

CHEMISTRY

IN SRI LANKA



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64 Graduate Chemists, 3 Licentiate Chemists, 2 Advanced Diplomates pass out at the Tenth Convocation held at Waters Edge



79 DLIC Diplomates pass out at the Tenth Convocation at Waters Edge



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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

Vol. 31 No. 2

May 2014

	Pages
Council 2013/2014	02
Outline of our Institute	02
Chemistry in Sri Lanka	02
Editorial	03
Cover Page	03
Forty Third Annual Sessions and Seventy Third Anniversary Celebrations 2014	04
Theme Seminar on “Curricula and Evaluation in Chemistry for a Sustainable Economy”	05
Forty Third Annual Sessions: Address by the Chief Guest	06
Forty Third Annual Sessions: Address by the Guest of Honour	11
Technical Sessions	15
Abstracts of Research Papers to be presented at the 43 rd Annual Sessions 2014	15
Guest Articles	
Can you teach University Chemistry Abroad?	18
Lasers in Chemistry	19
International Conference on Chemical Education, 3-4 April, 2014, Colombo, Sri Lanka	21
Tenth Convocation of the College of Chemical Sciences	
Convocation Address	25
Ruby Anniversary Oration	29
Graduate Chemists Welfare Fund	32
Student Corner: Organometallic Chemistry – Part 3	33
RSC News	35
Publications of the Institute of Chemistry Ceylon	36

Theme for the year -

“Curricula and Evaluation in Chemistry for a Sustainable Economy”

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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. 1500
Member	Rs. 1500
Associate	Rs. 1200
Licentiate	Rs. 1000
Technician	Rs. 500
Affiliate	Rs. 1000
Membership for Life	Rs. 15000

Entrance Fee

All the grades	Rs. 1000
Processing Fees*	Rs. 1000
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 September 2014.

- *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.

The “43rd Annual Sessions” of the Institute of Chemistry Ceylon is scheduled to be held on 18th to 20th June 2014 at Adamantane House, the headquarters of the Institute. The Annual Sessions is the most important event of the Institute where members not only get the opportunity to listen to many presentations related to chemistry but also to interact socially. The Annual Sessions signify the end of the current Council year. The holding of the complete programme of the Annual Sessions at the headquarters itself is a significant achievement for the Institute, indicating that the Institute now has adequate facilities to hold such important events. This was made possible due to the completion of the new wing of the building equipped with the necessary facilities. The theme for the year 2014 is “Curricula and Evaluation in Chemistry for a Sustainable Economy” and a theme seminar will be held on the same topic on 19th June. This seminar will provide ample opportunities for the members to gain current knowledge in curriculum development and evaluation. The members will present their research findings at the Technical Sessions to be held on 18th June.

The month of April was devoted to the commemoration of the 40th Anniversary of the commencement of professional education programmes of the Institute. An International Conference on “Chemical Education and Research for Industrial Development & Sustainable Growth in a Knowledge Based Economy” was held to celebrate the event. More than 100 research papers were presented. The main theme was on secondary and

tertiary education. Parallel sessions on Applied Chemistry & Natural Products Research and Distance Education & Online Learning were also held. The presence of several distinguished educationists and scientists from overseas including the members of the Royal Society of Chemistry added to the success of the conference. Coinciding with the celebrations, the tenth convocation of the College of Chemical Sciences and the 65th Executive Committee meeting of the Federation of Asian Chemical Societies (FACS) were held. At the convocation 64 students received Graduate Chemist status and 78 students obtained the Diploma in Laboratory Technology in Chemistry (DLTC). This event was graced by the former Minister of Science and Technology of Pakistan and a world renown scientist, Professor Atta-ur-Rahman, FRS, as the Chief Guest. The Guests of Honour were Professor Lars Bohlin, Professor of Pharmacognosy at the University of Uppsala, Sweden and Professor Andy Hor, President of the Federation of Asian Chemical Societies. FACS members present actively participated in the conference. The new Council room was declared open by the President of the FACS, Professor Andy Hor and was used during the conference.

A new Council will be elected for the year 2014/15 at the Annual Sessions and it is expected that the new Council will carry forward the activities with commitment for the benefit of the members of the Institute and the students of the College of Chemical Sciences. The active participation of the members is therefore essential to map out the future programme for the year 2014/15.

Cover Page

In a short while, 64 of those products comprising the 31st outgoing batch will be formally conferred Graduate Chemist status bringing the overall total production up to 2013 to 969 with the annual average production over the last 4 years being 76. The large numbers enrolling (and everyone of them having the potential and possibility of ending up as Graduate Chemists) means that our overall output might very soon exceed 100 which will represent about 50% of the total Graduate Chemist output from all the other six universities put together. (page 27)

The cover page shows the Graduate Chemists at the 10th Convocation of the College of Chemical Sciences at Waters Edge. More formal photographs of the Convocation are on the inner front & inner back cover.

Institute of Chemistry Ceylon

Forty Third Annual Sessions and Seventy Third Anniversary Celebrations 2014

Inauguration of the 43rd Annual Sessions, Institute of Chemistry Ceylon

Wednesday, June 18th 2014

P P G L Siriwardene Auditorium, Adamantane House, Rajagiriya

8.00-8.45 am	Arrival of Members and Guests (refreshment will be served)
8.45 am	Ceremonial Procession of the Council Members and Past Presidents
8.50 am	Inauguration by lighting of the Traditional oil lamp and playing the National Anthem
8.55 am	Welcome Address by Prof. H D Gunawardhana President, Institute of Chemistry Ceylon
9.00 am	Presidential Address
9.30 am	Address by the Chief Guest Dr. Ariyadasa de Silva <i>Retired Professor, Faculty of Education, University of Colombo</i>
10.00 am	Address by the Guest of Honour Prof. (Mrs.) M. Vithanapathirana <i>Professor, Faculty of Education, University of Colombo</i>
10.30 am	Presentation of Awards, Prizes and Certificates Graduateship Examinations in Chemistry-Scholarships, Prizes and Awards All Island Interschool Chemistry Quiz Prizes
11.50 am	Vote of Thanks by President Elect
11.55 am	Close of Ceremony
12.15pm	Annual General Meeting of Corporate Members of the Institute of Chemistry Ceylon

Theme Seminar on
“Curricula and Evaluation in Chemistry for a Sustainable Economy”
 19th June 2014

Venue: Adamantane House, 341/22, Kotte Road, Welikada, Rajagiriya

Programme

9.00 – 9.45 a.m.	Key note Address by Chief Guest Curricula and Evaluation in Science subjects for a Sustainable Economy Mr. Sterling Perera <i>Vice Chairman, National Education Commission and Former Commissioner – General Examinations</i>
9.45 – 10.15 a.m.	An overview of Science Education in Sri Lanka Prof. Manjula Vithanapathirana <i>Professor, Faculty of Education, University of Colombo</i>
10.15- 10.45	Tea
10.45 a.m. – 11.15 a.m.	Curriculum and Evaluation in Chemistry for value addition in Tea industry Dr. P A N Punyasiri <i>Former Senior Scientist at Tea Research Institute</i>
11.15 a.m. – 11.45 a.m.	Curriculum and Evaluation in Chemistry for value addition in Rubber industry Dr. L M K Tillekeratne <i>Former Executive Director, Rubber Research Institute</i>
11.45 a.m. – 12.15 p.m.	Curriculum and Evaluation in Chemistry for value addition in Palmyrah industry Mr. Sri Vijendiran <i>Research Officer, Palmyrah Research Institute, Kalthadi</i>
12.15 p.m. - 12.45 p.m.	Curriculum and Evaluation in Chemistry for value addition in Coconut industry Dr. Jayantha Gunatilleke <i>Director, Coconut Research Institute, Bandiruppuwa Estate, Lunuwila.</i>
12.45 p.m.	Lunch
1.15 p.m. – 2.00 p.m.	Curricula and Evaluation in Chemistry for value addition to some mineral resources Professor H D Gunawardhana <i>President, Institute of Chemistry Ceylon</i>
2.00 -2.45 p.m.	Curricula and Evaluation in Chemistry for Environmental studies - Air Professor K R R Mahanama <i>Dean, Faculty of Science, University of Colombo</i>
2.45 – 3.15 p.m.	Tea
3.15 – 4.00 p.m.	Curricula and Evaluation in Chemistry for Environmental studies - Water Mr. L P R J Wijesinghe <i>Chief Chemist, National Water Supply & Drainage Board, Ambatale, plant</i>
4.00 -4.45 p.m.	Curricula and Evaluation in Chemistry for Environmental studies - Soil (solid matter) Mr R P Samarakkody <i>Director, Waste Management Authority, Western Province</i>

Address by the Chief Guest

Dr. Ariyadasa de Silva

Retired Professor, Faculty of Education, University of Colombo

Sir, Madam, Guest of Honour, Members of the Institute of Chemistry, Distinguished guests and invitees, I feel greatly honoured and privileged to attend your forty third annual sessions as your Chief Guest.

I am much obliged to the members of the Council, especially the President, Professor H D Gunawardhana, for this honour accorded to me.

I must congratulate the Institute of Chemistry and its educational arm, the College of Chemical Sciences, on the rapid and remarkable progress achieved which I think is the direct result of the dedication and commitment shown by the senior members, some of whom I had the honour of associating as respected fellow academic members of the University of Colombo. This is not my first visit to your Institute for I have attended a number of important functions here previously too, and I sincerely hope that this will not be my last visit.

I must also congratulate the Institute on the very significant theme selected for this year's Annual Sessions for it will offer you the opportunity of examining the education of Chemistry professionals who can be expected to make a significant contribution in winning the battle to achieve a sustainable economy.

The concept of sustainable economy has been explained in many ways. It has been defined as one in which our resources are not used up faster than nature renews them and benefits are shared equally. Sustainability has also been defined as improving the quality of human life while living within the capacity of supporting eco-systems. Sustainability is the capacity to endure. For humans, sustainability is the potential for well-being, which has ecological, economic, political and cultural dimensions. Sustainability requires the reconciliation of environmental, social equity and economic demands, referred to as the three pillars of sustainability.

This concept has become a topic of considerable discussion in the 21st century but has only a very short history. In the mid-20th century a gathering environmental movement pointed out that there were environmental costs associated with many material benefits that were then being enjoyed. In the late 20th century environmental problems became global in scale. The 1973 and 1979 energy crises demonstrated the extent to which the global community had become dependent on non-renewable energy resources. In the 21st century there is increasing global awareness of the threat posed by the human greenhouse effect produced

largely by forest clearing and the burning of fossil fuels. Sustainable economic development now refers to the balance of economic growth with social and environmental needs. In order for economic growth to be considered sustainable it must not compromise resources or environmental factors that should be available for the future. Environmental and resource systems should be so managed that their ability to support future generations is not diminished. Healthy ecosystems and environments are necessary for the survival and flourishing of humans and other organisms.

In order to face the global sustainable development challenges including climate change, biodiversity and the elimination of poverty successfully, we need an ethical perspective based on wide understanding and basic agreement on key principles to guide our policies and approaches to dealing with them.

In spite of the vows and offerings being regularly made before the concept of a sustainable economy it appears doubtful whether human societies will ever achieve economic sustainability in the light of environmental degradation, climate change, over-consumption and societies' pursuit of indefinite economic growth within a closed system.

As a solution, perhaps, greater faith and reliance will have to be placed on education for sustainable development that will enable every human being to acquire the knowledge, skills, attitudes and values necessary to shape a sustainable future. Education for sustainable development means including key sustainable development issues in teaching and learning. Recently the concepts of "green university" and "green education" have been addressed and promoted to incorporate environmental education, environmental protection and sustainable development into all disciplines of natural and social sciences, as well as all aspects of campus life. In China, "green education" has made considerable progress in the past ten years, and a number of researches on how to construct "green universities" have also been conducted. "Green education" has been defined as "the process of reducing the multitude of on- and off-site negative environmental impacts resulting from campus decisions and activities, as well as raising environmental awareness within the human communities of a college or university".

There are a number of major ways of reducing negative human impact. The first is environmental

management. This approach is based largely on information gathered from the sciences which may be used to develop new technologies such as green technologies, renewable energy and sustainable Fission and Fusion power. The second approach is management of consumption of resources, which is largely based on information gathered from Economics and comprises re-organizing living conditions, reappraising economic sectors and work practices, and adjustments in individual lifestyles that conserve natural resources.

It has been urged by scholars that Green education should be integrated into every academic discipline, including art, philosophy, language, sport, law etc, to promote the concept of sustainability. Among the sciences that contribute information to sound environmental management Chemistry occupies a very important place. The products of Chemistry research are all around us. Chemistry research has changed our way of living and enhanced our quality of life. Fundamental Chemistry research remains indispensable in the search for solutions to some of the important technological and scientific challenges facing Sri Lanka and the outside world, such as climate change, energy, security, food supply and health.

The integration of Green education into Chemistry requires the development of a responsive curriculum specially developed for this specific purpose. The particular approach chosen by the developers of a curriculum stems, in part, from how they formulate the problem to which they are responding. Scholars use the term “green curriculum” to refer to a curriculum that includes environmental protection, natural conservation, rational utilization and saving of resources and, advocacy of environmental friendliness as the principal content and teaching.

Curriculum is a very significant area of professional study in Education; complex and truly difficult to conceptualize. The literature dating back nearly a century is voluminous. The boundaries that define what is and what is not curriculum are vague. Although the word “curriculum” had been in existence since about 1820 Curriculum as a field of professional study in Education marked its birth only with the appearance of Franklin Bobbitt's booklet entitled *Curriculum*, in 1918. For those not in education, the term curriculum is usually associated with a document such as a textbook, syllabus, teacher's guide or learning package. For educators, however, the term is more broadly defined. It may refer to a set of intentions, activities or outcomes that are delivered in a number of ways.

Traditionally, when education was the sole

preserve of the elite, curriculum was perceived as subject matter or information, passed from one generation to another, in the form of organized knowledge. When and where there is agreement on the purpose of education curriculum work becomes almost mechanical, concerning itself with updating and renewal. Under such a dispensation, curriculum would comprise a number of essential subjects or even the mastery of a collection of books.

However, with the enormous growth in knowledge resulting in new courses being added to the curriculum and with the composition of schools shedding their elite character and changing considerably with the addition of new students, such an orderly process could not survive. The traditional definition of curriculum proved unsatisfactory and new definitions came to be offered. Very soon it became an area of study that assessed and sorted out choices and procedures. As the views on what constitutes an education multiplied the field of curriculum expanded to accommodate the development of entire educational programmes.

In the early 20th century, with social change in USA, the frustration that occurred as the basic curriculum was delivered to a general population caused a broadening of the definition of curriculum which now came to be defined as an intention or plan rather than a subject or a number of subjects.

Later still, in the middle years of the twentieth century as the diversity of learners and an understanding of the differences in students broadened, the focus shifted to what was experienced by the students.

Still later, in the last third of the 20th century there has been concern about the performance of educational programmes. This focus often referred to as accountability or standards based learning in schools, has pushed the definition of curriculum towards an emphasis on ends or outcomes. Curriculum planners refocused their efforts and defined curriculum according to the product or outcomes. A definition offered in 1995 states as follows:-

“Curriculum is concerned not with what students will do in the learning situation but what they will do as a consequence of what they have learnt. Curriculum is concerned with results.” (D. Tanner & L. Turner)

By identifying the outcomes in advance curriculum planners could work backward to set the conditions necessary to achieve their goals. Then curriculum becomes the intended outcomes of learning and the learning experiences planned and guided to achieve these outcomes.

