff who have helped and assisted us in making such a spectacular progress.

It is indeed such a joy to see our students actively involved in their studies and other extra-curricular activities at Adamantane House on practically every day of the year. While our lecture programme is more or less confined to week-ends, practical work as well as research/project work of students goes during on week-days as well.

While we were able to conduct all our practical classes at Adamantane House during the last academic year and confine our use of S. Thomas' College premises at Mt. Lavinia largely for the conduct of examinations and first year lectures, the continuously increasing numbers of students as well as the decreasing attrition rate will compell us to conduct more lectures as well as practical in Mt. Lavinia during the current academic year. Although, this is not an entirely satisfactory arrangement and causes considerable inconvenience to staff & students, it seems to be unavoidable due to the acute shortage of space at Adamantane House premises.

It is therefore hoped that our current efforts to obtain more space to put up additional buildings nearby will materialize as soon as possible so that we will be able to overcome our acute space problems and accommodate even more students for many more years to come.

Diploma in Technology Programme in Chemistry (DLTC)

Our pioneering formal educational programme which commenced in 1973 continues without interruption; the 37th batch of DLTC students commenced their programme on 23rd October 2009. The 35th batch who received their diplomas today number 31 and has increased the total number of technicians/technologists produced so far to 731. This programme continues as the only such programme catering to the provision of middle level scientific personnel in any branch of the basic sciences in Sri Lanka.

Third Research Session

The Third Research Session was held on 10th October 2009 enabling students from the 27th batch to present their research/study results formally as part of their examination process.

Recruitment of full time academic staff to the College Professors

We have been able to obtain the services of **Professor M Dayal P de Costa**, formally Head of the Department of Chemistry, University of Colombo as a full time Visiting Professor of Chemistry from July 2009 during his sabbatical leave. Professor de Costa delivered the third inaugural Professorial Oration on "Fluorescent Sensors" on 24.07.09. **Professor S Sotheeswaran** is with us from April 2009 on a full time basis while **Professor S P Deraniyagala** also continues as Head of the Faculty & Visiting Professor for the second year while on sabbatical leave from the University of Sri Jayawardenepura.

Senior Lecturers

Dr. Vinitha Thadhani has resumed duties as Senior Lecturer on a part-time basis with effect from October 2009. Together with **Dr. Sisira Weliwegamage** who has been with us since March 2005, we now have a total of five academics on our regular academic staff at Adamantane House.

New Series of CCS Publications

The first of a new series titled "CCS Publications" was launched on 24th July 2009. This series will continue while 32 Monographs have so far been published under the series of Monographs, which has been published over the past two decades.

Lecture by Graduate Chemist

Dr. Ravindra Udagama, Graduate Chemist (1999), who is our first product to obtain a PhD from a

French University, delivered a lecture to our students at Adamantane House on the topic "Synthesis of Polymer-Polymer Hybrids by Miniemulsion Polymerisation and Characterization of Hybrid Latex" on 7th November 2009.

Certificate Course in Clinical Chemistry

A certificate course in Clinical Chemistry was conducted once a week over a period of three months. 19 persons participated in this programme. (Coordinator – Dr. Rohan Perera)

Training Seminars/Workshops organized by CCS

1. **Training seminar** on Bioactive Natural Products was held on 22nd January 2009. 53 persons participated in this training seminar. [Co-ordinator: Prof. (Mrs.) Priyani Paranagama]
2. **Two training seminars** for A/L teachers based on the new A/L Chemistry syllabus to enable them to meet the challenges of the new syllabus was held by the CCS on 28th & 29th May and again on 24th & 25th September 2009. (Co-ordinator: Prof. S P Deraniyagala) This programme will continue in 2010.
3. **Training seminar** on Biofuels held on 22nd July 2009. (Co-ordinators: Prof. S Sotheeswaran & Dr. Sisira Weliwegamage). 54 persons participated in this seminar.

