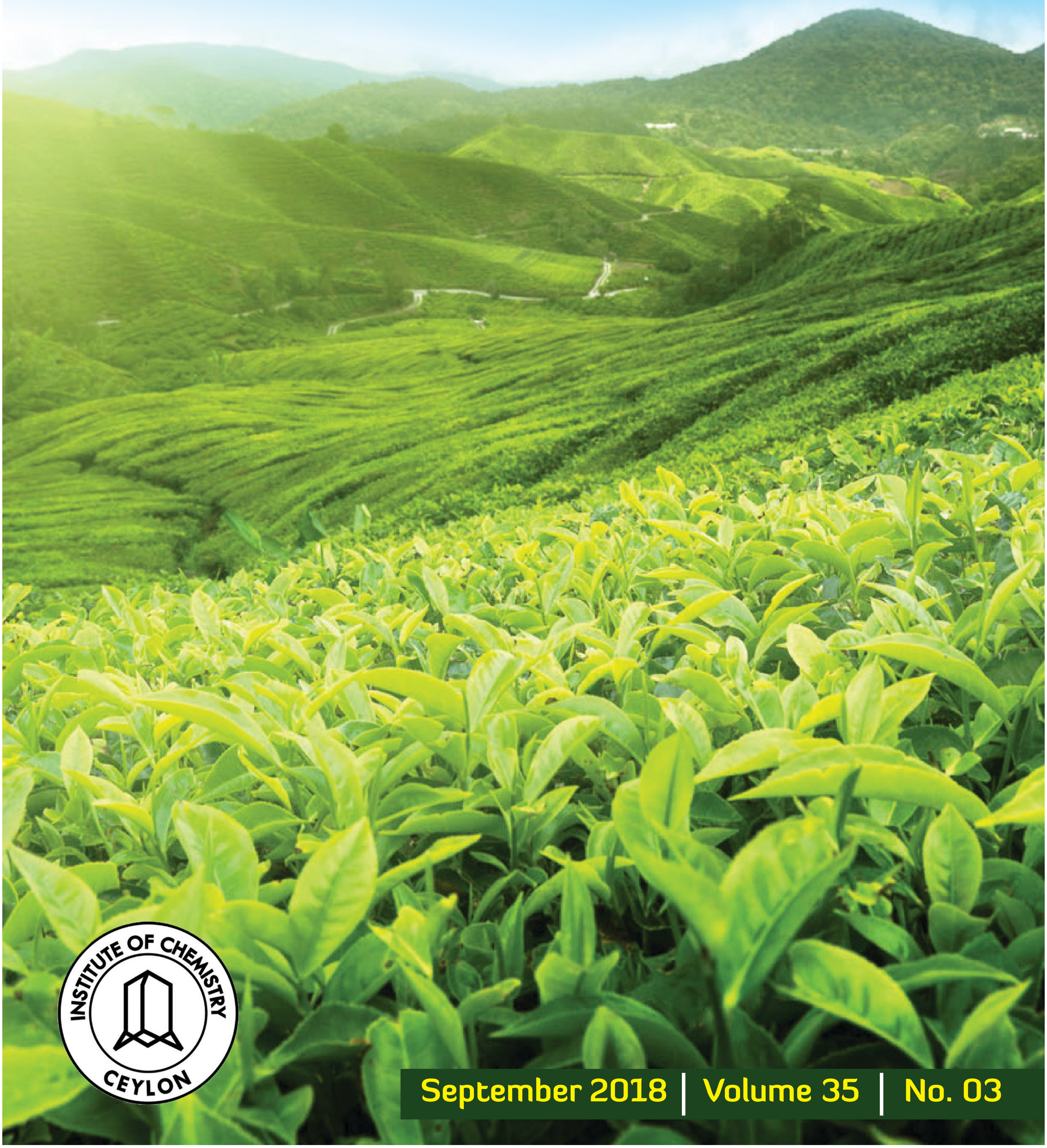
The Tri Annual Publication of the Institute of Chemistry Ceylon

CHEMISTRY
in Sri Lanka



INSTITUTE OF CHEMISTRY CEYLON

September 2018 | Volume 35 | No. 03

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Chemistry in Sri Lanka

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The Tri-Annual Publication of the Institute of Chemistry Ceylon

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

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

Vol. 35 No. 3 **September 2018**

Pages

Theme for the year -

Steering Chemical Industries Towards a Smarter Nation

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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.), Licenciate (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
(i) directly become Licentiate
(ii) 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 with Membership for Life 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 payed on 1st of July every year and will be in respect of the year commencing from 1st July to 30th June

Fellow	Rs. 2000
Member	Rs. 2000
Associate	Rs. 1500
Licenciate	Rs. 1200
Technician	Rs. 750
Affiliate	Rs. 1200
Membership for Life	Rs. 15000

Entrance Fee

All the grades	Rs. 1000
Processing Fees*	Rs. 500
Processing Fee for Chartered Chemist designation	Rs. 5000
Institutional Members	Rs. 2500

*per application for admission/transfer to any grade

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Council 2018/2019

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 750 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 January 2019.

- *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 suggestions from the members for improvement of the publication.

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Guest Editorial

Endolichenic Fungi in Sri Lanka; A Treasure Trove for New Bioactive Molecules

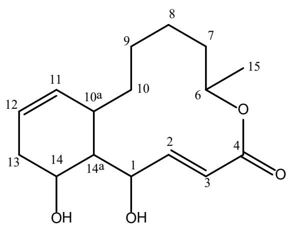
Professor Priyani A. Paranagama
Director, Institute of Indigenous Medicine, University of Colombo
and Chair of Chemistry, Department of Chemistry, University of Kelaniya

The demand for new and safe bioactive compounds from natural resources is increasing due to emergence of new diseases, development of drug resistance to pathogenic bacteria and development of toxic viruses, etc. This situation has forced researches to explore new natural sources with potent novel bioactive compounds as they continue to deliver a great variety of structural templates for drug discovery and encounter the challenges of the twenty first century. Fungi are an important resource of novel natural bioactive compounds with potential applications in agriculture, pharmaceutical industry and food industry. The first milestone in the field of drug innovation research from fungi was started with the discovery of penicillin, the first natural antibiotic discovered from a fungus, *Penicillium notatum*. Thereafter, exploration of microbial diversity has been encouraged by the fact that microbes are essential for sustainable development of bioactive compounds. Importance in the discovery of new bioactive compounds from fungi has garnered greater attention than that of plants by the fact that fungi can be grown using fermentation methods or solid cultures and need insignificant amounts of raw material indicating that it does not affect the biodiversity of the country. Since over 60% of the approved drugs available in the market are of natural origin, there is a great demand for bioactive secondary metabolites isolated from fungi with unique structural diversity in order to strengthen the drug discovery programs. Examples for isolation of biologically active molecules from fungal extracts with anticancer, antifungal and antibacterial activities are monocillin, radicicole and curvularin. Subsequently, there is a growing interest to identify new fungal species and isolate their secondary metabolites in order to obtain naturally occurring structurally diverse new bioactive compounds.