Although recent years have seen wider adoption of learning outcomes in higher education there remain some concerns about the way in which they are

currently used. It is widely recognized that learning outcomes can enhance the educational process, but they can also be potentially damaging, if used strictly in the prescribed way. A key concern is that learning outcomes, if taken too far, can endanger more critical open-ended notions of student-centred learning.

The requirement to pre-specify learning outcomes at the outset of a programme or module can also have potentially detrimental effects on the student learning experience. This can be attributed to a number of factors. Publication of pre-specified learning outcomes in course materials may inadvertently stifle creativity and originality in both staff and students. Used rigidly, there is a danger that learning outcomes become the driver of classroom interactions and prevent discussion of ideas or questions that do not clearly relate to the set outcomes for the course/module. Such a system may create what Ecclestone (1999) calls a 'subtle form of closure on ideas about what is important in learning' with critical or possibly important outcomes and discourses being marginalized. Rather than encouraging learner autonomy and deep engagement with the subject, learning outcomes may serve to restrict learning and encourage a reductionist approach where students merely aim to meet minimum threshold standards as specified in the learning outcomes."

Although there have been many criticisms of learning outcomes and their use in higher education, like the above, there is still recognition that considerable gains can be made by focusing on the *outcomes* of education rather than on *inputs*. Learning outcomes can be used in a way that meets the needs of all stakeholders in higher education, namely, the student, the teacher and external parties, but this may involve some rethinking at both a conceptual and practical level. Accepting that student motivation is an essential element in learning, it has been proposed that those who teach should begin to reclaim learning outcomes and begin to frame them more broadly and flexibly.

The evolution of operational procedures proceeded in parallel to the conceptual mapping of the field of curriculum.

Curriculum development is a process whereby the choices of designing a learning experience for students are made and then activated through a series of co-ordinated activities. It is a logical process that begins with clear goals and proceeds in a deductive manner, through finer and finer actions to accomplish the intended purpose of that curriculum. Through a process of deduction, broad statements become goals, objectives, standards and student learning outcomes, and eventually lesson or lecture plans and laboratory practical agendas.

The purpose of curriculum development, it has been stated, is to research, design and engineer the working relationship of the curricular elements that will be employed during the instructional phase in order to achieve the desired outcome. The curricular elements referred to have been described as time, space, materials, equipment and personnel.

Above all else, curriculum leaders are concerned with the value or purpose of the curriculum. A clarification of the purpose of the curriculum is always prerequisite to sound curriculum development. A curriculum developer has traditionally been likened to an architect. Inasmuch as an architect is unable to design a building until some information is provided about the use to which the building will be put, a curriculum developer cannot easily develop a Chemistry programme without knowing the purpose it will serve.

John Dewey's former student, Harold Rugg, in 1926, outlined the operational tasks of the curriculum development as a three-step process.

1. Determine the fundamental objectives
2. Select activities and other materials of instruction
3. Discover the most effective organization and placement of this instruction.

In 1949 Ralph Tyler of the University of Chicago published his landmark book, *Principles of Curriculum and Instruction*, the theories about curriculum reform which became known as "The Tyler Rationale." In addition to setting forth his views on curriculum reform, he is also credited with establishing the importance of evaluation in designing and implementing curricula.

In this short text he identifies four fundamental questions in planning curriculum:

1. What educational purposes should the school seek to attain?
2. What educational experiences can be provided to attain these purposes?
3. How can these educational experiences be effectively organized?
4. How can we determine whether these purposes have been attained?

The first three of these questions have been asked since the time of John Dewey, at the turn of the century. With the inclusion of a fourth question, Tyler is credited with ushering in an era of evaluation in modern education. Tyler's four questions are now referred to as Tyler's curriculum planning cycle of analyze, design, implement and evaluate. Tyler's cycle enabled curriculum developers to set goals, plan experiences, select content and assess outcomes of

school programmes. Tyler introduced the concept of the curriculum development cycle whereby evaluation led to the reconsideration of purpose.

The evolution of operational procedures did not stop with Tyler's work. The process continued. Tyler's cycle itself was subjected to further refinement. It has been stated that the most refined version of Tyler's procedure for curriculum development was outlined by Hilda Taba in 1962. She identified seven major steps of curriculum development.

1. Diagnosis of needs
2. Formulation of objectives
3. Selection of content
4. Organization of content
5. Selection of learning experiences
6. Organization of learning experiences
7. Determination of what to evaluate and how to do it

Within each step Taba provided substeps that identified criteria for action. For example, in the selection of learning experiences, it was shown that it was important that the curriculum developer consider the following:

1. Validity and significant of content
2. Consistency with social reality
3. Balance of breadth and depth of experience
4. Provision for a wide range of objectives
5. Learnability-adaptability of the experience to life of student
6. Appropriateness to needs and interests of learners.

More modern lists of these steps differ from the above in that they present curriculum as a more comprehensive process. For instance, curriculum has been presented as a problem-solving action chain, as follows:

1. Identification of the problem
2. Diagnosis of the problem
3. Search for alternative solutions
4. Selection of the best solution
5. Ratification of the solution by the organization
6. Authorizations of the solution
7. Use of the solution on a trial basis
8. Preparation for adoption of solution
9. Adoption of solution
10. Direction and guidance of staff
11. Evaluation of effectiveness (Feyereisen *et al.* (1970))

This process of revision and refinement will, no doubt, continue. However, it is feared that the introduction of new interactive technologies, using the internet as a focal point will make much of the existing models irrelevant. Curriculum developers will be hard

pressed to even catalogue, let alone control, select and order the new information available to learners. Real time delivery, anytime delivery and nonlinear delivery of information to the learner *via* the internet will not easily fit the historical development of the available models. New paradigms and new models will be needed if curriculum development is to survive the "rush" of the technological age.

The field of evaluation is still young and immature, when compared with established professions such as law, medicine, engineering and accountancy, and other service areas. Evaluation theory and practice evolved in the area of education. As referred to earlier, Ralph W. Tyler is often spoken as the father of educational evaluation. In the early 1930s Ralph Tyler coined the term Educational Evaluation and, in 1949, published a broad and innovative view of both curriculum and evaluation. Over about fifteen years he developed his views until they constituted a clear-cut alternative to the views prevalent then. What mainly distinguished his approach was his concentration on clearly stated objectives. In fact, he defined educational evaluation as determining whether objectives had been achieved.

The Joint Committee on Standards for Educational Evaluation, USA (1994), provided a basic definition of evaluation as follows: "evaluation is the systematic assessment of the worth or merit of an object."

Four main uses of evaluation have been observed: improvement, accountability, dissemination and enlightenment.

The first use is to provide information for developing a service ensuring its quality, or improving it. Evaluations to serve this use are labeled formative evaluations. Ongoing feedback for improvement is the essence of formative evaluation.

The second main use of evaluation is to produce accountability or summative reports. These are retrospective assessments of completed projects, established programmes or finished products. Summative evaluations typically occur following development of a product or completion of a programme. They draw together and supplement previously collected information and provide an overall judgment of the value of the object evaluated. Generally, formative evaluation will be dominant in the early stages of a programme and less so as the programme matures. Summative evaluation will take over as the programme concludes, and certainly after it is completed.

The third use of evaluation is to help developers disseminate proven practices or product and help consumers make wise adoption or purchasing decisions.

The fourth use of evaluation is to foster enlightenment, that is, new understandings arising from revelations.

Taking Ralph W. Tyler's seminal work as the main reference point scholars have identified five periods in the development of the evaluation profession. The fifth and the last period, namely the Age of Professionalism includes the developments from 1973 to the present day.

During these periods of development Tyler's rationale itself proved inadequate to the development task. New theories of evaluation and methods of evaluation came to be developed. Many new conceptualizations of evaluation also began to emerge.

Research related to assessment indicates that reliance on one form of assessment, such as multiple choice testing, can restrict achievement for certain groups of students and narrow the curriculum. Many processes and products are involved in one learning domain, meaning that an assessment task must be broad, or more than one type of assessment is required to capture all of the learning. The inclusion of different forms of assessment within a single learning programme can support students to demonstrate their abilities within a specific domain. Students at risk of not succeeding will only be supported if teaching and learning associated with the subject include the skills and understandings required to perform successfully within a type of assessment. The capacity of students to work with particular types of assessment cannot be assumed. Teaching practices are required that first gauge the skills of students and then develop their capacity to complete successfully the assessment types associated with particular subjects. Research on assessment highlights the importance of describing clearly assessment tasks within curriculum, so that the skills and understandings associated with particular forms of assessment can be explicitly taught. In addition, studies suggest that a close alignment of learning with assessment tasks and curriculum expectations will boost student achievement.

To conclude, achieving economic sustainability is vital to safeguarding the future of our human civilization. However, like most other things desired, economic sustainability will not dawn effortlessly by itself. It can be attained only by the careful and purposeful investment of human attention and endeavour. Education is one of the strategic fronts where our endeavours should be invested. Offering a specially planned curriculum and subjecting it to regular and effective evaluation enabling necessary revision and renewal is a *sine qua non* of the educational effort to attain economic sustainability. I

am happy that you have selected these two very significant professional fields in education for detailed scrutiny and study.

I wish this event and all deliberations with this regard to be an astounding success and lead to the desired capacity building of the participants in a very big way.

Acknowledgements

I am much indebted to the following sources for the information included in this brief presentation:

Wikipedia

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I am also much indebted to a Professor in the Faculty of Education of the University of Colombo who helped in a number of ways.

Address by the Guest of Honour

Prof. (Mrs.) M. Vithanapathirana

Professor, Faculty of Education, University of Colombo

President of Institute of Chemistry Ceylon, Professor H D Gunawardhana, Chief Guest, Prof. Ariyadasa De Silva, Council Members of the Institute of Chemistry Ceylon, Academics of the Institute of Chemistry, Distinguished invitees, Students and Ladies and Gentlemen,

I am privileged to be here today and to be received as the Guest of Honour of this esteemed event. I thank you Professor Gunawardhana and the members of the Council of the Institute of Chemistry for inviting me. Although I am an academic from the Faculty of Education, University of Colombo, I am very much aware that my beginnings in science has contributed in a big way to make me who I am today. I am able to recall my undergraduate studies in Chemistry at the Faculty of Science, University of Colombo where I studied under Prof. J N O Fernando and Prof. H D Gunawardhana. Your eminence and rigor as intellectuals and your student friendly teacher personalities will be remembered even to the future with heartfelt admiration.

Today I wish to share my analysis as an education scientist some key aspects on curriculum and evaluation trends in chemistry towards your theme of the Annual Sessions 2014, 'Curricula and Evaluation in Chemistry for a Sustainable Economy'.

Sustainability is a major global issue. Of the four Pillars of sustainability one is economic sustainability, the other three being environmental, social and time. Sustainability in **economic** terms means the efficient management of scarce resources as well as a prospering industry and economy. Sustainability builds on good education. Education has been prioritized as an important strategy that has a major role in bringing about sustainable development. The present global trends show that economic sustainability results through the emergence of knowledge-based economies. Knowledge economies are reliant on their effectiveness in developing and utilising knowledge. Knowledge embodied in new products and services has become the primary source of wealth creation. In today's changing world, knowledge, and the processes to generate and manage it, has become key factors in creating competitive business advantage.

Chemistry is a leading science. The applications of chemical sciences are more than we can count. Stronger sustainable chemical industry is an aspiration of many economies of the world. Chemistry has a huge role to play in solving society's current and future

challenges related to social, economic and environmental spheres. For example the chemical industry addresses the water quality issues by contributing with efficient technologies with reduced environmental and energy impact for water purification technologies, substitution of raw materials for industry improving resource and energy efficiency etc. Innovations in chemistry are based on the quality of chemistry education. Subject knowledge related to any discipline is imparted through the learning teaching process. In an educational setting all purposeful learning should be planned through a curriculum that has an appropriate underpinnings, rationale and suggestions for suitable pedagogies and assessment to inform and assist those who are responsible with its implementation.

'Knowledge-based curriculum' was the traditional model of the curriculum. Knowledge is powerful because it enables students to interpret and control the world. It is unfair and unjust when children are offered poor quality knowledge which fails to lift them with their experience. An objection towards the knowledge-based curriculum is, 'school subjects' soon become out of date and inappropriate in a world in which knowledge is changing so fast (Young, 2013). Further, there are concerns expressed about content selection in chemistry curriculum development. The main concern is that chemistry content has become too theoretical and that there is a need to place the content in a more relevant context. In this situation, the major problem is reaching an agreement about what might be left out of the general chemistry course in order to introduce such desirable features as the ability to solve problems and use chemical knowledge. Hence, the accepted idea is that the curriculum development in chemistry should avoid inclusion of theory for its own sake. Mbajorgu & Reid (2006) show that there is a necessity to address the following four issues in the process of curriculum development - Chemistry for Whom? What Chemistry? How to be Taught? How to be Assessed?

In addressing the issues of the chemistry curriculum it is necessary to understand and differentiate the purposes for chemistry education at school level and for higher education. The general conception is that, for school level, the contribution of learning chemistry would be to develop responsible citizenship and a population which can make informed decisions based on a sound understanding of the chemical issues encountered. This means that the school chemistry curriculum should not be determined

largely by the needs of the minority who might become chemists. The curriculum must be reconsidered in terms of the whole group - who will become the general citizenship in terms of knowledge in chemistry. Hence, in school curriculum design it becomes important to seek and define the kind of chemistry which the wider population will need. Syllabuses then can be planned around these major themes, the themes being those having significance for the majority. In this regard it is necessary to identify the core chemistry requirement and the advanced chemistry requirement. The core is intended to provide students with a basic experience at the very beginning. The core curriculum creates a common experience. The content must be consolidated with each core concept developed into a value-added/application/relevant package.

A rather recent curriculum change in school chemistry curriculum in several countries highlights the development and introduction of a 'context-based education'. Context-based science education adopts the view that science content is negotiated within realities, evolving and flexible and not just a set of rules and principles to be memorized. This reform is seen as a complete renewal of the chemistry high-school curriculum, touching upon the educational goals, the subject content and the pedagogy. Teachers need to understand and be prepared and equipped for context-based education, as they are the ones to enact it in their classes. Development of student learning material and teacher preparation can be combined through the involvement of teachers in the development of the material.

For higher education an important aspect is the need to develop the knowledge, skills and attitudes required for a very wide range of career opportunities which contribute to economic sustainability. In higher education, 'Sustainability science' is a newly emerged field as a strategy for developing sustainability. This new field is unique as it brings experts from different disciplines to devise more holistic sustainable solutions to global problems. Chemistry has been identified as an important discipline for contributing to the design of sustainable strategies. This interdisciplinary science has to be packaged as new courses. One such example is the integrated chemistry and business studies program. This newly conceived program gives students the opportunity to acquire the comprehensive scientific and business background needed to be competitive in the employment market - all within a relatively shorter period of time and without the need for expensive, time-consuming additional study. The program provides students not only with the theoretical and practical basis of

chemistry and research but also the students become familiar with current economic theories, thus learning how to think and act in the world of business. Thanks to the combination of two fields that are significant and fundamental to the economy, varied and exciting employment opportunities are open to graduates of the program.