Extra Curricular Activities

Amongst the extra curricular activities conducted by the College over the past year were the Inter Level Debating Competition for the third time as well as the Inter University Debating Competition amongst Chemistry Special students. We are glad to note that students from five Universities & CCS will compete this year on January 30th.

Recognition of two Chartered Chemists for rendering yeoman service in an honorary capacity and richly contributing to the success of the CCS (educational) programmes in an exemplary & noteworthy manner

At the last Convocation we recognized for the first time the honorary services of five of our members who rendered invaluable services to our educational programmes. Continuing with that practice, we recognized today **Mr. E G Somapala & Ms. Purnima Jayasinha** for the services rendered by them in a similar manner. I am glad to record with pride that Ms. Jayasinha is one of our own Graduate Chemists and is the first such to be so recognized. The manner & form in which we are recognizing their services are in fact insufficient and inadequate to pay the necessary tribute to their honorary and devoted services. Let us hope however that this formal recognition annually will also be an inspiration to others as well to come forward and contribute more & more of their expertise, talents and time towards the success of our educational activities.

Our happiness

Our increasing success in becoming a very significant contributor to human resources development

in Sri Lanka should be an eye-opener for planners, bureaucrats and politicians to take a more serious & pragmatic look at the current situation and recognize that any worthwhile expansion of the number of personnel qualified at a tertiary level in Sri Lanka can arise only through efforts such as ours outside the highly regimented, bureaucratic, inefficient and over politicized state sector.

The rate of production of Graduate Chemists from our humble efforts through the professional body of Chartered Chemists in Sri Lanka has increased by leaps and bounds from a mere 4 in 1983/84 to 92, twenty seven years later. This has been achieved through dedication, commitment and hard-work of everyone involved in this glorious endeavour: students, our members, academic staff, non-academic staff and all the stake-holders. In doing so we have continued to attain and maintain the highest quality possible while numbers qualifying have increased by leaps and bounds.

An earnest appeal to our Alumni

Many of our Graduate Chemists are increasingly pursuing post graduate programmes, both locally and abroad and are doing so very well! Whether in employment or in post-graduate studies or in any other way, our Graduate Chemists have convincingly proved the worth of the qualification they have obtained. Our only regret and what is most unsatisfactory is the fact that many of them for various reasons do not consider themselves patriotic enough to come back from abroad after achieving their primary goals (of obtaining higher degrees and/or making substantial financial savings) and serve their motherland. In this connection, may I quote our Chief Guest, Prof. Dayantha Wijeyesekera, from his Convocation Address last year:

"It is disappointing to see other countries benefitting from those who are educated in this country.... those who seek greener pastures must be cautioned that the greenest is your own home country. Though you could enjoy luxuries and comforts overseas, still for all you are a second class citizen in those countries."

I cannot also fail to indicate and perhaps complain once again that we do not have adequate help and assistance towards the work of our beloved professional body and the College from many of our past Alumni. Our Graduate Chemists now number 663 & represent over 60% of the total membership of the Institute of Chemistry Ceylon! It is sad to note that the number of them, who, though in Sri Lanka, assist us by taking up positions or in other ways can be counted on one's fingers. I am glad that we have been able to recognize today one such devoted alumnus – Ms. Purnima Jayasinha.

It is high time that more and more of our alumni recognized that the Institute and the College are their academic parents as mentioned to us by Professor Arjuna Aluwihare, the Chief Guest at our Convocation in 2007. Our Alumni must realize that the future progress and sustainability of both the Institute and the College will have to increasingly depend on their cooperation by providing physical support to run the programmes of both the Institute and the College. That

is their moral duty & obligation and they should also consider it their pride to take on the positions of office bearers of the Institute and the College and/or help it in numerous ways. I appeal to the Graduate Chemists passing out today to think over these matters very seriously since the future of the Institute & the College is to a large extent in your hands.

May I also appeal to the DLTC Diplomates who are also being produced in increasing numbers to involve themselves as well more & more in Institute & College activities at least to start with by joining the Alumni Association of the College and also becoming Technician members of the Institute.