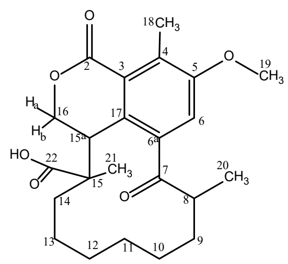
The endolichenic fungi (ELF) are the fungi that inhabit lichen tissues asymptomatically without causing disease symptoms, and their occurrence is similar to the endophytic fungi live within healthy plant tissues. It is evident that ELF are important in producing chemically diverse secondary metabolites with novel anti-inflammatory, antioxidants and anticancer compounds. In the course of the last 11 years, we have isolated ~1500 endolichenic fungi from lichens in tropical forest and mangroves and screened them for their biological activities. Many bioactive compounds have been isolated and structures of the biologically active compounds have been determined. The substances isolated originate from different biosynthetic pathways: isoprenoid, polyketide, amino acid derivatives, and belong to diverse structural groups: terpenoids, steroids, xanthones, chinones, phenols, isocumarines, benzopyranones, tetralones, cytochalasines and enniatines. The first report of isolation of bioactive compounds from ELF has been published in 2007 stating dehydroherbarin was isolated from an endolichenic fungal strain, *Corynespora sp*. occurring in the cavern beard lichen, *Usnea cavernosa* with significant inhibition of migration of human metastatic breast and prostate cancer cell lines, MDA-MB- 231 and PC-3M, respectively.

In Sri Lanka, a new research program on searching bioactive compounds from ELF was initiated by myself at Department of Chemistry, University of Kelaniya in 2009. Sri Lankan forests contain higher diversities of many varieties of lichen species such as fruticose, foliose and crustose. *Usnea sp*., *Parmotrema sp* and *Pseudocypellaria sp*. are some of the dominant lichen species in the lower elevation (1750 m) of Knuckles forest and Hakgala botanical garden in Sri Lanka were used in the present study to isolate ELF. In our investigations, it was revealed that isolated ELF can utilize substrates such as cellulose, starch, pectin and lignin, and it is indicated that all the fungal strains utilized starch except *Cladosporium sp*. and *Curvularia sp*. The cellulose utilization ability was demonstrated by *Phoma sp*., *Penicilium sp*. and *Chrysosporium sp*. whereas *Chrysosporium sp*., *Curvularia sp*. and *Penicillium sp*. showed the ability to produce both polygalacturonase and pectatelyase enzymes. *Broomella sp*. and *Nigrospora sp*. produced the polygalacturonase enzyme whereas *Cladosporium sp*., *Chrysosporium sp*. and *Phoma sp*. were able to produce pectatelyase enzyme. Only *Broomella sp*. showed the ability to produce all the lignases. Antifungal activities of ELF have been evaluated and it was found that growth of *Fusarium sp*. was inhibited by *Cladosporium sp*., whereas *Nigrospora sp*. inhibited the colony growth of *Botrytis sp*. and *Colletotrichum sp*. Furthermore, *Chrysosporium sp*. were able to inhibit the colony growth of *Colletotrichum sp*. Similarly, *Chrysosporium sp*. was also be able to inhibit the colony growth of *Fusarium sp*.

Isolation of two new biologically active compounds, PP-CT-01 and PP-CT-02, with anticancer and antioxidant activities were reported from *Curvularia trifolii*, an endolichenic fungal strain in *Usnea sp*. in Sri Lanka.

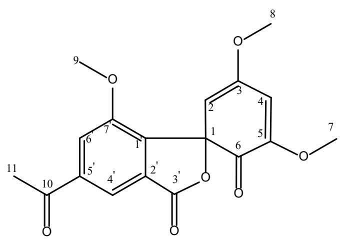


PP-CT-01

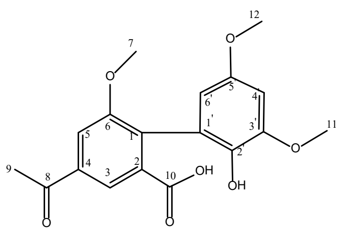


PP-CT-02

Ethyl acetate extract of Penicillium citrinum, an endolichenic fungus isolated from the lichen, *Parmotreama sp*., produced two novel polyketides, PP-PC-01 and PP-PC-02 with radical scavenging activity in DPPH antioxidant assay.



PP-PC-01



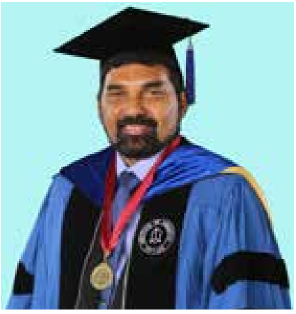
PP-PC-02

Being an island, Sri Lanka has several extensive coastal wetlands rich in mangrove forests covering approximately an area of 6000–7000 ha. The largest mangrove ecosystem in Sri Lanka is in Puttalam Lagoon covering 3385 ha. Although Sri Lanka is a biodiversity hot-spot, it is reported that prevalence and identification of lichens and microorganisms are understudied. Therefore, this research programme was extended to investigate bioprospecting of mangrove-associated endolichenic fungi. Considering the fact that harsh environmental conditions prevailing in mangrove ecosystems, it was hypothesized that ELFs of lichens living in mangrove ecosystems are rich in secondary metabolites. Since Sri Lankan mangrove associated ELF are untouched and no information is available, a study was conducted to evaluate bioactive compounds in ELF and identify the lichen species and to report the fungal diversity, and determine antioxidant, anti-lipase and amylase inhibition activities of secondary metabolites produced by solid cultures of ELF. This was the first comprehensive research on identification, phylogenic analysis and bioactivity of endolichenic fungi in mangrove ecosystem of Puttalam lagoon in Sri Lanka and the results obtained in this study will provide a starting point for discovering novel bioactive compounds from endolichenic fungi isolated from the lichens collected from mangrove and mangrove associated plants in Pullalam lagoon in Sri Lanka. In this study, identification of about 100 strains of ELF in lichens collected from mangroves was reported. The secondary metabolites produced by each ELF have been assessed for antioxidant activity using DPPH, anti-diabetic activity using amylase inhibition and anti-obesity using lipase inhibition assays. The ethyl acetate extracts of *D. eschscholtzii* and *Sordaria sp*. showed better radical scavenging activity. Hence it is suggested that the extracts with low IC_{50} for the antioxidant assay and the fungal extracts with high anti-lipase activities might be of therapeutic interest with respect to the treatment of obesity and other non-communicable diseases.

In conclusion, endolichenic fungi have become a promising source to isolate novel bioactive compounds and there is a dearth of information on endolichenic fungi. This is the first research programme on ELF in Sri Lanka and young researchers comprising of postgraduate and undergraduate students were trained on isolation and identification of endolichenic fungi and analytical techniques involved in the field of natural product chemistry to isolate bioactive compounds. Therefore, this research program has made a significant contribution to human resource development of the country and thereby provides an impetus to the study of bioactive compounds in endolichenic fungi in Sri Lanka.