It has long been recognized that education and training are concerned with bringing about change in individuals, and the use of learning outcomes to describe these changes in a curriculum is not a new practice. A learning outcome is 'something that students can do now that they could not do previously or a change in people as a result of a learning experience'. The most well known contribution to the development of outcomes-based curricula was '*A Taxonomy of Cognitive Objectives*' by Benjamin Bloom in 1956. Bloom's taxonomy provides a framework for classifying learning across cognitive, affective and psychomotor domains. The most controversial domain in the classification is the cognitive domain where six different kinds of student cognitive outcomes i.e. *knowledge, comprehension, application, analysis, synthesis and evaluation*, are laid out. The order of the arrangement indicates the advancement of the cognitive outcomes. The taxonomy is still being used with modification and revision.

In the revised Bloom's Taxonomy by Bloom's colleague David Krathwohl (2002), six types of thinking are arranged from simple to complex. The taxonomy is built on the assumption that the more complex or higher-level thinking skills are built on the simpler or lower level thinking skills. The skills at the top of the hierarchy have come to be thought of as higher-level thinking skills and those lower in the hierarchy have come to be thought of as lower-level thinking skills. The categories are expressed as verbs rather than nouns. *Knowledge* is changed to *Remembering*. *Comprehension* became *Understanding*, *Synthesis* is renamed as *Creating*. In addition, *Creating* is the highest level in the classification system, switching places with *Evaluating*. The version is now *Remembering, Understanding, Applying, Evaluating and Creating* in that order.

Over the past decade there has been a major move to position 'thinking' as a more explicit outcome within curricula including chemistry in many nations (Fensham & Bellocchi, 2013). Many nations are concerned to include explicit learning goals related to critical and creative thinking and problem solving in their educational systems, as a response to 21st century learning challenges. Mission of education should be to transform students from containers of information to

creators of knowledge through learning. Effective learning stimulates the thinking and reasoning power of the pupil for developing problem-solving ability and capacity of personal achievement to explore new ideas and concepts. Learning to think and thinking to learn are two imperative skills essential to knowledge economy. The concept of 'Thinking Skills Curriculum' (Lim, 2011) is a term used to thinking outcomes based curricula and has objectives of promoting critical thinking and problem solving.

The emphasis on developing higher-order forms of thinking that go beyond the mere recall of information, aims to enable students to grasp a deep understanding of what they are learning, to be more critical of evidence and arguments, to be creative and generate new knowledge, as well as to problem solve and make decisions. It is necessary to find effective ways to frame such skills within curricula and assessment. Defining and setting out thinking skills in a progressive framework is a design challenge for curriculum developers.

The future of global chemistry curriculum development efforts seem to be very much in the line of contributing to economic sustainability through research and innovation. The emphasis is that 'the chemistry curriculum should seek to develop higher order thinking skills and the assessment must reflect this'. An instructional system is only considered as coherent when curriculum, pedagogy, assessment and other drivers and incentives are all 'aligned and reinforce one another. Although there is a growing consensus about the need to pursue these broader learning goals, the challenge for many countries is to find effective ways to frame such skills within the chemistry curricula. The intended chemistry curriculum in various countries sets out inspirational statements for the levels of higher-order thinking to be attained by students. Research point out there is a serious gap between the intended curriculum and the attained one. (Noveanu, 2011; Fensham & Bellocchi, 2013).

One of the problems in the way students are taught science today lies with the way student learning is assessed. Although traditional measurement instruments are regarded as an identifier of what students learned in classical education system, it is the common view that these tests do not mostly reflect dimensions of students' 'real' learning. Furthermore, it is necessary that not only gains in cognitive field but also the gains of students in affective and psychomotor domain should be assessed. Even though cognitive development is assessed, there are concerns internationally that dominant assessment practices in science focus on low order thinking skills and that this

in turn encourages teachers to focus on pedagogies that emphasize rote-learning which is a lower order thinking skill. Frequently in examinations a greater distribution of marks are allocated for lower-order thinking questions. Examinations associated with a criterion-referenced examination tended to award greater credit for higher-order thinking questions. This suggests that the assessment instruments associated with chemistry curricula would play significant roles in supporting or hindering the intent for higher order thinking (HOT). Greater emphasis should be placed on the application of knowledge to analyze a problem and interpretation of chemistry situations rather than on the recall of facts. Terms such as linking, application, interpretation and explanation are indicative of HOT.

It is also anticipated that the explicit inclusion of thinking skills as part of the revised curriculum would require a pedagogical shift – away from traditional didactic methods of teaching towards a more interactive and dialogic pedagogy, with a focus on metacognitive self-regulation. Accordingly, students higher in metacognitive self-regulation monitor and evaluate their learning process and in this way they observe their progress. This process helps them to think critically. Students who take responsibility of their own learning, in other words, students using metacognitive self-regulatory strategies effectively, tend to be higher in efficacy. Empirical studies carried out in several countries have revealed that these students believe in their capabilities to both explain fundamental chemistry concepts and connect chemistry with everyday life.

Within this perspective inquiry based learning is widely recommended by science and education leaders around the world. Moving from a teacher-centred to a more student-centred instruction, involves a radical change in teachers' beliefs about the nature of teaching and learning. Thus, the adoption of a 'learning paradigm' in higher education puts the learner at the heart of the educational process. Curriculum experiments in chemistry are being done where active learning and problem based learning related laboratory studies are assessed for impact (Madhiri et al, 2012).

For an innovation to be used as a solution it has to be incorporated into the policy framework and accepted by the mindsets of the people in the society. Therefore, within the curriculum development process improving the image of chemistry in the community is also important. The poor public image of chemistry that blames chemicals for all our world's environmental ills has to be removed. Chemistry educators must understand how people form their opinions about chemistry. How can education encourage a positive image of science, shaping future students' interest in

science, attracting students to study science and graduating them as advocates of science? Positives of chemistry seem to be under emphasized in chemistry curricula especially at the secondary level. The students have not been subjected directly to the 'excitement' for chemistry and its 'value added' significance to our lives.

Communities are unaware that, the chemical industry has undergone a major restructure embracing the principles and practices of 'green chemistry', thereby forming the foundation of a sustainable chemical industry. This issue can be addressed through the community outreach activities in education within higher education institutions. Service learning projects related to chemistry, research and community outreach can embed the principles of sustainability. One of the side benefits of encouraging involvement of both faculty and students alike in community outreach is that the students can see from an early stage of their education towards scientific careers, how important it is for scientists to become involved in local educational initiatives. These activities give the public a positive picture of "real, live scientists".

It is also necessary that we study the curricula of this region to understand the general trends of chemistry curricula development. Emerging Positive characteristics of chemistry curricula from a few Australian universities are given below.

1. Exemplifies Chemistry in context
2. Exemplifies Chemistry as an enabling science
3. Shows chemistry as a human endeavor.
4. Quantifies 'sustainability' from a chemistry perspective.
5. Reveals the broad-ranging emphasis of chemistry in technological development
6. Reveals what chemists 'do' in real life – demystifies chemistry
7. Shows how chemistry provides a wide range of products to enhance the quality of life
8. Reveals the positives and negatives of chemistry in the global environment – in particular with respect to political overtones (climate change)
9. Raises the public image of chemistry via effective educational pedagogies.

(Hill and Warren, 2009)

The Malaysian 21st Century Chemistry Skills Test represents five domains such as,

- i) Digital Age Literacy;
- ii) Inventive Thinking which includes Entrepreneurship component;
- iii) Effective Communication;
- iv) High Productivity. The fifth domain which is Religion, Health, and Civic has been also been added (Sukor, Osman.& Abdullah 2010).

Finally, in view of these ideas it seems necessary for us to review our curricula, formulate priorities, identify commitments and resources towards a valued curriculum goal and outcome towards ensuring sustainability. It cannot be ignored that the interconnectedness of economic, social and environmental sustainability is strong and hence, the mission for chemistry education is challenging. Collaboration and interdisciplinary research and curriculum development experiments would be essential to address these challenges and move towards economically, socially and environmentally sustainable future.

I hope the sessions would address some of these issues during the next two days. I sincerely wish the very best for the sessions and to the future of the Institute. Thank you very much.

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Technical Sessions

Venue: Adamantane House, Rajagiriya

Time : 2.00 p.m. – 3.20 p.m.

Date: June 18, 2014

Time	Title	Authors
2.00 p.m.	Synthesis, characterization and antibacterial studies of novel Copper Ferrozine complexes	Supun Katugampala, Chandrika Nanayakkara and Theshini Perera
2.30 p.m.	<i>In-vitro</i> radical scavenging properties, anti-inflammatory and α -amylase inhibitory activities of <i>Eriocaulon quinqueangulare</i> aqueous extract	S C D Fernando and S S S B D P Soysa
3.00 p.m.	Activity of the Methanol Extract of leaves of <i>Cassia alata</i> against some plant pathogenic fungi	D G C Shashikala, S A Deraniyagala and R L C Wijesundara
3.30 p.m.	TEA / END	

Abstracts of Research Papers to be presented at the 43rd Annual Sessions 2014

Technical Sessions : A - 01

Synthesis, Characterization and Antibacterial Studies of Novel Copper Ferrozine Complexes

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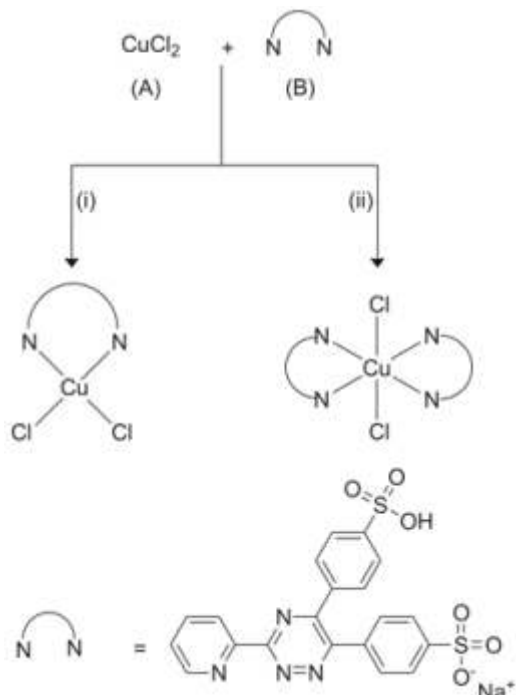
email: theshi.sjp@gmail.com

Metallotriazine complexes possess interesting biological and medicinal properties and the present study focuses on the synthesis, characterization, and antibacterial assays of two novel copper-triazine derivatives in search of potent antibacterial and anti-fungal drug leads. In this study, 3-(2-pyridyl)-5,6-diphenyl-1,2,4-triazine-*p,p'*-disulfonic acid monosodium salt hydrate (L, ferrozine) has been used as the ligands to study complexation towards copper(II).

$[CuCl_2L] \cdot 7H_2O \cdot MeOH$ (**1**) and $[CuCl_2L_2] \cdot 5H_2O \cdot MeOH$ (**2**) have been synthesized (**Scheme 1**) and isolated as light green and dark green crystalline precipitates, respectively with

almost 70% yield. Both complexes have been characterized spectroscopically and preliminary bioassays have been carried out. FTIR spectroscopic data have shown that the stretching frequencies of N=N and C=N complexes have shifted towards lower frequencies in comparison with that of the ligands, confirming new bond formation between Cu and N, which in turn lowers the strength of N=N and C=N bonds. Also a bathochromic shift has been observed for UV-Visible spectra (**Figure 1**) of complexes (**1**) and (**2**) in comparison with free ligand. Furthermore, elemental analysis data have been useful to obtain empirical formulas of these complexes and to establish the purity of each complex.

Scheme 1. Synthesis of ML₁ and ML₂



Reagents and conditions

(i) A : B = 1 : 1 (methanol, R.T)

(ii) A : B = 1 : 2 (methanol, R.T)

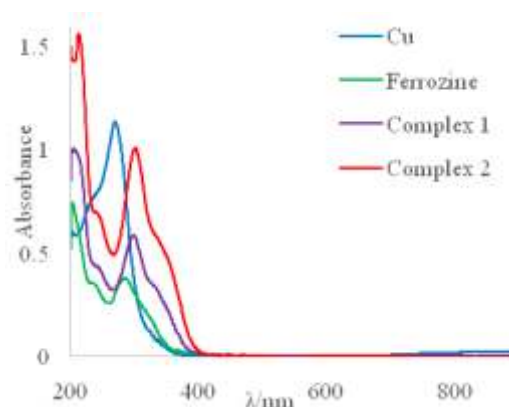


Figure 1. UV-Visible spectra of [CuCl₂], ferrozine, complex (1) and complex (2)

Complex (1) and (2) have shown antibacterial activity against the Gram positive *S. aureus* (ATCC 25923) and Gram negative *E. coli* (ATCC 25922) strains at 1 mg/disc concentration indicating its broad spectrum of activity and ferrozine showed marked activity against *C. albicans* at 1 mg/disc concentration than the positive control (Fluconazole). Bio activities of the said compounds are reported here in for the first time.

Technical Sessions : A - 02

***In-vitro* radical scavenging properties, anti-inflammatory and α -amylase inhibitory activities of *Eriocaulon quinquangulare* aqueous extract**

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Decoction prepared from the whole plant of *Eriocaulon quinquangulare* (Sinh: Heen kokmota, Family: Eriocaulaceae) is used in traditional medicinal system in Sri Lanka to treat patients suffering from vitiated pitta, inflammation, fever, pruritus, urinary system diseases, liver disorders, jaundice and splenomegaly since ancient times¹. Lyophilized powder of the whole plant of *E. quinquangulare* was investigated for its phytochemical constituents, *in-vitro* radical scavenging properties and anti-inflammatory properties in terms of nitric oxide scavenging ability and membrane stabilizing effects. In addition, this extract was also assayed for α -amylase inhibitory activity. The total phenolic and total flavonoid contents were determined using Folin Ceocalteu method and aluminium chloride colorimetric assay respectively. The radical scavenging properties of the decoctions were investigated using 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging assay and nitric oxide (NO)

scavenging assay. Hydrogen peroxide (H₂O₂) scavenging assay was conducted using horse radish peroxidase method². Membrane stabilizing effects of the decoction was determined by hypotonic solution induced human erythrocyte hemolytic assay. α -Amylase inhibitory activity was evaluated using 3,5-dinitrosalicylic acid (DNSA) method.