Dedication of the current Council Year 2009/10 to the Graduate Chemists produced by the College

I wish to take this opportunity to record my deep appreciation to our President, Professor Samitha Deraniyagala, for thinking it fit to dedicate the current year to the Graduate Chemists produced by the College. That by itself presents an opportunity to our alumni and in particular the Graduate Chemists passing out today to do all they can do further the activities of the Institute and the College. The theme for this year is appropriately titled "Beginning of a New Era: Challenges and Opportunities for Chemists in National Development" while the theme for the symposium during the Annual Session in June will be "Moulding Chemical Education for National Development in Sri Lanka". I am glad to learn that many Graduate Chemists have lent their support & assistance towards the success of this symposium.

2011 – International Year of Chemistry

2011 has been declared by the United Nations Organization as the International Year of Chemistry. Very few academic disciplines have been recognized in this manner. That represents a unique opportunity for all our alumni to respond to the appeals and demands of the College & the Institute. Many activities are being planned by a committee headed by a very active & energetic Graduate Chemist – **Mr. N M S Hettigedera**. He has approached many institutions both in the public & private sectors in order to celebrate this unique year in a very fitting manner. **We have only one more year to go**. Join him today to make Chemistry and the Chemical Sciences achieve a position of much greater importance in the life of our beloved Sri Lanka in 2011 and beyond. UNESCO which is co-coordinating the global scenario has chosen a very appropriate tag line for IYC – 2011: Chemistry - our life, our future! I am confident that you will respond to our appeal.

Acknowledgement

I wish to acknowledge with grateful thanks the receipt of an increasing number of scholarships & prizes at various levels of study for our Graduateship Programme.

The following Prizes have been received since the last Convocation:-

P Rohan K Fernando Prize for Special Topics in Chemistry from Mr. P R K Fernando, Graduate Chemist

Professor P. P. G. L. Siriwardene Memorial Prize for Further Topics in Inorganic Chemistry from Mr. J A Perera

Ms. Careen Manel Abeywardene Memorial Prize for Natural Products from Dr. Nissanka Seneviratne
Susila Jayaweera Memorial Prize for Biochemistry II from Dr. Amara Jayaweera

Mevan Pieris Prize for Polymer Chemistry & Technology from Mr. H S Mevan Pieris

Prof. Leslie Gunatilake Award for overall excellence in Organic Chemistry from Professor G M Kamal Bandara Gunaherath

Haniffa Award for Overall Excellence in Physical Chemistry from Mr. M R M Haniffa

Prof. J K P Ariyaratne Memorial Award for Overall Excellence in Inorganic Chemistry from Prof. Sudantha Liyanage & Prof. (Ms) Janitha Liyanage

Vasanthan & Menaka Prize for Further Management, Economics & Marketing from Mr. & Mrs. S Vasantha (Graduate Chemists)

Dr Sudath Kumarasinghe Memorial Prize for Selected Topics in Physical Chemistry from the Dr. Sudath Kumarasinghe Memorial Fund that was established one year ago with generous donations from Dr. Kumarasinghe's family members, friends, well-wishers and former students. (A **Dr. Sudath Kumarasinghe Entrance Scholarship** has also been established from 2010)

N M S Hettigedera Family Prize for Pharmaceutical and Medicinal Chemistry from Mr. N M S Hettigedera

There are more prizes that are still available for donation/endowment particularly in view of the increase in the number of optional courses now being offered at Levels 3 & 4 under the revised course structure & content. These include prizes for Food Chemistry & Technology, Computational Chemistry, Photochemistry, Chemical Sensors, Agro. Industries and Fundamentals of Chemical & Process Engineering.

I also wish to take this opportunity to thank the large number of persons, many of whom are our members, who continue to support the work of the College as academics, examiners and teaching assistants whether full-time or visiting and also provide financial support as & when the need arises. Their continued support together with the very ready help and cooperation we get from the entire staff of the Institute and the College will no doubt enable us to go forward with even greater strength and vigour on to the future!