Message from the President

Senior Professor Sudantha Liyanage, *PhD, C.Chem., F.I.Chem.C., F.PRISL, FRSC*
President, Institute of Chemistry Ceylon



I consider it a privilege to have been bestowed with the honour of serving as President of the Institute of Chemistry Ceylon, an organization which has gradually become one of the leading institutes and has contributed significantly towards the advancement of chemical sciences and its practice. Due to its pivotal role in being the largest contributor towards chemistry related jobs in Sri Lanka, I think the Institute of Chemistry has immense potential in bridging the gap between academia and industry and could enable the country to work towards achieving its goals. Thus, the theme for this year, "Steering Chemical Industries towards a Smarter Nation" was selected with a view to expand the contribution of chemists to steer the nation along the right path to development. The time is nigh for Sri Lanka to harness local talent to spearhead this process.

Through the many programmes that the Institute offers, the Institute of Chemistry is undoubtedly the largest contributor of chemists and laboratory technicians to industries in Sri Lanka. Thus, whatever practices the Institute instills in our students could surely be manifested in the many roles that they play as contributors to our society.

There are many goals for this year and right at the top of the list is to spearhead the Development Project at Malable to house the IChemC Campus which will provide adequate space for both teaching and research. Lack of sufficient space and facilities has been a long standing problem for the Institute and this project will surely suffice to provide the much needed atmosphere to truly uplift the learning experience for our students. The final draft of the agreement has been received from Devco Architects and it is hoped that we may begin construction work in November.

It is noteworthy that the GIC programme has received accreditation of the Royal Society of Chemistry. We hope to complete the College of Chemical Sciences Accreditation and Institutional Review process. We have submitted a proposal regarding the new BSc degree programme so that the Institute could be granted Degree awarding status and the self-evaluation report for the programme review has been submitted to the Higher Education Ministry. I hope to use the experience I have gained, through serving for nine years as the Dean of the Faculty of Applied Sciences, University of Sri Jayewardenepura, to overcome identified weaknesses at the Institute of Chemistry management and the GIC programme.

A smart nation can only be achieved by judicious steering of its industries in the direction of sustainability and green concepts. The role of the Institute as a bridge between academia and industry will surely benefit Sri Lanka towards becoming a smarter nation.

Finally, I would like to end with this quote from Mehmet Murat Ildan,

"*Every nation determines its own destiny; the clever the nation, the better the fate*!"

Forty Seventh Annual Sessions and Seventy Seventh Anniversary Celebrations 2018

Presidential Address

Dr. Poshitha Premarathne, *M.Phil, PhD, C.Chem , F.I.ChemC, CChem, MRSC*
Immediate Past President, Institute of Chemistry Ceylon

The importance of Chemistry and Chemical Sciences is evident by the undeniable growing role of Chemistry and its contribution to the chemical industry for the existence of mankind, as we witness more and more tremendous achievements of Chemistry and its applications across the globe. Even though Chemistry is the core science, it has now made inroads to other sciences such as Biology, Physics, Genomics, Medical Science, Agriculture and Horticulture, Alternative Energy, Marine Biology, Nutrition, Natural Products and Nano Science, to name but a few. The mission of the chemist is to advance the worldwide aspects of the chemical sciences and to contribute to the application of Chemistry for the benefit of the mankind. Therefore, the decision of the Institute of Chemistry Ceylon to select, "Chemists Contribution towards National Policy Development" as the theme for this year is timely, and our Annual Sessions will be based on this theme. With the active participation of the private sector as well as the State sector, the Institute wishes to play an active role in advising the Government towards National Policy Development based on the outcome of the Session.

The Institute, since its establishment in 1972, has made considerable advancements towards its contribution to increase the number of chemistry professionals required for the country. Since the commencement of the two major programmes, namely, the Graduateship in Chemistry-GIC and Diploma in Laboratory Technology-DLTC, it has been possible to produce 1402 Professional Graduates and 1325 laboratory technicians reflecting its extensive commitment and dedication to contribute to the chemical education in the country. In addition to obtaining their services by the private sector and the State sector in Sri Lanka, they are well employed overseas in academia, research and in scientific organizations. This proves the high value of the educational programmes that we impart to them. The Graduateship in Chemistry programme conducted by us has been accredited by the Royal Society of Chemistry (RSC) in the U.K.

We have come a long way, even at a slow pace, from an academic teaching institute, producing qualified graduates, but also towards making a fuller human being who can fit into the trials and tribulations of societal concerns which call for scientific solutions, because our curriculum has an additional components such as allied subjects including marketing, management, quality assurance, etc.

Activities on obtaining Degree awarding status which commenced in 2017 were continued during the year and much progress has been achieved on the additional requirements indicated in the Institutional Review Report of the Institutional Review Panel of the UGC. While all the new procedures in appointment of staff are being followed as required, we are in the process of appointing a Financial Manager to our Accounts Division as proposed by the Review Panel. We are confident that we could accomplish all the requirements pointed out by the Review Panel, and achieve the degree awarding status from the Ministry of Higher Education.

Apart from its two successful educational programmes stated above, the Institute embarked on several new activities through collaboration with other agencies in keeping with its theme for this year. We also initiated the process of setting up an Industrial Technology and Innovation Centre after conducting several discussions with the Ministry of Science and Technology, Ministry of Megapolis and Western Development and SLINTEC and with the guidance of Prof. Oliver Ileperuma, Emeritus Professor of Chemistry. Furthermore, the Ministry of Science and Technology invited us to advise them towards policy development in addressing national issues on Science and Technology. The Mineral Sands Company too was interested in obtaining professional advice from us on the improvement of their production processes as well as on the establishment of a laboratory in Pulmoddai and value addition to mineral sands.

The Ministry of Health and Indigenous Medicine has requested the Institute to provide services of its professionals for improvement of their food testing laboratories located in four sites. Paranthan Chemical Corporation too has chosen the Institute to get advice on their problems associated with manufacture and to train their staff on various issues. Through such collaboration with other industries as well as the State sector, we will be supporting them to develop their present and future administrative policies which will contribute to National Policy Development goals. For the first time in the history of IChemC in May 2018, we brought together the private sector industrialists from manufacturing as well as service industries and State policy makers to a common forum to address the issues faced by individual industries. The Institute has planned to set up a mechanism to address these issues through application oriented research in collaboration with the private sector.

Action has also been initiated with a view to highlight the importance of our Chartered Chemists as a certifying authority. In this connection, much work has been done towards the development of an appropriate system along with codes of ethics and regulations for Chartered Chemists, which we hope to complete soon.

The Institute initiated the Chemistry Olympiad programme under the advice and guidance of Professor Paul Likis of Imperial College of the University of London and the program was initiated in 2013 which gained momentum during the period of 2016/2017. The Institute has now been recognized by the International Olympiad Council as the representative of the Chemistry Olympiad for Sri Lanka.

The Institute has also initiated action to expand its physical facilities by developing IChemC Educational Complex at Malabe, on a land about one acre in extent, which has been allocated to us by the UDA. The project will cater to the ever increasing demand for our educational programmes GIC and DLTC by students and parents. A new BSc programme in Chemistry too has been initiated by the Institute. With the addition of more space we will be able to provide much more facilities to the students and staff to conduct the educational and research programmes.

We have also conducted more seminars/ workshops during the year on the subject of public health, food, pharmaceuticals, environmental and energy chemistry and we have formulated them in such a way that, both the students and industrial sector will benefit from them.