The mean $\pm$ SD for the levels of total phenolics and flavonoid contents were 10.32 $\pm$ 1.63 w/w % gallic acid equivalents and 45.55 $\pm$ 3.77 w/w % (-)-epigallocatechin gallate equivalents respectively. The EC₅₀ value demonstrated by the extract for DPPH radical scavenging assay was 37.18 $\pm$ 1.69 μ g/ml compared to L-ascorbic acid (EC₅₀ = 3.30 $\pm$ 0.27 μ g/ml). The extract possessed higher scavenging ability of nitric oxide radicals (EC₅₀ value = 31.85 $\pm$ 2.22 μ g/ml) than L-ascorbic acid (EC₅₀ = 276.3 $\pm$ 25.8 μ g/ml). A considerable potential to scavenge H₂O₂ was exhibited by *E. quinquangulare* (EC₅₀ = 381.98 $\pm$ 1.83 μ g/ml) compared to gallic acid (EC₅₀ = 7.82 $\pm$ 0.19 μ g/ml). The

EC₅₀ value of 1.794 ± 0.045 mg/ml elicited by the extract for hypotonic solution induced human erythrocyte hemolytic assay suggests that it can prevent hypotonic solution induced human RBC cell membrane rupture appreciably when compared to the standard anti-inflammatory drug, sodium salicylate (EC₅₀ = 2.548 ± 0.083 mg/ml) in a dose dependent manner. *E. quinquangulare* had a capability of inhibiting pancreatic α-amylase with an EC₅₀ value of 1.383 ± 0.066 mg/ml with respect to potent amylase inhibitor, tannic acid (EC₅₀ = 0.018 ± 0.003 mg/ml). The results obtained suggest that the decoction prepared from *E. quinquangulare* total plant possess outstanding anti-inflammatory properties in terms of NO scavenging ability and membrane stabilizing effects as well as an ability to reduce postprandial hyperglycemia via inhibition of pancreatic α-amylase. The higher levels of phytoconstituents present might be accounted for these activities which make it desirable to be used as a herbal medicament by the traditional medicinal system in Sri

Lanka. The quantification of the plant's individual phytoconstituents as well as pharmacological profile based on *in-vivo* studies and clinical trials should be further investigated.

Acknowledgement: Financial assistance by Department of Biochemistry & Molecular Biology, Faculty of Medicine, University of Colombo and National Science Foundation, Sri Lanka.

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Technical Sessions : A - 03

Activity of the Methanol Extract of leaves of *Cassia alata* against some plant pathogenic fungi

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Investigation of alternative natural compounds for management of plant fungal diseases has important scientific and economical values to society.¹ *Cassia alata* Linn. is an ornamental flowering plant and an important medicinal plant. It is used in traditional medicine and its efficacy has been proved scientifically for dermatophytic infections and some other human infections.^{2,3,4,5} The effectiveness of antifungal activity of leaves of *C. alata* against some plant pathogenic fungi has been tested in this study.

Leaves of *C. alata* collected from Puttalam District, Sri Lanka were extracted to cold methanol and hot methanol. The *in-vitro* antifungal activity of the methanol extracts of *C. alata* leaves were measured against four common plant pathogenic fungi. Antifungal activity was determined by the food poisoning method. In food poisoning method, plant extracts were mixed homogeneously with molten potato-dextrose agar to prepare the agar plates. Thereafter, a mycelium disk was inoculated in the middle of each plate. Mancozeb was used as the positive control.

The methanol extracts of leaves of *C. alata* significantly inhibited (p<0.05) the growth of *Rizoctonia solani* at both 1 mg/ml and 10 mg/ml

concentrations and significantly inhibited (p<0.05) the growth of *Rigidoporus microporus* at 10 mg/ml, but did not cause any inhibition of *Fusarium oxysporum* and *Corynespora cassiicola* at either 1 mg/ml or 10 mg/ml concentrations. Methanol extract of *C. alata* leaves had significantly higher (p<0.05) fungicidal activity than mancozeb against *R. microporus* at 10 mg/ml. Therefore leaf extract of *C. alata* has the potential to be developed as an efficient, environmental friendly, cheaper alternative to mancozeb.

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Can you teach University Chemistry Abroad?

Dr Julie Hyde, CChem, FRSC

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This was a question asked to me when we offered a 3 + 1 degree to a group of Chinese students at Nanjing University of Technology (NJUT). The Chinese students from NJUT would have the opportunity to study for a BSc in Chemistry by taking all of the Sheffield University Chemistry degree modules from our level 1 and 2 years but taught in China over 3 years. The Chinese students would study the modules in English and the course would be taught by lecturers from the University of Sheffield who would travel to China, stop for 2 weeks and deliver the modules during this two week block. Although this would be a demanding way to study the course, it has been successful for the students to date. Currently the first intake of students are in their 3rd year and are preparing to go to Sheffield during the summer of 2014 for the final year of their BSc.

A chemistry degree must be supported with practical work so I was challenged with the opportunity to deliver our undergraduate laboratories at NJUT in China. Although we have 2 years of laboratory work in Sheffield at level 1 and 2, it was necessary to develop a programme to deliver a laboratory course over 3 years, especially as a significant number of the Chinese students have studied none, or very little practical chemistry. The course in China would need to assume no practical experience, then develop their skills to be able to carry out the level 1 and 2 practical experiments from Sheffield.

The preparation included trials and selection of 6 suitable year 1 practicals that would give the student the skills required to carry out the level 1 Sheffield practicals. A mixture of inorganic, organic and physical practicals were selected and chosen so the students gained quantitative skills such as titration techniques. Volumetric skills were developed by carrying out by the analysis of vinegar, the determination of copper in an unknown salt together with a potentiometric titration to determine the relative molecular mass of an unknown organic molecule. Organic synthetic skills were developed by carrying out a simple preparation of a derivative of an oxime and extraction of a natural product and the use of quickfit apparatus through steam distillation. Physical practical skills such as use of a simple spectrophotometer were developed by the analysis of an indicator in different media such as acidic and neutral conditions. This also developed further quantitative analytical techniques and dilution skills. Recording data and use of the laboratory notebook followed by simple write

ups of results in English were also introduced. The year 1 was a good introduction to the practical skills and consolidation of techniques for students who did have some practical skills from previous chemistry courses.

The equipment and conditions in the laboratories in China together with good technical support from NJUT allowed successful delivery of the year 1 practicals. Year 2 and 3 practicals would be more challenging but with meetings and discussions between myself, my Chinese colleague and our technician which were carried out on my visits to China we were all clear what was required. I provided detailed equipment lists, chemical requirements and new procedures in advance so that preparation could be carried out in advance of my visits. This ensured equipment and chemicals were purchased and provided for the students and the practicals were delivered without any problems.

For Year 2 the practicals were the same as the level 1 Sheffield practicals except the language was modified slightly at this stage as the students were still developing and learning English. Again 6 practicals were delivered. There were two inorganic practicals, both involving preparation, analysis of products, and one synthesis used air sensitive conditions under an inert atmosphere of carbon dioxide. The two organic practicals developed synthetic skills with reflux, TLC, recrystallization and melting points through oxidation and an Aldol reaction. IR was also used during this year after delivering the theory in year 1. For the 2 physical practicals again data handling was very important to develop and this was carried out by students determining the equilibrium constant of the iron thiocyanate complex and then determination of the order of reaction using crystal violet. Both of these practicals used colorimetric methods and quantitative techniques for the sample preparation. Further use of documentation of results in the laboratory notebook as well as more detailed result write up's in English including discussions, conclusions and the use of literature references.

Year 3 was the most challenging for the programme, the practicals were exactly the same as the Sheffield level 2, no changes to the language this time to ensure they are fully prepared to enter directly into the Sheffield degree at level 3 for the final year of their BSc. Instead of taking just one day to complete the practical they would take one and a half days and with the expectation that the students will be ready practically to join the Sheffield cohort. There were 5

practicals, 2 inorganic, 2 organic and one physical. Students used all the techniques taught in earlier years and gained further new skills such as column chromatography and submission of their own proton NMRs. The 2 inorganic practicals were the preparation of optically active complexes and the acetylation of ferrocene, the 2 organic practicals included a Grignard and a Wittig reaction and the physical was a conductivity practical which required the determination of the order of reaction of *t*-butylchloride. As well as gaining further skills, the reports and laboratory notebooks were much higher standard typical to that of a student who will progress into a final year research group. Writing up their experimental's in the journal style and a full report was a challenge for the students English skills but they coped very well.

After completing the course of the 17 practicals over 3 years, and successfully passing their exams the

Chinese students will earn a place to complete the final year of their BSc degree in Sheffield. It will be interesting to see how this group of students progress as compared to the students who have studied their degree in Sheffield.

Acknowledgments:

My thanks to Dr Tom Anderson, Dr Jenny Burnham, Dr Colin Crook, Professor Mike Ward, Dr Ed Warminski, Richard Bottomley, Alison Smith, Dave Towers. Thanks also to the students who trialled the Year 1 practicals during their Level 3 project with me: Amy Cockram, Natalie Dunn, Sarah Fischer, Rebecca Gambrill, Kristine Sanchez, Tankia Stewart, Emma Tolson, Alex Woodmass (University of Sheffield). Gratitude for assistance also to Dr Laura Hancock (Keele University), Professor Haijian (Karen) Shi (Nanjing University of Technology, China) and Li (Shirley) (NJUT).

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## Lasers in Chemistry

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Lasers are extremely versatile and offer a vast choice of power, wavelength, and pulse frequency to satisfy a plethora of research objectives related mainly in chemistry and physics.

When lasers were invented back in 1960s, they were called a solution looking for a problem. Lasers are now ubiquitous, with compact disk players, bar code scanners, and eye surgery techniques as the most widely used applications. Since then, they have generated billions dollar businesses and about 10 Nobel laureates can thank lasers for the breakthroughs they achieved.

#### How do lasers work?

The word LASER is an acronym formed from **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation. In fact, today it is used as the noun "laser". The laser action is mainly governed by stimulated emission and population inversion. There should be a meta-stable excited state between ground and excited state where the stimulated emission<sup>1, 2</sup> is possible. A meta-stable state has a sufficient lifetime which can participate stimulate emission. Population inversion is the condition that there are more molecules in the upper state than that of the lower. There are several methods to achieve the population inversion. Figure 1(a) represents a possible meta-stable state that corresponds to laser light generation with a 3-level laser.

The molecules in the ground state (**X**) is excited to an excited state (**I**) by a process called pumping. Pumping, transfers molecules from **X** to **I** (**I**←**X**), is usually achieved with an electric discharge. In fact,

the state **I** may be a combination of several excited states and molecules in those states non-radiatively decay to low lying state (**A**) which is called the laser state or the meta-stable state. This non-radiative process is so fast and continues until the meta-stable state satisfies the requirement for lasing action "population inversion". Once there are more molecules in the level **A** compared to level **X**, the lasing will take place and usually this is a slow process compared to the non-radiative decay from state **I** to **A**.

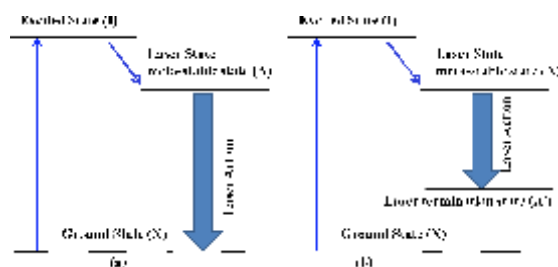


Figure 1: (a) Three level laser, (b) Four level laser

Three level laser requires that so many ground state molecules to be converted to excited state(s) molecules in order to achieve population inversion. Therefore, the above system is modified by introducing a different state (**A'**) which can terminate the lasing action instead of ground state as in the case of Figure 1(a). The new system (Figure 1 b) is called the 4 level laser and the process will be simplified compared to a three level laser as the lasing action terminates in the state **A'**. Since **A'** is also an excited state and not populated initially any population in the state **A'** will create population inversion. Moreover, the transition **X**←**A'**

will make the state A relatively empty and helps the lasing action.

The laser action in modern lasers is enhanced by different techniques such as Q-switching and mode locking.

There are a very few characteristics which are inherent only to the laser light as shown in the following Table 1<sup>1</sup>.

Table 1: Characteristics of laser light

| Characteristic            | Uses/Advantages                                             |
|---------------------------|-------------------------------------------------------------|
| High Power                | Can be used for multi-photon experiments Low detector noise |
| Monochromatic (one color) | Selective and High resolution                               |
| Collimated beam           | Long path length                                            |
| Coherent                  | Can interfere between beams                                 |
| Pulsed                    | Precise timing                                              |

### Types of Lasers

The lasers can be classified depends upon the amount of energy produces or the lasing medium. The following list shows the classification according to the lasing medium.

1. Gas lasers – CO<sub>2</sub> laser, He-Ne laser
2. Solid lasers – Ruby laser, Nd-YAG laser
3. Liquid lasers – Dye laser
4. Semi Conductor lasers – Junction diode lasers

### Applications of Lasers

Some of the most exciting applications in Chemistry are listed below.

1. Multi-photon Spectroscopy  
Since the laser light generates a relatively large number of photons in a short period of time this opens up a window for a new area. Since the photon density is high, a single molecule may be able to absorb more than one photon and these are called multi-photon processes. As an example if the process involves one photon only g u transitions are observable. However, if the process involves multi-photons (2 photons) both g g and u u are observable.
2. Raman spectroscopy  
With Raman spectroscopy, the shift in wavelength of the scattered light reveals molecular structure and provides a unique spectral signature. A photon of laser light can excite a molecule. If the molecule relaxes back to a different state, the emitted photon will have a different frequency (energy) from the one that was absorbed and the shift in energy can be used to infer the different vibrational and rotational states of a molecule and hence give away the identity of the molecule itself. The monochromaticity of laser light is a great advantage for the Raman spectroscopy which makes possible to clearly identify scattered light and high resolution. In addition, the monochromaticity allows observing very close absorption frequencies which are used in

FT-Raman spectroscopy and Resonance Raman spectroscopy.

### 3. Cavity Ring Down Spectroscopy<sup>3</sup>

This is one of the most commonly used techniques to determination of the absorption. Figure 2 shows a setup which was developed by the author of this for the determination of absorbance of a substrate coated on a thin film. In this technique the life time is measured and then absorbance is calculated.

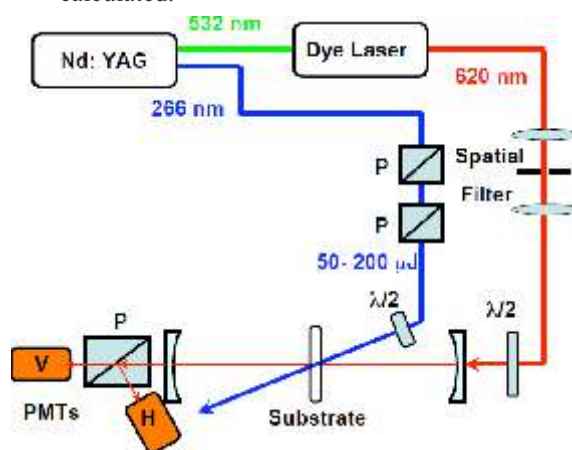


Figure 2: Cavity Ring Down setup for a solid state sample

There are several advantages of this method.

- a. Can be used to study gas phase, liquid phase, and solid phase samples
- b. Very high resolution up to 10<sup>-6</sup> of absorbance units which may never be achieved by the conventional absorption techniques
- c. Can be used for ultraviolet, visible, and infrared regions in the spectrum
- d. Life time decay is measured as a function of time and then absorbance is calculated instead of direct measurement of absorbance

Beside these advantages listed above there are disadvantages associated with this method. This needs a considerable amount of funding to set this up and the damage to the people working with the high energy laser beams may be prominent.