Dr J N Oleap Fernando, *C.Chem, C.Sci.*

Honorary Dean, College of Chemical Sciences

Professor Pearlyn Pereira Memorial Oration Gold Medal Award

Calling for papers

Dear Members,

It is with much pleasure that I announce to you the decision of the Council of the Institute of Chemistry Ceylon, to provide an opportunity to our members to honour and remember the late Professor Pearlyn Pererira whose contribution to the field of Chemical Sciences and Education has been significant. The Pearlyn Pererira Gold Medal Award oration will be held on **26th May 2010**. It will be yet another opportunity for one of our members to carry away a valuable Gold Medal and earn fame.

Late Professor Pearlyn Pereira served the Department of Chemistry, University of Colombo (successor to the University of Ceylon) for 32 years with distinction until her untimely demise in 1989. She was the first Professor of Physical Chemistry at the University of Colombo and played the leading role in directing the teaching of Physical Chemistry at the Department of Chemistry. She also served as the Head of the Department of Chemistry for many years. Her generosity is well known among the university community during her period of service. She took a keen interest in the welfare of the students and extended her generosity to help the needy students. Improving the standards of teaching and research in Physical Chemistry at the University was her lifelong ambition, in pursuit of which she made a tremendous sacrifice. Her commitment to this task was amply demonstrated by her decision to set aside a large sum of money, by a provision of her last will, for the establishment of a trust for research in Physical Chemistry at the University of Colombo. Magnanimous in her desire to help needy students, she donated Rs. 50,000 to establish a scholarship at the University of Colombo in memory of her mother.

Late Professor Pearlyn Pereira was an active member of the Institute of Chemistry Ceylon and was the President of the Institute in 1985/86. She established a scholarship at the Institute of Chemistry in memory of her father by donating Rs. 50,000 for the benefit of the Graduateship students. Professor Pereira participated at the Physical Chemistry teaching programmes conducted by the Institute of Chemistry Ceylon. During 1980s she drafted the course contents of chemical kinetics for GIC Part I & II.

Professor Pereira was also an active member of the Sri Lanka Association for the Advancement of Science (SLAAS). She served as Secretary, General Research Committee, Secretary for Foreign relations and in 1985 as the President of the Chemical Sciences Section of the SLAAS.

Considering her tremendous contribution to science education in Sri Lanka it is befitting to honour late Professor Pearlyn Pereira by awarding of a Gold Medal in her memory for the best piece of research in Chemistry.

The members of the Institute of Chemistry are invited to submit their research work to reach the President of the Institute of Chemistry Ceylon on or before 19th of March 2010. The Gold Medal Presentation will be held on 26th May 2010 at 4 pm. at the PPGL Siriwardene auditorium, Adamantane House, Rajagiriya.



Professor S.P Deraniyagala
President/Institute of Chemistry

Selection Procedure

Members of the Institute in any category are eligible to apply for consideration to be selected as the orator. Applicants are required to forward the full paper of their oration to the President of the Institute of Chemistry Ceylon, and a one page CV on or before the closing date. Applications for the Pearlyn Pereira Memorial Oration will close on Friday the 19th March 2010.

Applicants are required to submit the full paper electronically to the President's e-mail address <s.p.deraniyagala@gmail.com> and in addition a single hard copy under sealed cover shall be addressed to the President and delivered to the Institute of Chemistry Ceylon, 341/22 Kotte Road, Welikada, Rajagiriya.

The Council of the Institute will appoint a panel of three or more experts and in addition the President will serve ex officio as chair of the panel. The panel will evaluate the papers and select the orator. The decision of the Council made on the recommendation of the panel shall be final. The successful applicant will be informed of the decision with minimum delay and shall have the right to upgrade the oration whilst preserving the substance of the paper originally submitted for evaluation.

Guidelines for selection the orator

The oration shall be an erudite presentation made with the aid of a suitable computer application such as Power Point. The quality of the oration must reach a high standard, and the presentation skills of the applicant, to the extent that they are known, will be taken into consideration.