While wishing all the success in conducting the 47th Annual Sessions of the Institute, I extend my sincere thanks to all the Past Presidents, members of the Council, all academic and non academic staff, well wishers of the private sector as well as the State sector and, to our CCS students for their cooperation and support extended to me during my tenure.

Cover Page

Cover page is dedicated to the Dr. C L de Silva Gold Medal Award Lecture on "Metabolite profiling of the Sri Lankan tea (*Camellia sinensis* L.) germplasm". Please see pages 11-14 for the award lecture.

Chief Guest's Address

Mr. Kulathunga Rajapaksa
Managing Director, DSI Samson Groups (PVT) Ltd.

Today science and technology plays an integral part in our life. In that scenario Chemistry plays a dominant role. Lab tests are needed not only in the field of medicine but in many other fields, lab reports are needed.

When the economy was opened as far back in 1977, all types of products were imported and goods were flooded. People who did not have the opportunity of using imported products including all types' food items were very happy. This happiness was very short lived when complaints came pouring in, with regard to food safety and quality of the products. Then the government had to focus on standards and quality of food, food safety, health, etc and started investing in quality control measures for which SLS standards and other standards were introduced. Media exposed the dangers on eating apples, grapes using of preservatives, etc. All these needed controls and the need of chemists was realized. Several testing institutions and laboratory facilities were established in most of the manufacturing units.

Research and development (R & D) started playing a major role in many local industries and realizing the importance of R & D, the government, through a budget proposal, introduced 200% tax relief for factories who engaged in R & D work and even encouraged to install testing equipments. The test certificates became vital documents in most of the products and product labeling became mandatory in food items. Now even sugar level needs to be indicated. To do all these analyzing, ingredients were necessary.

In the case of the rubber industry in which I am involved, we have to give various test certificates such as flame resistance, allergies, fat resistance, etc. We are unable to do some of these tests in Sri Lanka and hence, get them done overseas spending enormous amounts of money. Now people are concerned about the environment and hence demand for emission tests, water pollution, waste water treatment etc are increasing. All of these need Chemistry.

The old system was to control imports by imposing duties and cess. This system has now changed with various bilateral agreements giving zero duty concessions. However, western countries are very smart and they are now controlling imports by controlling quality and requesting various types of certificates such as ORGANIC certificate, REACH compliance, FAT resistance, level of heavy metals in various products, EN certificate especially for toys, Lead content in ceramic wear, etc. Some of these tests cannot be conducted in Sri Lanka; hence, we have to get the certificate of the products tested from the importing country and that is how they control imports.

Now Glyphosate is a hot topic in which Monsanto is involved. There, multinational politics are involved and many scientists who have done their postgraduate studies in the United States will always favour the usage of these chemicals as the test methods have been developed by them. Now this has taken a completely different turn. I do not like to comment on this as this is a controversial topic.

As a Director of Mawbima Lanka, the institute that promotes local products, I do have the experience in handling the case of melamine in the milk powder industry in which most of the multinationals did not agree until there were a few child deaths in China. It was only then that the Sri Lankan government took steps to restrict the import of milk powder and made the test certificate compulsory. The DCD issue which came up was also hushed up. These are the places that we need the scope of Chemistry and unbiased chemists are needed. Now agriculture has taken a 360^0 turn and is back to using the traditional agriculture systems used by our ancient kings under the terminology "organic". Here again Organic Certificate is needed. Nano and digital technology is fast developing to meet the need of increasing demand for food.

Waste is another subject that needs great attention and we need to control import of various types of waste as raw materials. Even radioactive waste can come into our country. If we are not vigilant as most developed countries seek under developed countries like ours as dumping grounds. Already, various waste such as waste tyres, tubes, plastic, metal, recycled materials are coming in and all these imports technically need environmental authority licenses for which testing facilities are needed.

In conclusion, this institution has a vital role to play not only in the future but even when you are presenting an adverse test certificate you need to do a presentation for which you must be familiar with Engineering and accounting knowledge. This is how you can be a fully fledged practical chemist. This is what has happened to Glyphosate and pesticide controls.

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Guest of Honour's Address

Mr. Madura Vithanage, *Attorney at Law*
Mayor Sri Jayawardenepura Kotte Municipal Council

Today, I am here as the Mayor of Sri Jayawardenpura Kotte, the administrative capital of Sri Lanka, or broadly as a politician to talk about the importance of science, or specifically chemistry, to achieve higher growth, development and also progress of our country. Generally politics is defined as "the science of government" although you may find little or no science in government. However, we can compare the relationship between science and politics to a "Marriage"; what this implies is that, to develop the two partners should not become alike, but must respect each other's differences. Economic significance of science and technology must not be underestimated and political authorities as well as policy makers have understood this fact very well.

Endless examples can be cited from history to show how the contributions of many scientists to the different fields of science free of politics, religion, cast and region have served humanity. In fact, their contributions have enormously improved the quality of life of living beings across the world. Science should be regarded as a basic human right around the world. Therefore, it must not be limited to a place, race, culture or region. Each and every innovation of science and technology should be transferred from one generation to the next and also from one side of the globe to the other. The concept of "Science for the benefit of all" must be understood as utilization of science to find solutions to our problems and also to satisfy human needs.

Chemistry, identified as "the central science" too plays a fundamental role in bringing about economic benefits, transforming our everyday lives for the better. Discoveries of chemistry result in patents and other forms of commercialization. Many examples can be cited to prove the said point. Chemical scientists designing drugs, building diagnostics that contribute to improve human health, developing new clean energy technologies etc., in fact umpteen number of examples can be given towards this. Science and material chemistry make the lives of every human throughout the world healthier, safer and more sustainable. Bottom line is that all these will finally contribute to the growth and development of a country improving the quality of life of human kind. In fact, public investments in R & D are motivated by the conviction that advances in scientific knowledge will contribute to the economic progress of a country.

What is the role of a politician in this exercise? Most importantly there should be an attitudinal change. I like to share one of my experiences with you here. Once I took Prof. Montee Casim, the Vice Chancellor of a leading Japanese university to meet the then Science and Technology minister of ours to explore possibilities of assisting us. You may not believe the response of our minister. Surprisingly the minister was very unhappy about the portfolio given, thinking that it was a useless ministry. In other countries the Ministry of Science and Technology is considered one of the leading ministries. This kind of attitude will naturally act as a barrier. Although advances in science and R & D contribute immensely to improve the lives of humans, Sri Lanka's spending on R & D is the least in the region; in 2010 we spent just 0.16% of GDP on R & D which is significantly lower than other countries in the region and the situation has not improved since then. Therefore, the role of the politician, the role of the government, rather, in making advances in this field cannot and must not be under estimated. Coordination among academia, industries and more importantly, political authority is extremely important for the growth of science and thus, in the growth of the economy.