### 4. Time Resolved Spectroscopy

As mentioned in characteristic in laser light the pulse generation and the duration of such short pulses are quite useful in chemistry specially to study the kinetics of chemical reactions. Depends upon the pulse duration laser can be further categorized and are used for different purposes. Most commonly used pulsed involve nano-second lasers to study rates of reactions, femto-second and pico-second pulses to study the energy conversion from one mode to another mode. The time resolved laser pulses are used to obtain the absorption, emission, and sometimes intermediates states.

This is possible due to the short pulse length of the laser light.

In addition to above mentioned methods there are a large number of other applications of lasers related to or not to chemistry. In fact, today laser has been used from very basic copying machine to highly sophisticated space investigations. It is the duty of human to utilize this great technique in a manner to create the betterment of mankind.

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## International Conference on Chemical Education, 3-4 April, 2014, Colombo, Sri Lanka

The International Conference on Chemical Education was held on the 3<sup>rd</sup> & 4<sup>th</sup> of April 2014 at the Waters' Edge, Capital City and Adamantane House, Institute of Chemistry Ceylon, Sri Lanka, with over 200 national and international participants. Prof. Atta-ur-Rahman, FRS, Former Minister for Higher Education, Pakistan, attended as the Chief Guest. Prof. Lars Bohlin, Uppsala University, Sweden and Prof. Andy Hor, President of the Federation of Asian Chemical Societies were the Guests of Honor.

Other foreign delegates came from countries such as Australia, China, Bangladesh, Germany, India, Iran, Japan, Kashmir, Malaysia, Nigeria, Pakistan, Papua New Guinea, Saudi Arabia, Singapore, Sweden, Taiwan, Thailand, United Kingdom, USA etc.

There were 5 Plenary lectures delivered by Prof. Atta-ur-Rahman (Some Adventures in Natural Product Chemistry and Higher Education), Prof. Lars Bohlin (Medicinal Chemicals from Natural Sources – Education and Research), Dr. Michael Limbach (CaRLa – The Catalysis Research Laboratory Catalyzing the Cooperation between Science and Industry), Prof. Soon Ting-Kueh (Chemical Weapons Convention, OPCW and Multiple Uses of Chemicals) and Dr Peter Wothers (Inspiring the Scientists of the Future).

There were, at the conference, 94 oral presentations and 6 poster presentations under the following sessions.

1. Tertiary Education
2. Applied Chemistry Research
3. Natural Products/Drug Discovery
4. Secondary Education/ Teacher training
5. New development in Chemical Education for a knowledge based economy

#### Tertiary Education

At this session, there were 22 papers, and the Keynote addresses titled, “The Role of

Multidisciplinary Research in the Twenty First Century Science Education” was delivered by Professor Eugene de Silva, Virginia Research Institute and Institute of Physics, USA and “The Role of Technology in Chemical Education” by Dr. David Reed, University of Southampton, Highfield, Southampton, UK. Other papers concentrated mainly on the Graduateship Program in Chemistry of Institute of Chemistry Ceylon. Dr. Julie Hyde, University of Sheffield, UK presented a paper on “Journey through the Chemistry Education System in England, from Secondary through Tertiary to HE and beyond”.

#### Secondary Education/ Teacher training

The session on secondary education, focused on various aspects of secondary education in Sri Lanka and 14 papers were presented. The Keynote address titled, “Problem-based Learning to Enhance Chemistry Education” was delivered by Professor Sunethra Karunaratne, University of Peradeniya, Sri Lanka. Prof. J N O Fernando, Honorary Rector, College of Chemical Sciences, Institute of Chemistry Ceylon, presented a paper titled “Performance Levels of Excellence at the National Examinations in Sri Lanka do not Appear to be a True Reflection of Mastery of Material?”, and the paper “Providing Challenging Environment to Learn Chemistry Concepts and Gain Skills through Problem-Based Learning Method” was delivered by Ms. C K Narampanawe, University of Peradeniya, Sri Lanka. This session was mainly attended by school teachers from all over the island.

#### Symposium on New Development in Chemical Education for a Knowledge Based Economy

A symposium was organized on “New Development in Chemical Education for a Knowledge Based Economy” with the aim of discussing various new developments occurring throughout the university systems.

9 papers were presented at this session, and the Keynote address titled “Post Graduate Science Education in Sri Lanka: Then and Now” was delivered by Prof. Namal Priyantha, University of Peradeniya, Sri Lanka. Various developments in other universities including The University of Peradeniya, The University of Ruhuna and The University of Jaffna were discussed and compared along with the teaching developments in The College of Chemical Sciences, Institute of Chemistry Ceylon.

#### **Applied Chemistry Research**

There were presented, at this session, 35 papers and the Keynote addresses titled, “Novel Coordination Polymers and Metal-Organic Frameworks Containing Main-Group Elements for Energy Applications” was delivered by Professor P D Lickiss, Imperial College, London, UK and “Fluorescence Sensors: Past, Present and Future” by Professor M D P de Costa, University of Colombo, Sri Lanka. The main topics of the papers presented were “Green Chemistry, Nanotechnologies, University Industry Interactions and so on. Prof. Jasim Ahmad, Jahangirnagar University, Bangladesh presented a paper titled “University Industry Interaction in Bangladesh : The Role of Bangladesh Chemical Society” and a paper titled “LDH-Curcumin Nano-Composites and Their Therapeutic Potentials” was presented by Supun Samindra, College of Chemical Sciences, Institute of Chemistry Ceylon. The following are some of the other papers presented in this session: “Development of Moisture Management and Health Care Textile” by R W Gunasekera, University of Colombo, Sri Lanka; “From Traditional Chinese Medicine to Modern Cosmetics: A Strategy for Developing New Active Ingredients” by Prof. Lu Long, Shanghai Institute of Organic Chemistry, Chinese Academy of Sciences, China.

#### **Natural Products/Drug Discovery**

8 papers were presented at this session, and the Keynote address titled, “Why study Marine Natural Products?” was delivered by Professor S Sotheeswaran, Dean, College of Chemical Sciences, Institute of Chemistry Ceylon. This session included various types of researches related to natural products/ drug discovery carried out in areas such as Medicinal Chemistry, Molecular Biology and so on. Prof. S N Jayashree, Manipal University, India presented a paper titled “Targets in Anti Cancer Research” and Mr. S C D Fernando presented a paper titled “Time Course Variation of Phenolic, Flavanoid Contents and Antioxidant Activity During Steeping of Sri Lankan CTC Black Tea (*Camellia sinensis*) Infusion”.

#### **Distance Education & Online Learning**

6 papers were presented at this session, and the Keynote address titled, “Opening up Educational Practices with OER-based e-learning” was delivered by Dr. S P Karunanayake, The Open University, Sri Lanka. Various types of researches on the innovations in the distance education systems were presented at this session. Professor S Sotheeswaran, Dean, College of Chemical Sciences, Institute of Chemistry Ceylon presented a paper titled “Innovations in Chemical Education in the South Pacific by the Distance and Flexible Learning Mode (DFL)”.

The conference was an enriching experience for Sri Lankan scientists, who were able to interact with distinguished scientists from overseas, during the sessions and also during the informal dinner and cocktail gatherings. It is hoped that the foreign visitors also found their experience in Sri Lanka rewarding both academically and socially. It is hoped that contacts made during the conference will lead to mutually beneficial collaborative work in the future.

### **Mrs. Sakunthala Tennakoon - New Government Analyst**



**Mrs. Sakunthala Tennakoon**, a Fellow of the Institute of Chemistry Ceylon and a Chartered Chemist has been appointed as the new Government Analyst in March 2014. She Graduated from the University of Peradeniya in 1982 and obtained MSc at the University of Strathclyde, UK in 1993. She received the “Zeneca Pharmaceutical Prize” award given to the most meritorious student in the master’s programme. She joined the Government Analyst’s Department in 1983 as an Assistant Government Analyst and has over 30 years of service at the time she was appointed as the Government Analyst.

She has several publications in peer reviewed journals of international repute and has attended many international conferences. She has been a Council Member of

the Institute of Chemistry (2010- 2012) and held the position of Secretary, Admissions to Ethical Practices Committee.

We congratulate her and wish her very best in her new position as the Government Analyst.

## International Conference on Chemical Education, 3-4 April, 2014, Colombo, Sri Lanka

Inauguration of the International Conference by lighting the traditional oil lamp



Prof. Andy Hor, (Singapore)  
Guest of Honour



Prof. Lars Bohlin, (Sweden)  
Guest of Honour



Conference Participants on 4<sup>th</sup> April at Adamantane House

Conference Dinner at Grand Oriental Hotel in Fort on 3<sup>rd</sup> April



Welcome Dinner for FACS delegates at Dutch Burgher Union Premises on 2<sup>nd</sup> April



Executive Committee Members of the Federation

**Opening of the New Board Room on 2<sup>nd</sup> April  
by President, Federation of Asian Chemical Societies (FACS)**



**65<sup>th</sup> Executive Council Meeting of FACS at new Board Room on 2<sup>nd</sup> April**



**500<sup>th</sup> Council Meeting of the Institute of Chemistry Ceylon  
and unveiling of photographs of Distinguished Service Awardees (2013)**



## Tenth Convocation of the College of Chemical Sciences

Convocation Address:

### Developing a Knowledge Economy

**Professor Atta-ur-Rahman, FRS**

*Nishan-i-Imtiaz, Hilal-i-Imtiaz, Sitara-i-Imtiaz, Tamga-i-Imtiaz*

*Ph.D. (Cambridge), Sc.D. (Cambridge)*

*UNESCO Science Laureate*

*HEC Distinguished National Professor*

*Patron-in-Chief, International Center for Chemical and Biological Sciences*

*President, Pakistan Academy of Sciences*

*International Centre for Chemical and Biological Sciences, University of Karachi, Karachi, Pakistan*

Professor H D Gunawardhana (President of the Institute of Chemistry Ceylon), Professor J N O Fernando (Honorary Rector of the College of Chemical Sciences), Professor Lars Bohling (Guest of Honour), Members of the Council and Academic Board, Staff of the Institute of Chemistry Ceylon and the College of Chemical Sciences, Passing out Graduate Chemists, Advanced Diplomates and DLTC Diplomates, Conference delegates including those from the Federation of Chemical Societies, Invited Guests, Parents and well-wishers, Students of the Institute, Ladies & Gentlemen.

Today is a historic day for you dear students. It marks the beginning of a new journey of your lives --- one that can take you to new heights, given the determination, effort and passion for learning. I hope that many of you will embark on exciting careers of research and discovery, as I have done and enjoyed so much.

We live in an age where innovation determines progress and truth has indeed become far stranger than fiction. The remarkable manner in which innovation is transforming our lives is illustrated by the following examples. The blind can today see with their tongues. How do they do that? A company, Wicab, in Wisconsin, USA has developed a device that comprises a camera fitted on the glasses worn by the blind person. The optical signals captured by the camera are converted into electrical signals and then transmitted into a lollipop like device in the mouth of the blind person. These signals are then transmitted to the brain through the nervous system in the tongue, thereby restoring partial eyesight. Almost miraculously, the blind person can then differentiate between a knife and a fork and see the lift buttons!

In another development a cap fitted with certain sensors has been invented that allows a completely paralysed person to move his wheel chair just by thought control. Our brain emits four types of thought signals, one of which is the command signal. This can be recognized by the sensors on the cap linked to a

computer and the paralysed person can thereby move his wheelchair in any direction purely by giving a thought command through a computer to the wheel chair. A car was driven around Germany last year just by thought control using the same technology.

There have been other striking developments too. The "disappearing cloak" in the Harry Potter books is now a reality! This is the result of the development of "metamaterials" that have the ability to bend light around them. Objects cloaked with this magical material actually disappear! The technology is now being applied by defense agencies for cloaking tanks, submarines and airplanes. Bullet proof paper has been invented using nanotechnology. Genes of luminescent deep sea jelly fishes have been transplanted into orchids, thereby affording flowers that glow like fire flies in the dark! 3D printing has come into the fore, and many objects are being manufactured using this exciting new technology. Tomorrow you may well be driving a car most of the components of which may have been printed on a 3D printing machine. Anti-aging compounds have been discovered, and when these were administered to old mice, the mice became younger (work of David Sinclair at Harvard, <http://www.hms.harvard.edu/agingresearch/pages/faculty.htm>). A small building was constructed last year in China with flying robots working in unison. Airplanes have been developed that can fly without internal fuel. These are scramjets. When they reach 12 times the speed of sound, they can capture oxygen from the stratosphere and use that as fuel. A robotic fly has been developed that is alive but fitted with cameras and sound systems. It can be remotely manipulated and guided. There are a large number of such drone insects now being used for espionage. They can sit on the desk of your Prime Minister or President and send all the pictures and conversation to the foreign embassy of a super power a few miles away. A car has been invented in France that can run purely by compressed air. The first synthetic life was experimented with and a cell has been developed

that is fitted with a completely synthetic genome. It replicates and exhibits the features of life. A completely synthetic cell is now being built (work of Craig Venter in Maryland, <http://www.guardian.co.uk/science/2010/may/20/craig-venter-synthetic-life-form>). A new material graphene has been invented which is a much better conductor of electricity than copper and 200 times stronger than steel. It has a honeycomb structure of carbon atoms, and a strand of it 150 times thinner than the human hair is so strong that you can hang an elephant without the strand breaking!

These are just a few examples of the strange and wondrous world of science and innovation that we live in. The Nobel Laureate (late) Arthur Kornberg once stated in a lecture that I attended in Trieste that "Necessity was once considered to be the mother of invention--- this is no longer true. The inventions are coming fast and furious, and are becoming our daily necessities"

Countries that have invested massively in quality education, science & technology, and have then linked the research to the development of innovative products through fostering entrepreneurship are cashing in from the brain power of their youth. Some 4000 companies have emerged from the graduates of just one institution, MIT, that have annual sales of about \$250 billion and employ over a million people. Stanford, with the silicon valley that emerged around it, is one of many examples how the strengthening of the triple helix, government, academia and the private sector, can result in huge benefits to those countries that have the will and passion to travel on the "knowledge road" to socio-economic development.

The four pillars on which a knowledge economy can be built are: (1) education, (2) science & technology, (3) innovation & entrepreneurship and (4) good governance. This last pillar encompasses the need for a merit-based system, a strong independent judiciary that swiftly punishes the corrupt in an exemplary manner, and a visionary, honest and technologically competent government.

There are numerous examples of how poor and weak nations have been transformed into powerful countries within a couple of decades once they have given the highest priority to these factors.