The oration, which is expected to be about 60 minutes in duration, may cover any field of chemical sciences of interest to the applicant. It could be based on

- **A review of the Current Progress in the selected field AND/OR**
- **The Applicant's own research.**

THE ORATION

The oration will be held at the PPGL Siriwardene Auditorium of the Institute of Chemistry Ceylon, at 5.00 pm on 26th May 2010 and will be preceded by a reception.

Molecular Shapes

by

Prof. S. P. Deraniyagala

1.0 Introduction

The article published in Chemistry in Sri Lanka (Volume 25 No. 3 2008) described how to draw acceptable Lewis structures or Lewis dot and cross structures of molecules/ions. Although Lewis structures help us to understand how atoms are bonded and the number and type of covalent bonds present along with lone pairs on atoms, they do not show one of the most important aspects of molecules – their overall shape. Polyatomic molecules and ions have sizes and shapes that are defined by the bond angles and distances between the nuclei of the component atoms. Of these two quantities most important are bond angles in determining shapes of molecules and ions. The shape and size of a molecule of a particular substance, together with the strength and polarity of its bonds, largely determine the physical and chemical properties of that substance.

Although Lewis structures are simple 2-dimensional (2D) representation of the position of electrons in a molecule/ion, next we will learn how to predict 3-dimensional (3D) shape of the molecule from 2D Lewis formula. There is a simple model that allows you to predict shapes of molecules from Lewis structures. This is referred to as valence shell electron pair repulsion (VSEPR) model which predicts the spatial arrangement of atoms in polyatomic molecules/ions. It does not, however, explain how covalent bonds are formed and how the lone pairs are directed. The valence bond theory (VBT) describes how the bonding takes place in terms of overlapping atomic/hybrid orbitals. The valence bond theory provides further insight into why bonds form and at the same time reveals that bonds have definite direction in space.

1.1 Valence Shell Electron Pair Repulsion Theory (VSEPR) model

This theory or model is useful to predict the shape or geometry of covalent molecules and ions of non-transition elements. This model focuses on pairs of electrons in the outermost (valence) electronic shell. Electron pairs whether bond pairs or lone pairs repel one another and they assume orientation in space to minimize repulsion. (i.e. electron pairs are kept far away from one another as possible. The closer together two pairs of electrons are fixed, the stronger the repulsion between them. Repulsion between two electron pairs is much stronger 90° than at 120° or 180°) This tendency to minimize repulsion causes bonds from central atom to assume certain orientations which results in particular shapes for polyatomic molecules/ions.

For example:

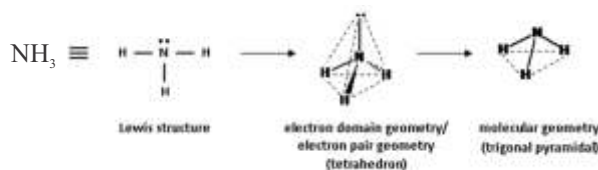
· If there are only two electron pairs (bond pairs) in the valence shell of an atom, these pairs tend to be at opposite sides of the nucleus, so that repulsion is minimized. This gives a linear arrangement of electron

- If three electron pairs – trigonal planer with bond angles 120°
- If four pairs – tetrahedron, with bond angles $109^\circ 28'$
- If five pairs – trigonal bipyramidal with bond angles 90° , 120°
- If six pairs – octahedron with bond angles of 90°

These molecules conform to general formula AB_n , in which central atom A is bonded to n B atoms with bond pairs or covalent bonds.

The possible shapes of AB_n molecules are shown in Table 1 and sometimes these are referred to as basic shapes of molecules. Bonding electron pairs and lone pairs are sometimes referred to as **electron domains**. For example Lewis structure of NH_3 () has a total of four electron domains around the central nitrogen atom (three bonding pairs and one nonbonding pair or lone pair). The arrangement of electron domains about the central atom of a molecule or ion is called its **electron – domain geometry**. In contrast, molecular shape or geometry is the arrangement of only the atoms in a molecule or ion. The lone pairs do not contribute to the description of the molecular shape. In the VSEPR model we predict the electron-domain geometry or **electron pair geometry** and from knowing how many lone pairs are present, we can predict the molecular geometry or shape of a molecule or ion from its electron – domain geometry. In the absence of lone pairs on the central atom electron – domain geometry becomes identical to molecular geometry or shape. When, however, one or more domains involve lone pairs or nonbonding pairs of electrons, we should ignore these in determining the molecular geometry or shape. Molecular geometry is the general shape of a molecule as determined by the relative position of the atomic nuclei. (i.e. their coordinates which helps to calculate bond distances and angles)

Let us consider NH_3 as an example.