Let us strive hard to create this link for the betterment of the country and its people. However, do not forget we have been very fortunate to get free education; therefore it is our foremost duty to serve our country as best as we can. Let us try to light one candle without cursing the darkness.
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Dr. C L de Silva Gold Medal Award

Awarded for an outstanding research contribution in any branch of Chemical Sciences and/ or the use of such research for National Development during the last five (5) years in Sri Lanka. Credit will be given for the utilization of local raw materials, and where the contribution has already resulted in;

(i) a publication in a Citation Indexed Journal or (ii) Registering a Patent or

(iii) where the contribution has already resulted in a positive impact in the development and innovation in the industry

Dr. C L de Silva Gold Medal Award - 2018

Professor P A Nimal Punyasiri is Professor and Chair of Biochemistry at the Institute of Biochemistry, Molecular Biology and Biotechnology, University of Colombo. He is a graduate of the Institute of Chemistry Sri Lanka and obtained a Postgraduate Diploma in Advanced Biochemistry and PhD in Biochemistry from University of Peradeniya. He has carried out part of his doctoral research at the Technical University Munich and at the University of Uppsala, Sweden.

He is a Fellow of the Royal Society of Chemistry, UK and Fellow of the Institute of Chemistry Sri Lanka. He was a Senior Research Officer attached to the Biochemistry Division, Tea Research Institute of Sri Lanka for 28 years. He was also a Postdoctoral Research Fellow at the Chemical Ecology Section, Swedish University of Agricultural Sciences, Sweden and Institute of Biochemistry, Molecular Biology and Biotechnology, University of Colombo. He has also worked at the Nature`s Beauty Creations Ltd (Nature`s Secrets) as Director – Research and Development and Head of Plant Research Centre.

Professor Punyasiri has over 30 peer-reviewed publications to his credit. He has received 13 National Awards for his research which include 6 Presidential Awards. He was the recipient of the Kandiah Memorial Award of the Institute of Chemistry Ceylon.

Metabolite profiling of the Sri Lankan tea (*Camellia sinensis* L.) germplasm

P A N Punyasiri[1]*, B Jeganathan[2], J D Kottawa-Arachchi[3], M A B Ranatunga[3], I S B Abeysinghe[3], M T K Gunasekare[4], B M R Bandara[5]

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The above extensive study will be described in three sections for ease of understanding.

Genotypic variation in biochemical compounds of the Sri Lankan tea (*Camellia sinensis* L.) accessions and their relationships to quality and biotic stresses

Tea (*Camellia sinensis* L.) is well known for its biochemical constituents that define the product quality and confer pest and disease resistance. Seven major metabolites – epicatechin (EC), epicatechin gallate (ECg), epigallocatechin (EGC), epigallocatechin gallate (EGCg), caffeine, theobromine, and gallic acid – of 87 beverage type and six non-beverage type tea accessions from Sri Lankan tea germplasm were profiled using HPLC and LC-MS/MS. All seven metabolites varied widely in the beverage type accessions. The non-beverage types only contained gallic acid and epicatechin. Results prove the presence of high EC and ECg contents in green leaves to be a reliable marker for identifying high-quality black tea-producing accessions. High EC and low EGCg contents in green tea leaves appear to enhance traits of resistance to blister blight disease. Significant variations detected in theobromine, caffeine, and total polyphenol content define the affinity of germplasm to the main three tea taxa, and we conclude that *C. sinensis* ssp. *lasiocalyx* predominates the Sri Lankan germplasm collection.

The sustainability of the tea industry relies mainly on the success of tea (*Camellia sinensis* L.) breeding programmes. The characterisation and analysis of genetic diversity in any germplasm collection is important for its rational utilisation in breeding programmes and in manufacturing products of desired attributes. Although the use of various descriptors has been helpful in characterising the tea germplasm, its biochemical parameters focusing on metabolite profiling play a pivotal role in analysing the variability present in the germplasm collection. The presence of many chemical constituents in tea leaves has been documented with respect to plant defence mechanisms against pests and diseases as well to the quality of the final product. However, the results of such studies reveal some discrepancies due to varying environmental factors in the field, different analytical techniques employed and varieties of teas used in the studies.

Polyphenols, the major chemical type of water soluble compounds present in tea flush, constitute 25–30% of dry weight. Among the polyphenols, catechins (flavan-3-ols) have the least complex chemical structures, and function as precursors in the formation of complex polyphenols. There are six major catechins in tea leaf, viz. (+)–catechin (C), (−)–epicatechin (EC), (−)–epicatechin gallate (ECg), (+)–gallocatechin (GC), (−)–epigallocatechin (EGC), and (−)–epigallocatechin gallate (EGCg). When black tea is produced, the catechins EC, EGC, ECg, and EGCg, in pairs, form the major types of theaflavins, through the action of the enzyme polyphenol oxidase and atmospheric oxygen. Gallic acid is an important phenolic carboxylic acid found in tea leaf and forms esters with catechins. ECg and EGCg are galloyl esters of EC and EGC, respectively. Caffeine confers briskness and creaming properties to black tea, and stimulates the central nervous system. The caffeine content may vary with the genetic origin of the tea plant. *C. sinensis var sinensis* is known to have a lower level of caffeine than *C. sinensis var assamica*. Apart from the very high content of polyphenols, gallic acid, caffeine, and other purines such as theobromine and theophylline also give tea shoot a better identity.

Metabolite profiling, which measures a broad range of metabolites in a single extract would establish a distinct identity among different species or varieties of plants and animals. Furthermore, the metabolites are present in different quantities among tea cultivars of different geographical origins. The abundance of catechins has been used to differentiate tea cultivars. Polyphenols, the major chemical type of water-soluble compounds present in tea flush, constitute 25–30% of dry weight. Among the polyphenols, catechins (flavan-3-ols) have the least complex chemical structures, and function as precursors in the formation of complex polyphenols. There are six major catechins in tea leaf, viz. (+)– catechin (C), (−)–epicatechin (EC), (−)–epicatechin gallate (ECg), (+)–gallocatechin (GC), (−)–epigallocatechin (EGC), and (−)–epigallocatechin gallate.

The present study is the first systematic study initiated to quantify the major metabolites present in tender tea leaves and to generate a wealth of information on the metabolite diversity of the Sri Lankan germplasm accessions. The present study reports the quantification of total polyphenols (TPP) along with the seven major metabolites – caffeine, EC, ECg, EGC, EGCg, theobromine, and gallic acid – present in tea leaves of 87 beverage type accessions and six non–beverage type accessions selected from the Sri Lankan tea germplasm, using high throughout techniques.

Conclusions

There is a wide variation in the contents of TPP, major catechins, caffeine, theobromine, and gallic acid in the Sri Lankan tea germplasm. The amounts of dihyroxylated, trihydroxylated, gallated, and non-gallated catechins and their ratios present in tender tea leaves (two leaves and a bud) determine the ultimate quality of black tea. The accessions used to produce high-quality black tea had high amounts of dihydroxylated catechins, EC and ECg, high ratios of dihydroxylated to trihydroxylated catechins, and low ratios of gallated to non-gallated catechins. Metabolic profiles can be effectively used in choosing accessions of desired tea quality for propagation and in tea breeding programmes to generate progenies with wide variation.