In a number of countries in Asia this was achieved with remarkable success due to strong and visionary leaderships. Take the case of Singapore. It is a small country with no natural resources. In 1960, it had a small but rapidly growing population of 1.6 million. In the subsequent decades it was transformed into an economically powerful giant, all because of the visionary and honest leadership of one man ---Lee Kwan Yew, Singapore's first Prime Minister. He took

charge as Prime Minister on 5<sup>th</sup> June 1959 and governed Singapore for three decades. He established a corruption-free government, ensured the availability of a skilled work force and developed excellent infrastructure, thereby attracting huge foreign investments. In the period between 1964 to 1978, Singapore changed from an import substitution policy to an export oriented one. Between 1965 and 1978, the manufacturing sector's share of GDP jumped from 14% in 1965 to 24% in 1978. The growth rate averaged a remarkable 10% per annum and the unemployment rate fell from 10% in 1965 to 3.6% in 1978. During the subsequent 8-year period (1978-1985), the share of skilled employees in the total employment doubled from 11% to 22%. The salaries of workers also increased from an average of \$18,400 in 1979 to \$27,000 in 1985. In the subsequent period between 1986 to 1997, focus was given to niche industries such as electronics, engineering and petrochemicals. The GDP growth rate averaged 8.5% and the number of research scientists shot up from only 3,361 in 1987 to 11,302 in 1997. Its GDP increased from US \$12 billion in 1980 to US\$ 251 billion in 2010. About 3,000 multinational companies have begun operations in Singapore. The biotechnology industry has been given top priority and a number of leading pharmaceutical companies have set up manufacturing plants in Singapore. Singapore continues today to be the fastest growing economy in the world, with an enviable growth rate.

In Malaysia, a similar story was repeated under the leadership of Mahathir Mohammed. Malaysia had an economy based on mining and low value agriculture in 1970. In 1980, the GDP of Malaysia was only US\$ 26 billion. It made a determined effort to shift to a manufacturing economy. By 2010, its GDP has shot up to US\$ 414 billion, and the per capita income now stands at US\$ 14,700. Malaysia alone contributes 86.5% of the total high technology exports from the Islamic world, such as microchips and semiconductors, a truly remarkable figure.

The transformation of Korea serves as another excellent example. The corrupt democracies prior to 1961 had contributed to its dismal failure. The foundations of a powerful industrial nation in Korea were then laid by the visionary policies of General Park Chung-hee. He seized power in 1961 and ruled till his assassination in 1979. Korea was a poor country with a per capita income of only US\$ 72 in 1961. Today the per capita income stands at a stunning figure of US\$ 30,200, while its GDP stands at US\$ 1.423 trillion! General Park brought about a radical change with export-oriented industrialization policies. He mended relations with Japan, and Korea developed rapidly

with Japanese investments and technology.

If countries such as Pakistan and Sri Lanka are to emerge from the shackles of foreign debt, poverty and hunger, they need to unleash the tremendous creative talents of their youth. We must tap into this vast reservoir of creativity and employ it to migrate from our present low value added agricultural economy to a high value added knowledge economy.

The ability of nations to develop a strong knowledge economy depends critically on their ability to access and absorb external knowledge, in particular knowledge about technology, to adapt it to local conditions and to generate new knowledge for value addition, industrial diversification and competitiveness. Research & Development (R&D) expenditure, both public and private, is essential not only for generation of new knowledge, but for absorption, adaptation and diffusion of external knowledge. R&D directly determines the levels of innovation, national competitiveness and economic growth.

Engineering represents the single most important sector vital for national development. Expertise in engineering lies at the heart of all national development strategies as it determines the level of industrial growth as well as self-reliance in defense manufacture. The steel industry, special alloys, engineering goods, manufacture of industrial machinery, automobile manufacture, electronic, household appliances, robotics and computer science, textiles, chemicals and pharmaceuticals, industrial design---indeed every sector of the national economy depends on engineering.

While public R&D expenditure is important for supporting university research in both basic and applied fields, it is the private sector (business) R&D expenditure which is critical for firm level learning and building up absorptive capacities in order to bring about a major economic change. Globally, the share of private sector R&D expenditure has risen much faster than public R&D expenditure. The total global R&D expenditure is estimated at around US\$ 1.4 trillion, of which the share of private companies is 63% and the share of governments is 37%. In most OECD countries, the share of the public R&D expenditure has declined but business R&D spending has been rising. Business R&D accounts for 70% of total R&D spending in China, 68% in the United States, 75% in Korea and Japan and 70% in Germany. The R&D expenditures of countries such as Sri Lanka's percentages of GDP are very low compared to India's 0.8%, China's 1.6% and South Korea's 3.4% of much larger GDPs. In China and South Korea, about 80% of R&D expenditure is spent on development.

Unlike most developed and East Asian countries,

public policy in countries such as Pakistan and Sri Lanka, has not stimulated private R&D through incentives such as tax allowance, tax credits or innovation grants. Contract R&D between industry and university is very limited due to absence of incentives and bridging institutions such as incubators and technology parks.

There are important pro-poor innovation lessons that can be learnt from China. In 1998 China started producing electric bikes indigenously with just 12 producers who produced over 56,000 units per year, whereas conventional bike production stood at 42 million in the same year. The policy instruments favored predominantly the efficient, low cost and environmentally friendly commuting solution for the masses. As a result within 12 years by 2010 China was able to dominate the electric bike market, with 2000 producers manufacturing 30 million units of electric bikes annually, 80% of which were sold domestically. Currently, due to such timely and well planned policies, China has emerged as a leading producer, consumer as well as exporter of electric bikes in the World. From component manufacturing to mining of lithium metal in China, the government channelized investments in the sector through China Investment Corporation.

Demand for innovation is also created through priority setting or identifying areas for specialization as no country has the resources or capabilities to compete in all areas. India's focus on ICT services industry and China's specialization in the manufacturing industry are just two examples from many. Finland is ranked as number one in global Innovation ranking. Its fast catch-up strategy is based on selecting Telecommunication as the area of specialization. Supporting local firms with public R&D expenditure, provision of high quality scientists and engineers, encouraging inter-firm collaboration and mergers within local and with international firms resulted in the emergence of Nokia as a top multinational firm. In 2001, Nokia's sales were EUR30.4 billion with an operating profit of EUR 5.8 billion. Nokia had established its manufacturing facilities in 10 countries, its R&D units were established in 14 countries and most of these units were located close to leading universities and research organizations in host countries.

So the key to developing a strong knowledge economy lies in high quality education at all levels. Sri Lanka has developed a strong school system but its universities remain very weak, largely because of low government priority to higher education and lack of a clear policy to migrate to a knowledge economy. At a conference of Vice Chancellors of Sri Lankan

Universities held recently in Banderawela, where I was Chief Guest, I was stunned to hear a statement from a senior government official of the Ministry of Education that the vision of Sri Lanka was to have a few universities in the top 1000 universities of the world over the next decade. It was not realized that only the top 300-400 universities have reasonably good standards. There are many weak universities at the bottom of the list in the top 500 and below them are mostly second and third rate universities. The vision is therefore incorrect and requires a major adjustment. Sri Lanka should be striving to have at least 3 universities in the top 300 over the next 10 years.

I would like to once again congratulate the students that have been awarded various degrees today. I pray that this mark the beginning of long and illustrious journeys to serve your mother land.

In the end I would like to state that over the years I have learnt that certain basic values in life are vitally important so that one can live with grace and dignity. I have summarized these below:

- Let the acquisition of knowledge be a life – long passion – for knowledge will turn you into a jewel. Blessed are those who can illuminate others around them by spreading knowledge far and wide.
- Be fearless in speaking the truth – since it is the suppression of truth which is the source of most evils.
- Value integrity above all else – for men without honour are a shame to humanity.
- Have the courage to stand up for what you believe in, but do not let arrogance distort your personality – knowledge leads to humility, and ignorance to arrogance.
- Have confidence in your abilities but do not be boastful, for it is the empty ones who swagger the most.
- Be polite, for courtesy is an important virtue.
- Be firm and patient in the face of adversity, since difficult times will soon give way to better days, provided that you have the fortitude to continue the struggle with determination.
- Strive for excellence in whatever you do, and try to do what you do in a manner that no one else could do it better.
- Be gentle and caring for others since it is the attribute that reflects what is the finest in a human being.
- Do not hesitate or be afraid to love – love is a rare gem, once found it must be nurtured and treasured.
- Let not hate or jealousy be a part of your character, as it will only diminish you.
- Be generous and charitable, for generosity of spirit will elevate your personality.
- Have a sense of humour, and be pleasant and charming – this is a virtue which once cultivated will make you likeable among others and bide you over difficult times.
- Be bold, frank, straightforward and sincere since you should have nothing to be ashamed about.
- Learn to understand yourself, discover your strengths and weaknesses, it is only then that you can unleash your true potentials.
- Do not be afraid to stand up and be counted on the side of righteousness, since most of our problems are due to men who sit on the fence for the sake of expediency while injustice is perpetuated around them.
- Be just, and accept no less from others.
- Do not accept the printed words blindly but question everything, for even Newton or Einstein can be wrong. However do not reject the other point of view till you have analyzed its logical basis.
- You are surrounded by the wondrous beauties of nature – learn to appreciate them and to explore their secrets – for this is why you were created.
- Learn to persevere in what you do – hard work, done intelligently, never goes unrewarded.
- Learn to smile at your failures and laugh at your successes, take failures in your stride, for success and failure go together.
- Do not let time slip by wastefully but make every moment count, for time is a precious commodity.
- Take pride in your religion, in your culture, and in your heritage but let moderation prevail since fanaticism leads only to destruction.
- Learn to work hard and with consistence – it is rightly said that genius is 99% perspiration and 1% inspiration. Indeed let statistics work for you – remember that even if you have only 2% chance of success, you are bound to succeed twice if you try a Hundred times.
- Stand up and fight for your rights, but take care that you do not infringe on the rights of others.
- Remember that rights and duties go together – so perform your duties diligently.
- Be thankful for all the things with which you have been blessed – for there are many others around you whom fate has blessed with much less.
- Do not be extravagant even though you are blessed with plenty – and give what you can to others who are more needy than you – remember that the little which you give will mean much to them.
- Live your life with grace and wisdom, in a manner that it is useful to others, so that when you are gone, others may say 'their truly was a Man'.
- Above all, be God fearing, for in spite of all our apparently magnificent achievements, we are handful of atoms in temporary resonance with one another, destined to disperse and then reassemble to be judged for our deeds.

**RUBY ANNIVERSARY ORATION :**

## **A unique, productive and creative contribution towards Human Resources Development over four decades**

**Professor J. N. Oleap Fernando**, CChem, CSci.

*(Honorary Rector and Honorary Professor, College of Chemical Sciences, Institute of Chemistry, Ceylon.)*

Perhaps I may be the only person in this distinguished audience who was present and have nostalgic memories of the inauguration (in May 1973) at Aquinas College of the first and only **Technicians Training programme** in Chemistry (now re-designated as the **Diploma in Laboratory Technology in Chemistry**). I cannot fail to mention the efforts of our forefathers led by **Dr. Sente Shanmuganathan**, (then President, IChemC and founding coordinator) who felt the dire need and necessity to provide a middle level training programme in Sri Lanka. We have to remember with gratitude and respect the foresight, forethought and the altruistic sense that enabled a serious lacuna at the middle level in Sri Lanka to be thus filled, I use the word **altruistic** very meaningfully since very small payments were made to the dedicated lecturers and the Institute as a body did not make any charge whatsoever for all the academic services provided in the first decade of the programme. Our Institute had been incorporated by Act of Parliament only an year earlier (on 15.4.72) but we had no money, no office, no staff, no infrastructure; however we had the dedicated commitment and selfless service from many members and others who put in their maximum effort to make this programme a resounding success. I am glad that I myself functioned as a lecturer in physical chemistry and analytical chemistry for over fifteen years at the inception. Today we pass out the largest number ever -78- of such Technician Diplomates who have qualified in either Clinical Laboratory Technology or Food & Industrial Chemistry. I am glad to note that increasing numbers of DLTC Diplomates are now also registering to follow the Graduateship programme. We also accept the DLTC qualification as an alternate qualification for admission to our Graduateship Programme.

The **Graduateship Programme in Chemistry** commenced only six years later in 1979 – the Institute still having no money, no infrastructure, no staff, no office but continuing to have the support and assistance of chemistry academics, researchers and experts working in many universities, research organizations, service institutions and the private sector. Our Institute commenced this higher level Graduateship Programme in Chemistry to supplement the woefully inadequate small number of about 40 honours level (special degree) Graduate Chemists

produced at that time from four universities (Colombo, Peradeniya, Jaffna and Sri Jayewardenepura). The seventies was also a period of acute foreign exchange scarcity in Sri Lanka with imports of chemicals and instruments even for educational institutions very difficult and virtually non-existent. It was also a time where, unlike today there were virtually no other openings - outside the non-fee paying state university sector – for undergraduate level education in most fields in Sri Lanka. Our Institute recognized this distressing unfortunate and depressing tertiary education scenario in Sri Lanka and formulated our Graduateship Programme to cater largely for middle level personnel (such as technicians), late developers, adults and the matured who had missed earlier opportunities. I must once again place on record the dominant influence exerted by the then Institute President, **Professor R. S. Ramakrishna** who weathered all storms and took the bull by the horns and launched this programme in May 1979. There were many critics who likened our unique efforts to that of Advanced Level tuition classes, which were quite predominant even at that time as well with the customary mercenary objectives. Our Institutes' objectives were however to be of service to many who had, for various reasons, missed the bus to obtain tertiary educational opportunities but were qualified and suitable to receive same. Although we did not have even the minimum infrastructure and the physical resources, we laid our foundation on the invaluable human resources we had.

To cut a four decade old history short, our efforts and objectives were fulfilled in a manner we could never have dreamt of! Of course, the peculiar situation in Sri Lanka in which only a microscopic minority of students were able to benefit from university education within the non fee levying state sector meant that the bulk of our student clientele very soon transformed largely to that of young school leavers. That change was inevitable but welcome!

In a short while, 64 of those products comprising the 31<sup>st</sup> outgoing batch will be formally conferred Graduate Chemist status bringing the overall total production up to 2013 to 969 with the annual average production over the last 4 years being 76 The large numbers enrolling (and everyone of them having the potential and possibility of ending up as Graduate

Chemists) means that our overall output might very soon exceed 100 which will represent about 50% of the total Graduate Chemist output from all the other six universities put together. This is indeed a classic example of what a professional body could achieve free of bureaucracy and party politics. Consider also the fact that our programme costs a student today only around Rs. 400,000 (USD 3000) **over a four year period** which undeniably is perhaps the most economical amongst any such parallel programme in any part of the world. With no external funding (local or foreign) our production of 969 Graduate Chemists and 942 Chemistry Technicians over the past four decades amounts to on national terms a notional contribution of over Rs.2.5 billion (USD 200,000) if one recognizes that the average **annual average** cost to the national exchequer to produce a non fee levying University science graduate in something of the order of rupees 400,000 (USD 3,000) per year. We have also been able to construct and make available at Adamantane House using savings from the fees collected from students about 20,000 square feet of space, over the past 10 years. This international conference will continue tomorrow using some of the extended space so obtained.

Ten years ago in April 2004 we held a two day conference on Chemical Education at a regional level with the participation of the Executive Committee members of the Federation of the Asian Chemical Societies. (FACS) That event commemorated the 25<sup>th</sup> anniversary of the establishment of the Graduateship Programme in 1979. Today we inaugurate (to commemorate the completion of 40 years of professional chemical education provided by our Institute) an International Conference on Chemical Education with the participation of not only the Executive Committee members of FACS but also other distinguished speakers and participants from the global scene. The Institute of Chemistry Ceylon and its educational arm – the College of Chemical Sciences – are indeed greatly honored and privileged to welcome you all and host this conference over the next two days. We hope you will all have an academically satisfying conference and also be able to receive traditional Sri Lanka hospitality.