We can now generalize the steps one should follow in using VSEPR model to predict the shapes of molecules or ions.

1.2 Four step procedure in the prediction of molecular shape by VSEPR model.

1. Draw an acceptable Lewis structure of the molecule or ion.
2. Count the total number of electron pairs or electron domains around the central atom. In counting each lone pair, each single bond, each double bond and each triple bond is considered as one electron domain. This total number is sometimes referred to as VSEPR pairs. The p bonds are not considered in

this count since these do not influence the shape of molecule or ion. In other words they play only a secondary role in determining molecular shape. It is only the bonds and lone pairs which decide the shape of a molecule or ion. With few, exceptions the number of VSEPR pair ranges from 2 – 6.

3. Determine the electron domain geometry or electron pair geometry by arranging these VSEPR pairs about the central atom so as to minimize repulsions as in table 1 i.e. linear trigonal planar, tetrahedral, trigonal bipyramid or octahedral.
4. Use the arrangement of the bonded atoms (ignore lone pairs) to determine the true molecular shape. This information is given in Table 2.

Table 1: Arrangement of electron pairs around an atom

Number of electron domains	Arrangement of electron domains	Electron domain geometry	Predicted bond angles
2		Linear	180°
3		Trigonal planar	120°
4		Tetrahedral	109° 28'
5		Trigonal bipyramidal	90°, 120°
6		Octahedral	90°

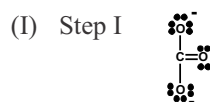
Table 2: Molecular Shapes E= lone pair

Total	Electron pairs		Electron pair geometry/electron pair domain	Molecular Shape		Example
	Bonding Domain	Non-bonding Domain (Lone pair)				
2	2	0	Linear	Linear AB ₂		Ref: F—Se—F
3	3	0	Trigonal planar	Trigonal planar AB ₃		SF ₆
	2	1		Angular AB ₂ E		SO ₂
4	4	0	Tetrahedral	Tetrahedral AB ₄		CH ₄
	3	1		Trigonal pyramidal AB ₃ E		NH ₃
	2	2		Bent (or angular) AB ₂ E ₂		H ₂ O

5	5	0	Trigonal bipyramidal	Trigonal bipyramidal AB ₅		PCl ₅
	4	1		Seesaw (or distorted tetrahedron) AB ₄ E		SF ₄
	3	2		T-shaped AB ₃ E ₂		ClF ₃
6	2	3	Octahedral	Linear AB ₂ E ₃		XeF ₂
	5	1		Square pyramidal AB ₅ E		BrF ₅
	4	2		Square planar AB ₄ E ₂		XeF ₄

1.3 Examples: Determine the shape of the following molecules/ions using the VSEPR model

- (I) CO₃²⁻ (II) NO₂⁻ (III) SF₄
 (IV) ClF₃ (V) BrF₅ (VI) ICl₄⁻



Step II VSEPR pairs = 3 (2 single bonds + one double bond)

Step III VSEPR pairs = 3 $\Rightarrow$ electron pair geometry = trigonal planar

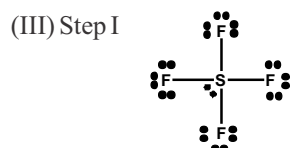
Step IV No lone pairs on central atom
 electron pair geometry = shape
 Therefore shape of CO₃²⁻ is **trigonal planar**



Step II VSEPR pairs = 3 (2 single bonds + 1 double bond)