New sample preparation method for quantification of phenolic compounds of tea (*Camellia sinensis L. Kuntze*): a polyphenol rich plant

Chemical analysis of the Sri Lankan tea (*Camellia sinensis* L.) germplasm would immensely contribute to the success of the tea breeding programme. However, the polyphenols, particularly catechins (flavan-3-ols), are readily prone to oxidation in the conventional method of sample preparation. Therefore, optimization of the present sample preparation methodology for the profiling of metabolites is much important. Two sample preparation methodologies were compared, fresh leaves (as in the conventional procedures) and freeze-dried leaves (a new procedure), for quantification of major metabolites by employing two cultivars, one is known to be high quality black tea and the other low quality black tea. The amounts of major metabolites such as catechins, caffeine, gallic acid, and theobromine, recorded in the new sampling procedure via freeze-dried leaves, were significantly higher than those recorded in the conventional sample preparation procedure. Additionally new method required less amount of leaf sample for analysis of major metabolites and facilitates storage of samples until analysis. The freeze-dried method would be useful for high throughput analysis of large number of samples in shorter period without chemical deterioration starting from the point of harvest until usage.

Indeed, our studies found that the freeze-dried sampling procedure recorded significantly higher amount of metabolites with small leaf quantity and facilitates storage of samples without chemical deterioration starting from the point of harvest until usage. Hence, the method is more suitable for metabolite profiling of tea germplasm using high throughput analysis where large number of samples need to be handled.

Phenolic compounds are the most commonly studied of all secondary metabolites because of their significant concentration and their significant roles in plant tissues. This highly diverse group of secondary metabolites is widely distributed in vegetable foods (legumes, cereals, and fruits) and beverages (tea, cider, and wine), which are important constituents of the human diet. Therapid degradation of flavonoids during the extraction is a major drawback for the accurate quantification of this ubiquitous group of compounds. Quantification of flavonoids in fruits, vegetable, and other crops are important because of their importance as potent antioxidants molecules. They become perishable mainly due to the enzymatic oxidation regulated by the enzyme polyphenol oxidase and light. Polyphenol oxidase is activated when the plant tissues are macerated and the enzymes get mixed with the substrate and the major parts of the native flavonoids are destroyed before quantification.

Thus, metabolite profiling of representative accessions from the Sri Lankan tea germplasm by chemical analysis of tea leaves would immensely contribute to the success of a tea breeding programme. The polyphenols, particularly catechins (flavan-3-ols) and their oxidation products, which are eventually responsible for the quality of tea [14], are readily oxidized by polyphenol oxidase enzymes. The collection, handling, and storage of a large number of leaf samples for metabolite profiling thus require a sample preparation procedure that would minimize the oxidation of polyphenols and formation of artifacts. In this backdrop, this research has been carried out with the objective to optimize the sample preparation procedure to minimize the chemical deterioration that takes place in tea flush due to the inevitable delay in analysis. For this purpose, a comparative study has been conducted between the fresh leaves (conventional procedures) and freeze-dried leaves (new sampling method), for quantification of some critical metabolites—gallic acid, catechins, and methylxanthines, by employing two cultivars, one (DT1) of which is known to yield high quality black tea and the other (TRI2025) poor quality black tea.

Conclusions

The freeze-dried sampling procedure recorded significantly higher amount of metabolites with small leaf quantity and facilitates storage of samples without chemical deterioration starting from the point of harvest until usage.

Genetic variation of flavonols quercetin, myricetin, and kaempferol in the Sri Lankan tea (*Camellia sinensis* L.) and their health-promoting aspects

Flavonol glycosides in tea leaves have been quantified as aglycones, quercetin, myricetin, and kaempferol. Occurrence of the said compounds was reported in fruits and vegetable for a long time in association with the antioxidant potential. However, data on flavonols in tea were scanty and, hence, this study aims to envisage the flavonol content in a representative pool of accessions present in the Sri Lankan tea germplasm. Significant amounts of myricetin, quercetin, and kaempferol have been detected in the beverage type tea accessions of the Sri Lankan tea germplasm. This study also revealed that tea is a good source of flavonol glycosides. The *Camellia sinensis* var. *sinensis* showed higher content of myricetin, quercetin, and total flavonols than var. *assamica* and ssp. *lasiocalyx*. Therefore, flavonols and their glycosides can potentially be used in chemotaxonomic studies of tea germplasm. The nonbeverage type cultivars, especially *Camellia rosaflora* and *Camellia japonica* Red along with the exotic accessions resembling China type, could be useful in future germplasm studies because they are rich sources of flavonols, namely, quercetin and kaempferol, which are potent antioxidants. The flavonol profiles can be effectively used in choosing parents in tea breeding programmes to generate progenies with a wide range of flavonol glycosides.

Tea is the second most popular beverage after water which represents a major source of dietary polyphenols. Thus, the scientific community is interested in exploring the health promoting constituents present in tea, namely, flavan-3-ols, flavonols, and their derivatives. Recent epidemiological studies have demonstrated a protective effect of fruits and vegetables against the incidence of degenerative diseases. Several classes of compounds have been assumed as potential protective factors, one of which is the flavonoids, generally considered as non-nutritive agents. Flavonoids are known as secondary metabolites which are the largest class of polyphenols widely distributed in the plant kingdom. It can be subdivided into six major subclasses based on the structural variations: flavones, flavanones, isoflavones, flavonols, flavanols, and anthocyanidins. Tea is a good source of flavonols. Flavonols have recently received much attention due to their antioxidant, antimicrobial, anticancer, antiatherosclerotic, and antiproliferative properties. Common flavonol aglycones in tea are quercetin, kaempferol, and myricetin. Ceylon tea from Sri Lanka, acclaimed as the best tea in the world, has its inherent unique characteristics and reputation running over more than a century. The objectives of this study were to investigate the variation in flavonol aglycones, namely, quercetin, kaempferol, andmyricetin in tea (*Camellia sinensis* L.) accessions including beverage and non-beverage types. Therefore, we have reported the first systematic study on the flavonol content in representative accessions of the Sri Lankan tea germplasm.

Conclusions

Significant amounts of myricetin, quercetin, and kaempferol have been quantified in the beverage type tea accessions of the Sri Lankan tea germplasm. The var. *sinensis* showed higher content of myricetin, quercetin, and total flavonol than var. *assamica* and ssp. *Lasiocalyx*; therefore, flavonols and their glycosides can be useful to chemotaxonomic studies of tea germplasm. The non beverage type cultivars, especially *Camellia rosaflora* and *Camellia japonica* Red along with the exotic accessions resembling China type, are worthwhile in future germplasm studies because they are rich sources of flavonols, namely, quercetin and kaempferol, which are potent antioxidants and possess health-promoting aspects. Additionally, the flavonol profiles can be effectively used in choosing accessions in tea breeding programmes to generate progenies with wide variations.