#### **Accreditation by the Royal Society of Chemistry, UK**

We are glad to report that the virtual doubling of our output over the past decade has not been at the expense of quality and standards. On the recommendation of the RSC accreditation team which visited the College of Chemical Sciences in June 2012, we were formally accredited by the RSC, UK (as satisfying the academic requirement for Chartered Chemist status) in March 2013. The number of internal

academic staff has increased from one in 2005 to 12 in 2014. The number of regular Teaching Assistants employed by the College of Chemical Sciences has increased to twenty nine. The total regular staff has increased from 16 in 2005 to 60 in 2014.

According to ongoing surveys and investigations carried out by us, it can be confidently estimated that about 100 of the passed out Graduate Chemists have already obtained PhD degrees while another 150 have obtained other postgraduate degrees such as a Master's degree. Another 100-150 are currently reading for PhD/MSc degrees in some of the best universities around the world (Including USA, Canada, UK, Ireland, France, Switzerland, Italy, Norway, Australia, Singapore and New Zealand).

#### **Duplication of Level 1 of the Programme**

In order not to disappoint and reject any qualified applicant, we took steps to duplicate level 1 of the programme on three week days (In addition to the week-ends) for the second successive year.

#### **Diploma in Laboratory Technology Programme in Chemistry (DLTC)**

We are commemorating the completion of four decades of our technician programme this year with the holding of this international Conference. This programme which is open basically to those with at least GCE (O/L) qualifications has also gone from strength to strength particularly after it was shifted to our own building- Adamantane House – in 2005. The 78 who have passed out as the 39<sup>th</sup> batch this year increased the overall total (39 batches) to 942. The average annual output has trebled from 18 (2002-2005), to 31 (2006-2009), to 53 (2010-2013).

This programme continues to date as the only such programme producing chemistry technicians at a middle level in Sri Lanka. We also recognize today three of our DLTC products who have excelled in their respective careers – **Professor Eugene de Silva, Mr. K.R. Dayananda and Mr. Priyath John.**

#### **The Extension to Adamantane House**

The extension to Adamantane House has now enabled additional space for lecture halls, undergraduate laboratories, a dedicated research laboratory, staff rooms, library, canteen, toilets etc. All the space available has been used to provide staff and students with, we hope at least better moderately comfortable facilities. It is also relevant to remember that so far not a single officer/official of the Institute/College has gone abroad on Institute/College expenses for any official activity. No space in our buildings has been rented out and we are perhaps one of the few bodies which have put up buildings on UDA

leased property not to have rented out space. However we note with great regret that while we are acutely pressed for space and all our efforts to obtain even promised land nearby have still not borne fruit, despite even paying a non-refundable advance, some of the buildings put up on UDA leased land are used entirely for earning rented income for even nonprofessional organizations. What a tragic catastrophe and a calamity?

I cannot but once again quote a statement made by a former President (Dr. R O B Wijesekera) in a letter to us in which he indicates how much he is filled with admiration for the efforts made by our College to convert a very modest narrow academic outfit that threatened to remain as such forever into a vibrant agent for the National Chemistry professional community to give our Institute dimension and stability. While we are energized, inspired, motivated and emboldened by such genuine expressions, may I take this opportunity to appeal to and encourage our wider chemistry professional community (including the 969 Graduate Chemists) to make a positive contribution, financial or otherwise, big or small to make our services to our members, our alumni and the student community that much bigger.

#### **Full time Academic Staff of the College**

Professor E Dilip de Silva from the University of Colombo is spending 9 months of his sabbatical leave at the College until July 2014. This together with the appointment of Dr. Vinitha Thadhani, Dr. Udaya Jayasundara, and Dr. Ireshika de Silva as senior lecturers, has increased the number of regular academics to twelve.

#### **Research Session**

The seventh Research session of the College was held on 3<sup>rd</sup> August 2013 with one of our own Graduate Chemists, Dr. P Thavarajah, present as chief guest.

We were also able to commence this year the award of two research assistantships for two research projects formulated by our internal staff members. We are intending to award a third research assistantship this year. More equipment for research and advanced undergraduate studies are also been purchased. A dedicated research laboratory is being established.

#### **Co-Curricular Activities**

The inter level Debating Competition held in November 2013 and the inter University Debating Competition held in January 2014 enabled other types of important talents inherent amongst our students to be surfaced once again.

#### **Extra-Curricular Activities**

Our College increasingly encouraged numerous

extra-curricular activities to enable our students to exhibit and enhance their leadership, sporting, communication and organizational skills as well as display their hidden talents in a formal manner. These activities included Aura-2014 (talent show), Religious activities, Social Action Programmes, Entertainment, Rotaract Club, Cricket, Rugby and Martial Arts. Swimming facilities have also been provided.

#### **Out-reach Activities**

Our out-reach activities included the conduct in October 2013 of the **National Titration Competition** for the third year in succession and was once again ably co-ordinated by Professor H.D.Gunawardhana. St. Thomas College, Matale was placed first in the competition.

The **CHEMEX-3** exhibition was held from 22-24 January 2014 and was declared open by Past President, Mr. Mevan Pieris on 22<sup>nd</sup> January. The Exhibition was held in the extension to Adamantane House that was completed at a cost of about Rs. 65 million rupees. Equipment and other improvement will need at least another 35 million rupee. Donors are welcome.

The exhibition enabled about 500 of our students to arrange, organize and exhibit numerous exhibits in Chemical Sciences for the benefit of a large number of school children from all parts of the country who came to view the exhibition. The A/L Practical Demonstrations evoked much interest amongst students. The Chemistry Magic Show as well as the Orchestra added much entertainment and colour to the exhibition. In this connection, We have to record the receipt of a recent letter received from a senior chemist, Dr. R.O.B Wijesekera who viewed the exhibition and states "I was especially heartened to note the enthusiasm, the dedication of the young students and mostly the fluency of their exposition when they were explaining the exhibits. It was obvious that they had put in much effort. While it brought back to me memories of over a half a century ago it also reminded me that you have at the CCS revived a nursery of scientific education and research, which I am sure will grow with much prominence in the years to come. There was to me a vibrant aura among the young and an enthusiasm that could only have come from the leadership of you and your colleagues. I trust that the new Adamantine House will open all students and their supervisors to a flourishing development of chemical education and research.

#### **Corporate Social Responsibility**

Taking into consideration our very close connection and relationship to the Sri Lanka Association for the Advancement of Science, which was established in 1944 on a proposal initiated by us,

we made an unsolicited donation of Rs.100,000 towards the Theme Seminar of SLAAS at its annual session in December 2013.

#### Acknowledgements

We wish to acknowledge with grateful thanks the receipt of an increasing number of prizes at various levels of the Graduateship Examination. These include,

1. Dr and Mrs Swaminathan Memorial Prize for Information Technology from Dr. G.D. Chellapa
2. Rasanthika Nayomi Jayatissa Memorial Prize for the third best performance in Levels 3 & 4 from her parents Mr. and Mrs. T.A. Jayatissa in memory of a former Graduate Chemist
3. Chandani Udawatte All rounder Prize from Dr. Chandani Udawatte
4. Professor. Noel Baptist Prize from his children Dr. E.D Herath, Mr. F.E.N Baptist and Mrs. A.J Ebeneze
5. North American Alumni Commemoration in Prize for Knowledge of Chemistry and the Institute of Chemistry Ceylon from Prof. J.N.O. & Mrs. Mandrupa Fernando.

#### Conclusion

Our Graduate Chemists now constitute about two-thirds of the total membership of our Institute. As members for life of our Institute they are therefore not only alumni of the College of Chemical Sciences but also stake holders of the Institute. Every alumni is thus also a collective shareholder. The future programmes and development of the Institute are therefore increasingly dependent on them.

In this connection we note with great pleasure that one of our Graduateship Alumni from the first batch, who also followed technician Programme

before that, **Mr. K.R. Dayanada**, has been elected as a Vice President of the Institute of Chemistry Ceylon and will become President in the Council year 2015/16. This is a very significant and notable development and we look forward to more of our alumni taking up important roles in the activities of the Institute of Chemistry Ceylon, CCS and the Academic Board of the College.

We continue to go forward with confidence, enthusiasm, satisfaction and fulfillment that our Institute and the College have over the past four decades been able to make an immense contribution towards Human Resource Development in Sri Lanka. This Oration has shown very clearly how we have from very small beginnings been able to convert from a very modest narrow outfit that threatened to remain as such forever into a vibrant agent to give our Institute dimension and stability.

Before I conclude may I take this opportunity to thank everyone, academic and non-academic, who has provided us all the support, assistance and co-operator to reach our current state after a fruitful period of four decades.

Let the activities which we have initiated this year in connection with the Ruby Anniversary of our professional chemical education programmes climaxing with this international conference on Chemical Education encourage us and activate all of us so that when we celebrate the Golden Jubilee Anniversary of the commencement of professional chemical educational programmes of the College, a decade from now, we would have achieved a status and standing that would be more than even a dream and an exponential development to what exists today.

Let us all look forward to that situation with strength, courage and confident hope!

### Graduate Chemists Welfare Fund

This fund has been established with effect from 1-1-2012. The principal benefits towards CCS Graduate Chemists would be,

- i. To provide partial assistance towards international travel of those proceeding abroad for PG degrees (once a life time). Assistance for  
Active Graduate Chemists: Rs. 60,000                      Passive Graduate Chemists : Rs. 30,000
- ii. To provide partial assistance towards registration fees in respect of IChemC /CCS events such as international Conferences.
- iii. To provide assistance towards registration fees for IchemC /CCS training seminars etc.
- iv. To provide partial assistance towards activities of the Alumni Association.

**Note:** Depending on the demand, Graduate Chemists who maintain positive contact and participate in IChemC/Alumni activities will get preference for the above mentioned assistance scheme.

## Organometallic Chemistry – Part 3

By  
Dr Buddhie S. Lankage

Applications of organometallic complexes are many in academic and industrial research. Out of these organotransition metal compounds has led to a significant upsurge in synthetic chemistry research. There are two main types of organometallic reactions, they are

- *Catalytic reactions* (organometallic compound is been used during the reaction and finally regenerate it)
- *Stoichiometric reactions* (organometallic compound is consumed and generate a new compound)

The reactions of these organometallic compounds in solution phase are referred to as homogeneous catalysis.

**Homogeneous catalysis** is a sequence of reactions that involve a catalyst in the same phase as the reactants. Most commonly, a homogeneous catalyst is co-dissolved in a solvent with the reactants.

**Heterogeneous catalysis** refers to the form of catalysis where the phase of the catalyst differs from that of the reactants. Phase here refers not only to solid, liquid, vs gas, but also immiscible liquids, e.g. oil and water. The great majority of practical heterogeneous catalysts are solids and the great majority of reactants are gases or liquids.

The advantages and disadvantages of homogeneous catalysis and heterogeneous catalysis.

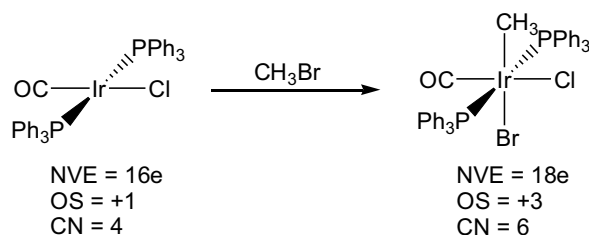
| Homogeneous catalysis                                          | Heterogeneous catalysis                               |
|----------------------------------------------------------------|-------------------------------------------------------|
| Operate under mild conditions, i.e. temperature and pressure   | No costly separation of catalyst and products         |
| High reaction selectivity                                      | Good catalyst stability                               |
| Can be tailored to a specific reaction requirement             | High productivity                                     |
| Unstable to O <sub>2</sub> , moisture and temperature extremes | Cannot be tailored, limited modifications can be done |
| Fragile compounds                                              |                                                       |

### General reaction types in organometallic chemistry

Some of the reactions of organometallic compounds involve a change in the number of valence electrons (NVE) of the complex and in the coordination number (CN) and oxidation state (OS) of the metal by a gain or a loss of ligands.

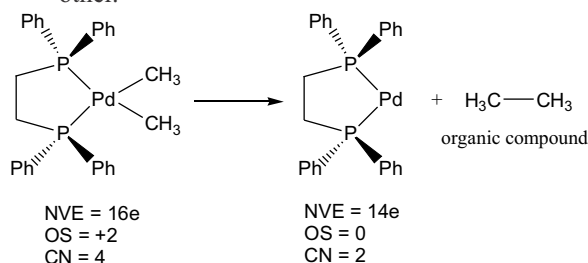
#### 1. Oxidative Addition

*Increase in NVE, CN and OS.* Since metal centre get oxidized, this type of reactions are favoured by metal centres in low oxidation state (i.e. -1, 0, +1).

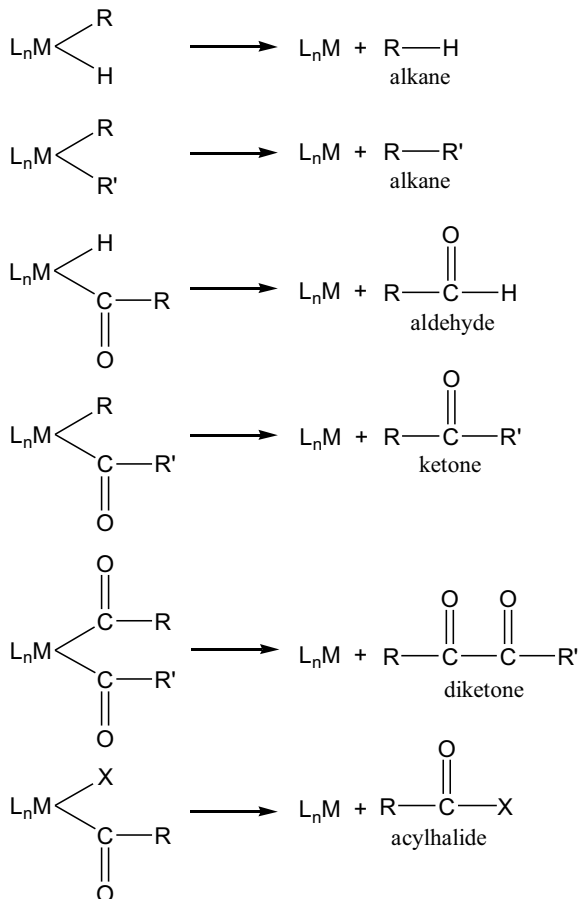


#### 2. Reductive Elimination

*Decrease in NVE, CN and OS.* Since metal centre get reduced, this type of reactions are favoured by metal centres in high oxidation state (i.e.  $\leq +2$ ) and the two eliminating groups MUST be *cis* to each other.