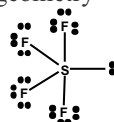
Step III VSEPR pairs = 3 $\Rightarrow$ electron pair geometry = trigonal planar

Step IV One lone pair on central atom (ignore this)
 Therefore shape of NO₂⁻ is **angular or bent**

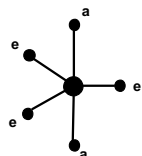


Step II VSEPR pairs = 5 (4 single bonds + lone pair)

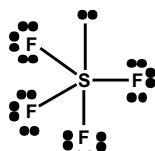
Step III VSEPR pairs = 5 $\Rightarrow$ electron pair geometry = trigonal bipyramidal



NB Trigonal bipyramid has two geometrically distinct positions. They are referred to as axial (a) and equatorial (e) positions as shown below. The three equatorial electron pairs define an equilateral triangle with bond angles 120° and two axial positions lie above or below the plane of the triangle and they form 90° angles with any equatorial domains. If a molecule/ion has non bonding pairs (lone pairs), they will always occupy the equatorial positions.



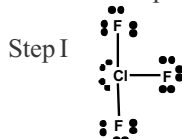
Therefore in Step 3 we will not consider the following possibility where the lone pair occupies an axial position.



Step IV One lone pair on central atom (ignore this)

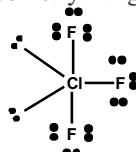
Therefore shape of SF_4 is **see-saw** ($\searrow \xrightarrow{90^\circ} \nearrow$)

(IV)



Step II VSEPR pairs = 5 (3 single bonds + 2 lone pairs)

Step III VSEPR pairs = 5 $\Rightarrow$ electron pair geometry = trigonal bipyramidal



(lone pairs occupy equatorial position)

Step IV Two lone pairs on central atom (ignore these)

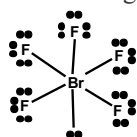
Therefore shape of ClF_3 (T) is **T shape**

(V)



Step II VSEPR pairs = 6 (5 single bonds + lone pair)

Step III VSEPR pairs = $\Rightarrow$ electron pair geometry = octahedral

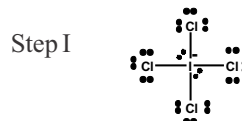


(all six positions of an octahedron are equivalent) Hence lone pair can be placed at any vertex.

Step IV one lone pair on central atom (ignore this)

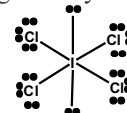
Therefore shape of BrF_5 ($\searrow \nearrow$) is **square pyramidal**.

(V)



Step II VSEPR pairs = 6 (4 single bonds + 2 lone pairs)

Step III VSEPR pairs = 6 $\Rightarrow$ electron pair geometry = octahedral



NB although the vertices of an octahedron are equivalent we have to place the lone pairs directly opposite to minimize lone pair – lone pair repulsion. Lone pairs spread out more than do bond pair electrons. Therefore repulsive forces are strongest for repulsion between lone pairs and lone pairs.

Remember the golden rule –

lp - lp repulsions > lp - bp repulsions >> bp - bp repulsions

lp – lone pair bp – bond pair

Step IV Two lone pairs on central atom (ignore these)

Therefore the shape of ICl_4^- is **square planar**.

Study Questions:

- 1) Why are molecular shapes important?
- 2) Why do molecules have shapes?
- 3) What is meant by 'molecular shapes'?
- 4) What is meant by 'molecular geometry'?
- 5) What concepts in chemical bonding will help one to determine the shapes of molecules?
- 6) Determine shapes of following molecules/ions?
(i) PO_4^{3-} (ii) SO_3^{2-} (iii) SO_4^{2-} (iv) NOCl
(v) $\text{S}_2\text{O}_3^{2-}$ (vi) NO_3^- (vii) SO_3 (viii) SO_2
(ix) N_2O_3 (shapes around N atoms)
(x) SnCl_3^-
- 7) Although CH_4 , NH_3 and H_2O have tetrahedral electron domain geometries, their bond angles differ. Explain
- 8) Why do lone pairs exert greater repulsion than bond pairs?
- 9) Arrange the following in the decreasing order in terms of the volume occupied by electron pairs
Single bonds, double bonds, triple bonds, lone pairs
- 10) Although ClF_3 , BrF_5 , SF_4 exhibit molecular distortions, XeF_4 does not. Explain.
- 11) Although one expects 120° angles for COCl_2 , the observed values are 111° and 124° . Explain.
- 12) Predict the shapes around the two carbon atoms and hydroxyl oxygen $\text{H}_3\text{C}-\text{C}(=\text{O})-\text{OH}$ in acetic acid and sketch its shape.
- 13) Using SF_4 and ClF_3 as examples, show that lone pairs always occupy equatorial positions of the trigonal bipyramid.