Related Publications

1. P. A. Nimal Punyasiri, Brasathe Jeganathan, J. Dananjaya Kottawa-Arachchi, Mahasen A.B. Ranatunga , I. Sarath B. Abeysinghe, M. T. Kumudini Gunasekare, and B. M. Ratnayake Bandara, 2017, Genotypic variation in biochemical compounds of the Sri Lankan Tea (*Camellia sinensis* L.) accessions and their relationships to quality and biotic stresses. *J of Horticultural Science and Biotechnolgy*, https://doi.org/10.1080/14620316.2017.1289070
2. P. A. Nimal Punyasiri, Brasathe Jeganathan, J. Dananjaya Kottawa-Arachchi, Mahasen A. B. Ranatunga, I. Sarath B. Abeysinghe, M. T. Kumudini Gunasekare, and B. M. Ratnayake Bandara, 2015, Optimization of Sampling Methodology for Metabolite Profiling of Sri Lankan Tea. *Journal of Analytical Methods in Chemistry*, ID 964341, 6 pages. http://dx.doi.org/10.1155/2015/964341
3. Brasathe Jeganathan, P. A. Nimal Punyasiri, J. Dananjaya Kottawa-Arachchi, Mahasen A.B. Ranatunga, I. Sarath B. Abeysinghe, M. T. Kumudini Gunasekare, and B. M. Ratnayake Bandara, 2016, Genetic Variation of Flavonols Quercetin, Myricetin and Kaempferol in the Sri Lankan Tea (*Camellia sinensis* L.) and Their Health-Promoting Aspects. *International Journal of Food Science*. Article ID 6057434, 9 pages, http://dx.doi.org/10.1155/2016/6057434

Full articles listed above could be emailed to any interested researcher – nimal@ibmbb.cmb.ac.lk.

Acknowledgments

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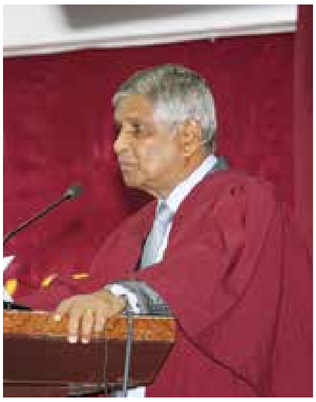
47th Annual Sessions of the Institute of Chemistry Ceylon


Dr. Poshitha Premaratne, President, IChemC delivering the Presidential Address


Mr. Kulathunga Rajapaksha, Chief Guest delivering his Address


Mr. Madura Vithanage, Guest of Honour delivering his Address


Ms. K Anoosheya receives the Prof. M U S Sultanbawa Award


Prof. P A N Punyasiri delivering the Dr. C L de Silva Gold Medal Award Lecture


Winners of the All Island Chemistry Quiz 2017/18 - Vincent Girls' High School, Batticaloa

Chemistry Olympiad Sri Lanka 2018 - winners with Officials


Section of Participants


Section of Participants

Theme Seminar: Chemists' Contribution towards National Policy Development

Professor Ajith de Alwis

Dr. (Ms.) Ilmi G N Hewajulige

Ms. Chandrika Thilakaratne

Ms. Nazeema Ahamed

Ms. M M S K Karunaratne

Ms. W M V Tennakoon

Section of Participants

Technical Sessions

AGM at SLFI

Induction Ceremony of 81st President and Annual Dinner of the Institute of Chemistry Ceylon

Lighting of the oil lamp by the Chief Guest Prof. Sampath Amarathunge

Introducing the new president by Snr. Prof. S. P. Deraniyagala

Prof. Sudantha Liyanage being inducted as the 81st President of the IChemC

Prof. Sudantha Liyanage addressing the audience

Proposing the toast by Prof. Emeritus A M Abeysekera

Cultural item

Section of Participants

Section of Participants

Theme Seminar on

Chemists' Contribution towards National Policy Development

Date : 14th June 2018 **Venue : Sri Lanka Foundation Institute, Colombo 07**

Keynote Address

Chemists' Contribution to National Development and Policy

Professor Ajith de Alwis

COSTI, Ministry of Science Technology and Research and University of Moratuwa

Ability to Transform

Chemistry is a fundamental science. Since moving from Alchemy to Chemistry with a sound scientific basis, the world has seen many developments and advances thanks to this Science - Chemistry. If an economy that was changed due to chemistry and chemists can be identified it is Germany. The chemists worked in harmony with mechanical engineers (chemical engineers have not arrived on the scene in Germany!) in transforming its economy basically due to transforming organisations such as BASF, the largest chemical producer in the word. The history of BASF nicely illustrates its growth attributed to five basic raw materials – salt, crude oil, air, sulphur and natural gas. It is in Germany that Haber created the process for ammonia synthesis thereby supporting the fertilizer industry. Still the highest use of ammonia is in fertilizer, which keeps feeding the growing billions on our planet.

As shown in the following figures the BASF was literally transformed from the innovative developments of a few key raw materials. In bringing this internal changes it played a dominant role in the economy is no doubt.

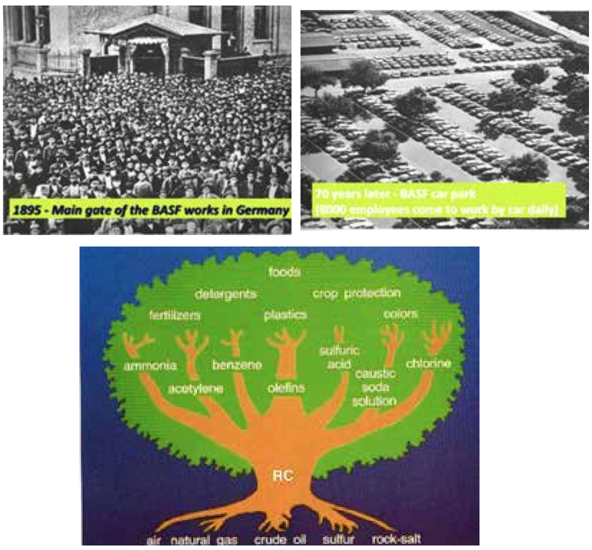


Figure 1: Transformation of BASF and the Basic Raw materials

Know your Value

It is important that those in science understand their value. Their ability to contribute to the society using their knowledge has not been fully understood. This is especially true in a developing country such as Sri Lanka. Chemists have left economies to the Economists to add value when they are quite ill prepared to do that alone! The innovation process as indicated below in many a sphere demands significant chemist inputs.

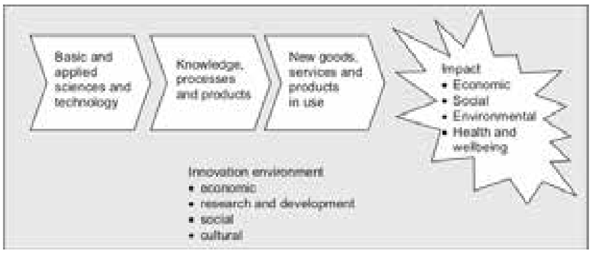


Figure 2: Innovation Process

Yet, we need to stress the importance of partnerships and teamwork in realizing real value but most of today's decision making is done with hard sciences ignored. Chemists must build strong relationships with the development economists. This is especially true in Sri Lanka.

Responding to challenges

Today in the world it is a fact that one cannot proceed in the way that one has progressed over the past years in the future as well. Climate change is real and is posing a threat that put all of us at risk. It was Arrhenius who initially calculated the possibility of temperature rise if the humans were to continue to use coal etc. but his simple calculation having yielded 1000 years he was not moved into any action. However, today the understanding is much more exact and the need to act much more urgent. The demands on food, water and energy in the coming decade is going to be quite challenging as one observes with results from modeling studies which had been published.