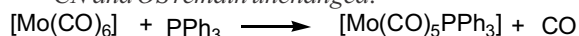


This reaction often involves the elimination of an organic molecule, such as



### 3. Ligand Replacement or Substitution

A ligand is replaced by another ligand. *Here NVE, CN and OS remain unchanged.*



NVE = 18e  
OS = 0  
CN = 6

NVE = 18e  
OS = 0  
CN = 6

### 4. Ligand Dissociation

Removal of a ligand, a reverse process of an association. Coordinatively saturated compounds undergo this type of reactions. *Decrease in NVE and CN; OS remains unchanged.*

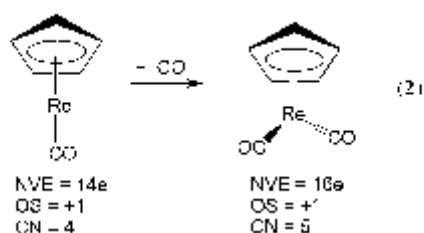
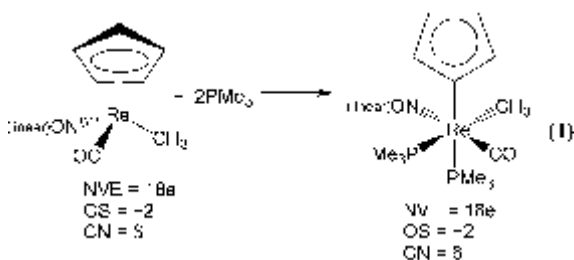


NVE = 18e  
OS = 0  
CN = 4

NVE = 16e  
OS = 0  
CN = 3

### 5. Ligand Association

A coordinatively unsaturated complex can often take up a suitable ligand(s) to form a coordinatively saturated complex (2) or coordinatively saturated complex could also undergo change in the CN/number of electron donation by letting another ligand to coordinate with the metal centre to form a coordinatively saturated complex [(1),  $\eta^5\text{-Cp} \rightarrow \eta^1\text{-Cp}$ ]. *Change in NVE and CN; OS remains unchanged.*



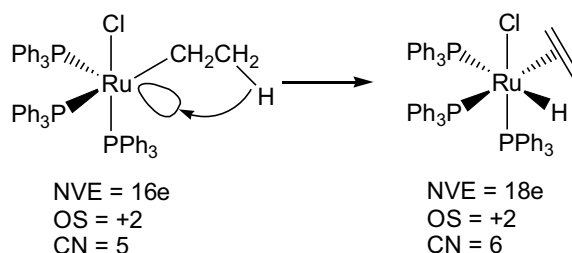
### 6. $\beta$ -Hydride Elimination

In this reaction the  $\beta$ -H is eliminated from the  $\beta$ -carbon and attached to the metal centre. For  $\beta$ -elimination to take place following conditions must be satisfied,

- the  $\beta$ -carbon of the alkyl should bear a hydrogen substituent
- $\alpha$ -carbon,  $\beta$ -carbon and the hydrogen are roughly coplanar to the metal centre
- there should be a vacant site *cis* to the alkyl (here vacant site means that there should be an empty orbital ready to accept the  $\beta$ -H or

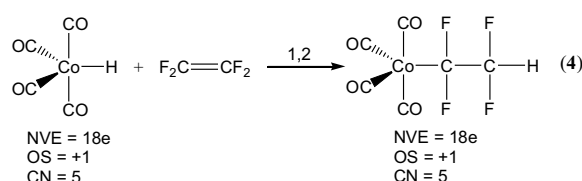
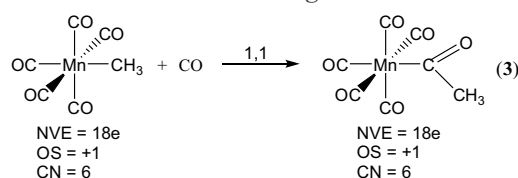
the pair of electrons that constitutes the  $\beta$  C-H bond).

*Increase in NVE and CN; OS remains unchanged.*



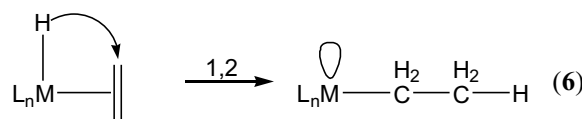
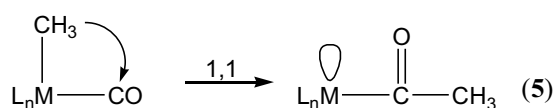
### 7. Insertion

A reaction in which a molecule is inserted into a metal-ligand bond. Insertion reactions are primarily two types: 1,1-the metal and ligand end up bound to the same atom of the inserted molecule (3) and 1,2-the metal and ligand end up on adjacent atoms of the inserted molecule (4). *The OS remains unchanged*



### Migratory Insertion

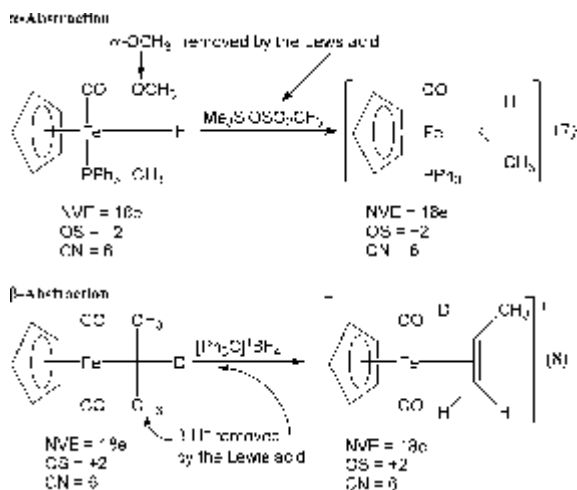
Migrating group should be *cis* to the adjacent group to which the migrating group is transferred. Migratory insertion reaction has two types depending on the atom to which the migrating group is transferred: 1,1 - the migrating group and metal is attached to the same atom, i.e. carbonyl carbon (5) and 1,2 - migrating group and the metal is attached to two different atoms (6).



### 8. Abstraction

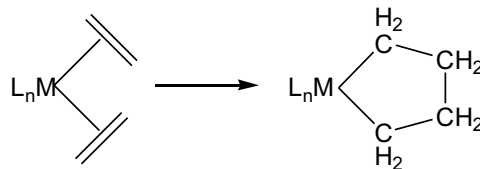
This is an elimination reaction in which the *CN of the metal does not change*. Generally, they involve removal of a substituent from a ligand, often by an external reagent such as Lewis acid. There are two types of abstraction,  $\alpha$  (7) and  $\beta$  (8) (removal of the substituent from the  $\alpha$ -position and  $\beta$ -position of the coordinating ligand, respectively).

(PTO)



## 9. Oxidative Coupling

Here metal induces the coupling between alkenes and alkynes to give a metallocycle. This is due to the back donation, metal is in low oxidation and electron density of the metal centre is high. Higher the withdrawing ability of the substituent (i.e. F, CN) attached to the C=C, also favour the oxidative coupling. *Increase in OS by +2, decrease in NVE and no change in CN.*



NVE = 2e donor to 1e donor  
 OS = 0  $\rightarrow$  +2  
 CN = same



# 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

#### Number

|                                         |                  |
|-----------------------------------------|------------------|
| CChem, FRSC                             | 11               |
| FRSC                                    | 05               |
| CChem, MRSC                             | 10               |
| MRSC                                    | 20               |
| AMRSC                                   | 08               |
| Affiliate /Under Graduate.              | <u>06</u>        |
| <b>Total Membership as at July 2013</b> | <b><u>60</u></b> |

### 2. Committee of Management

The following were elected to the Committee at the 52<sup>nd</sup> Annual General Meeting held on 27<sup>th</sup> July 2013.

|                 |   |                         |
|-----------------|---|-------------------------|
| Chairman        | - | Prof. Sudantha Liyanage |
| Vice Chairman   | - | Mr. W J P D Jayalath    |
| Chairman Elect  | - | Mr. I M S Herath        |
| Hony. Secretary | - | Dr. Positha Premaratne  |
| Hony. Treasurer | - | Mr. R M G B Rajanayake  |

|                    |                    |  |
|--------------------|--------------------|--|
| Committee Members  | -                  |  |
| Prof. W S Fernando | Dr. M P Deeyamulla |  |
| Mr. W A P Silva    | Mr. S Perasiriyana |  |

### 3. Activities

- 3.1 Contributions to Activities of the Institute of Chemistry Ceylon
  - (a) Full page advertisement of "Chemistry in Sri Lanka".
  - (b) Contribution for the Interschool Chemistry Quiz
  - (c) Award for the Best Performance at the Graduate ship Examination in Chemistry Part II Theory Examination
  - (d) Contributions for the International Conference
- 3.2 All - Island Inter School Chemistry Essay Competition.
- 3.3 Inter - University Chemistry Competition.
- 3.4 A/L teacher workshops.
- 3.5 Advanced Level chemistry seminar.
- 3.6 Book donation programmes
- 3.7 Industrial Visit.
- 3.8 Collaborations with SLAAS -E2 Work Shop and Seminars
- 3.9 Supporting Chemical Societies of Universities of Sri Lanka

### 4. Web Site

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

Dr. Positha Premaratne  
 Hony Secretary

## PUBLICATIONS OF THE INSTITUTE OF CHEMISTRY CEYLON

| Monograph | Title                                              | Author                                  | Price             |
|-----------|----------------------------------------------------|-----------------------------------------|-------------------|
| 01        | Textile Fibers                                     | Mr T Rajasekeram                        | Rs.50/-           |
| 02        | Principles of Food Preservation                    | Prof U Samarajeewa                      | Rs.75/-           |
| 03        | Biotechnology                                      | Prof C P D W Mathew                     | Rs.75/-           |
| 04        | Recombinant DNA Technology                         | Prof J Welihinda                        | Rs.75/-           |
| 05        | Natural Toxins in Foodstuffs                       | Prof E R Jansz & Ms A S Perera          | Rs.50/-           |
| 06        | Fat Soluble Vitamins                               | Prof E R Jansz & Ms S Malavidana        | Rs.50/-           |
| 07        | Nucleic Acid and Protein Synthesis                 | Prof J Welihinda                        | Rs.75/-           |
| 08        | Extraction of Energy from Food                     | Prof J Welihinda                        | Rs.50/-           |
| 09        | Corrosion of Materials                             | Dr A M M Amirudeen                      | Rs.75/-           |
| 10        | Vitamin C-Have all its mysteries been Unravalled ? | Prof E R Jansz & Ms S T C Mahavithanage | Rs.75/-           |
| 11        | *Environmental Organic Chemistry (second edition)  | Prof S Sotheeswaran                     | Rs.150/- (US \$3) |
| 12        | Enzyme Kinetics and Catalysis                      | Prof (Mrs) S A Deraniyagala             | Rs.100/-          |
| 13        | Insecticides                                       | Prof (Mrs) Sukumal Wimalasena           | Rs.95/-           |
| 14        | Organotransition Metal Catalysts                   | Dr S P Deraniyagala & Dr M D P De Costa | Rs.75/-           |
| 15        | Some Important Aspects of Polymer Characterization | Dr L Karunanayake                       | Rs.75/-           |
| 16        | Hard & Soft Acids & Bases                          | Prof (Mrs) Janitha A Liyanage           | Rs.65/-           |
| 17        | Chemistry of Metallocenes                          | Dr Sarath D Perera                      | Rs.65/-           |
| 18        | Lasers                                             | Dr P P M Jayaweera                      | Rs.65/-           |
| 19        | *Life and Metals                                   | Prof (Mrs) Janitha A Liyanage           | Rs.75/-           |
| 21        | *Silicones                                         | Prof Sudantha Liyanage                  | Rs.65/-           |
| 22        | Pericyclic Reactions: Theory and Applications      | Dr M D P De Costa                       | Rs.65/-           |
| 23        | Inorganic NMR Spectroscopy                         | Prof K S D Perera                       | Rs.65/-           |
| 24        | Industrial Polymers                                | Dr L Karunanayake                       | Rs.75/-           |
| 25        | *NMR Spectroscopy                                  | Dr (Mrs) D T U Abeytunga                | Rs.65/-           |
| 26        | Mosquito Coils and Consumer                        | Ms D K Galpoththage                     | Rs.100/-          |
| 27        | Atomic Absorption Spectrometry                     | Dr K A S Pathiratne                     | Rs.100/-          |
| 28        | Iron Management on Biological Systems              | Dr (Ms) R D Wijesekera                  | Rs.100/-          |
| 29        | Nutritional Antioxidants                           | Prof. (Mrs) Sukumal Wimalasena          | Rs.100/-          |
| 30        | *f-Block Elements                                  | Prof Sudantha Liyanage                  | Rs.65/-           |
| 31        | Scientific Measurements and Calculations           | Prof (Mrs) S A Deraniyagala             | Rs. 80/-          |

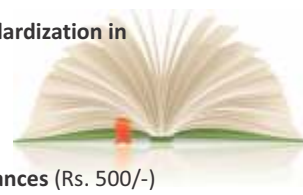
\* - Second Edition /new print published on popular demand

### CCS Publications

|    |                                                |                                                 |           |
|----|------------------------------------------------|-------------------------------------------------|-----------|
| 01 | Functional Group Analysis in Organic Chemistry | Prof AAL Gunatilake                             | Rs. 175/- |
| 02 | Zinc Metalloproteins                           | Prof S Sotheeswaran<br>Prof (Ms) R D Wijesekera | Rs. 175/- |

### General Publications

- ★ **Chemist & The Environment** (Rs.300/-)
- ★ **Infrastructure Support Services for Industrial Development** (Rs.200/-)
- ★ **Chemical Industries in Sri Lanka – Part II** (Members: Rs. 200/-, Non-members: Rs.275/-)
- ★ **Proceedings of the Workshop on the Technological aspects of the Production & Processing of Essential oils in Sri Lanka** (Rs.100/-)
- ★ **Proceedings of the Training Seminar on Towards a Cleaner Industrial Environment in the New Millennium** (Rs.150/-)
- ★ **A-Level Chemistry Facts, Patterns & Principles by Dr. Seetha I Rodrigo** (Rs.1500/-)
- ★ **Proceedings of the Prof R S Ramakrishna Memorial Training Seminar on Modern Analytical Methods** (Rs.200/-)
- ★ **Historical Accounts of the Educational Activities (1972 - 2004)** (Rs.350/-)
- ★ **Proceedings of the Training Seminar cum Workshop on Sampling, Statistics and Standardization in Chemical Analysis and Environmental Management** (Rs.150/-)
- ★ **Polymer Industries of Sri Lanka** (Rs. 200/-)
- ★ **Industry & Environment** (Rs. 200/-)
- ★ **Herbal Medicine Phytopharmaceuticals and Other Natural Products: Trends and Advances** (Rs. 500/-)
- ★ **Chemistry in Sri Lanka** (Rs. 150/-)



## Tenth CCS Convocation at Waters Edge, 03.04.2014



Chief Guest's Procession



Graduate Chemists in Procession



Graduate Chemists in Audience



Foreign Guests & Invitees



Shireen Jayasuriya Gold Medalist



Ms. H Jessica Peteira



Dr. G C N Jayasuriya (DLTC) Awardee

Ms. A H F Rikasa

### Yeoman Services to Educational Activities recognised



Mr. Mevan Pieris



Mr. N I N S Nadarasa



Kandyan Dancers lead the processions



DLTC Diplomates in Procession



DLTC Diplomates in Audience



Head Table personnel stand for the National Anthem

### DLTC Ruby Awards presented to distinguished DLTC alumni



Mr. K R Dayananda (Silvermills Group)



Mr. Neil Priyath John (Asiri Hospital)



Professor Eugene de Silva from USA