(Answers to study questions will appear in the next issue)

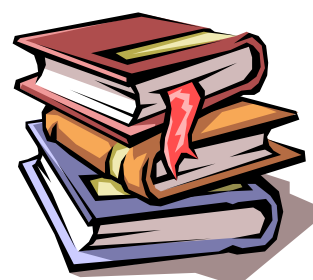
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RSC NEWS

THE ROYAL SOCIETY OF CHEMISTRY SRI LANKA SECTION

1. Membership

According to the records sent to us from the parent body, a breakdown of the membership is as follows:-

Category	Abbreviation	Number
Fellow Life Member.	F E L	05
Fellow C Chem.	F C C	09
Member C Chem.	M C C	09
Member	M E M	17
Associate Member	A M E	08
Affiliate /Under Graduate. A F U		02
Total Membership as at March 2009		50

2. Committee of Management

The following were elected to the Committee at the 48th Annual General Meeting held on 26th June 2009.

Chairman	- Mr. S Perasiriyan
Vice Chairman	- Dr. M A J Mendis
Hony. Secretary	- Mr. R M G B Rajanayake
Hony. Treasurer	- Dr. M P Deeyamulla
Committee Members	- Prof. W S Fernando Dr. Positha Premaratne Dr. Sudantha Liyanage Mr. W A P Silva Mr. I M S Herath Mr. P A N Punyasiri Mr. W J P D Jayalath
Hony. Auditor	- Prof. L G Chandrasena

The house appointed Mr. R M G B Rajanayake for the new post of Chairman/elect.

3. Proposed Activities for the year 2009/2010

1. Inter University Chemistry Competition 2009/2010 was held at University of Sri Jayewardenapura. Results will be release soon.
2. All Island Inter School Chemistry Essay Competition 2009/2010 – Mr. Sanjeeva Herath will co-ordinate the event Mr. P D Jayalath will be assisting him to organize the event.

3. Teacher Training program at the University of Sabaragamuwa – Prof. W S Fernando and Prof. Sudantha Liyanage will be the Coordinators for the event.
4. Popular lectures proposed to be held at Kandy – English lecture - by Dr. Mendis, Sinhala lecture – by Mr. Rajanayake and Tamil lecture – by Mr. Perasiriyan.
5. Donation of Teaching and learning resources for chemical society of a selected University.
6. Writing Monographs by RSC SL Section.
7. Newton A Dias Weerasinha Memorial scholarship – This will be proceeded with the amendments accepted at the A G M.
8. Donations to the Institute of Chemistry Ceylon – Full page advertisement in Chemistry in Sri Lanka, R S C Graduate ship award, Annual Dinner etc.
9. Book donation program.
10. Industrial visits.
11. Committee decisions
 - (a) Committee also decided to establish a mobile laboratory for demonstration purposes for chemistry students from schools in remote areas.
 - (b) Committee decided to have a representative “core” school from each Province to popularize Chemistry and English in that particular Province through the respective core school.
 - (c) Web Site

The web site of our Section, the address of which is as follows:-[www.rsc.org/Membership/Networking/InternationalSections/Sri Lanka/ index. asp](http://www.rsc.org/Membership/Networking/InternationalSections/SriLanka/index.asp).

Gamini Rajanayake
Hony Secretary