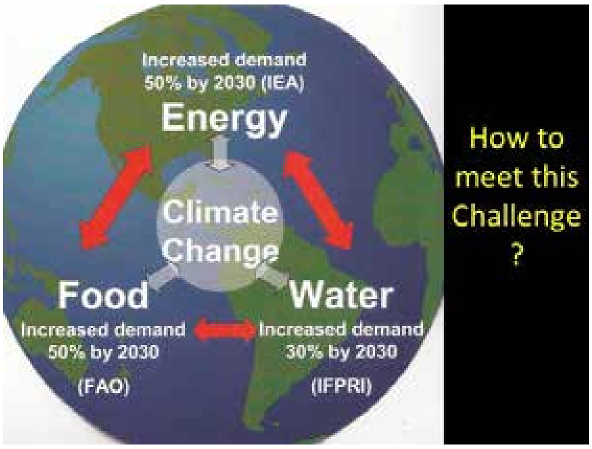


Figure 3: The change in global demand for water, food and energy (simulated data)

Chemistry has given way to Green Chemistry. Yet we appear to learn Chemistry in the normal way first and then study Green Chemistry almost as an afterthought. This is where the more enlightened chemists should initiate action. The future human capital we need to equip with what the future demands. Action in industry needs to be aligned the same way. Recently more ozone depleting substances again have been noted and measurements have pointed certain pockets in China going back to use banned chemicals due to cost reasons. Economics for shorter gain compromising long term sustenance. National policies need clear direction and action.

Figure 4: Principles of Green Chemistry

Chemists on World Stage

When certain net outcomes are observed and analysed we can definitely feel the importance of scientifically minded people governing us. Again, although this is almost absent in Sri Lanka many a developed economy witnesses this situation.

Israel founding president was Chaim Weizmann who was a biochemist who incidentally played a big role in process design in supporting the outcome of the First World War for Great Britain. Weizmann developed the acetone–butanol–ethanol fermentation process, which produces acetone through bacterial fermentation. His acetone production method was of great importance for the British war industry during World War I. He founded the Weizmann Institute of Science, which today is a globally top research institute.

Margret Thatcher funded her politics initially as a researcher – she developed an emulsifier for ice cream production - and she went on to change the use of coal in UK and supporting the establishment of the Intergovernmental Panel on Climate Change (IPCC) and also the Hadley Center for Climate Prediction and Research. As a Quantum Chemist Angela Markel is considered one of the most powerful persons on earth today! The exact chemistry used in governance is not quite clear but her fame as an Iron Chancellor is well known. His Holiness the Pope who speaks eloquently on the Climate Change and Social equity has had his training as a Chemist. It has been recorded that careful measurement ranks high in his list of values. May be his Chemistry upbringing definitely has shaped his views and he is determined to influence policy of not just one country but of many.

It is important to understand that scientific decision-making can really benefit, at least in terms of ensuring adequate financing, to support national science policies. Science Policy is what usually determines what science is worth pursuing and how much money the scientific establishments should be receiving.

With a woefully inadequate research funding in Sri Lanka there is a serious need for advocacy from the chemistry community to support enhanced allocations. The community should be equally prepared to ensure that allocations are meaningfully utilized.

Role of the Ministry of Science, Technology and Research

Nazeema Ahamed
Director Planning, Ministry of Science Technology and Planing

Introduction

While Sri Lanka is notably known to excel in certain areas such as health care and education, there is a need to complement the growth in technological advancement including relevant infrastructure that can ensure a promising economic growth while ensuring a knowledge based economy. Technological advancements are often supported with enhanced focus on innovation. It is evident over the past few years, that although there is a growing trend in new startups and entrepreneurships, they are still local and not innovative. In competing with the global market, it is important that the country adopts new technologies and innovative thinking in businesses and processes in addition to research and development. Since innovation cuts across through a larger spectrum, Chemists' contribution is vital and interrelated to all aspects of innovation.

The Ministry of Science, Technology and Research (MSTR) has a significant role in contributing towards creating an innovation based economy by linking all sectors of the economy as well as the scientific aspects. Recognizing this, the MSTR is specially engaged in promoting demand driven research, innovation focused industry-research tie-ups and creating an enabling environment by supporting techno entrepreneurships both financially and technically. On the other hand, special attention is given towards developing and adapting emerging technologies such as biotechnology, nanotechnology, robotics, artificial intelligence etc. In essence, the Ministry continued to accord the highest priority to create a link between research, industry tie-ups and creating a technology based space for economic growth where Chemists could engage by providing technical and technological inputs.

In addition, the Ministry is also engaged in popularizing science at all levels through various initiatives such as promotion of Science, Engineering, Technology and Mathematics (STEM education), development of technology based curriculum in collaboration with the Ministry of Education, promoting grass root technology transfer mechanism through Vidatha Resource Centres, etc.

There is always a phenomenon that the government investment on R & D gets a lower priority i.e. 0.1% of GDP which compares unfavorably to a regional average of 2.41% according to a recent report by UNESCO. There are also concerns that Sri Lanka has not seriously looked at ways to synergize emerging technologies for greater economic gain and export of hi-tech exports. Transforming this traditional approach, the MSTR was able to initiate implementation of various projects focusing on emerging technologies and high-tech exports. This include, the project on prototype manufacturing of solar panel, establishment of proposed Biotechnology Innovation Park, proposed project on Mechatronic based Economic Development Initiative (MEDI), supporting incubator facilities at provincial and district level, innovation accelerator funding mechanism to support high end innovations, etc.

Acquisition of more sophisticated productive capabilities requires stronger partnerships between the private sectors, industry associations, public research institutes and universities. Upon realizing the above, the MSTR has made a huge investment to develop high end laboratory facilities that could be used by all parties. The Institute of Chemistry of Ceylon could also become a partner of these initiatives through engaging in R & D and innovation so as to ensure the maximum usage of government investment.

In addition, the MSTR in collaboration with the UNDP has recently initiated the Social Innovation Lab that will provide a space for experimentation, collaboration and innovation of new ideas, policies and strategies in a controlled environment there by enabling citizen feedback from the beginning. It is expected that through this mechanism, policies, idea and concepts that are tested for implementation success in advance. Here again, the Chemists could engage or interconnect with these new initiatives and become an Institute that is aligned with government priorities in the fields of Science, Technology and Innovation (STI).

The Ministry also strengthened its international cooperation efforts through bilateral negotiations with India, China, Belarus, Slovenia, Japan and Pakistan. Joint research programmes are already being implemented with India, China and Pakistan. International cooperation between countries helps us to increase the R & D engagement and technology transfer mechanisms through joint research programmes. The Ministry provides space for all R & D institutes to submit their research proposals for funding under this cooperation and this would be an ideal research platform for the

IChemC to get connected with the public sector.

The Profile

In meeting the commitments in the field of Science, Technology and Innovation, the Ministry currently functions with the vision of "Sri Lanka becomes a scientifically and technologically advanced country by the year 2020". The Ministry's Mission is to "formulate and implement policies pertaining to the popularization and advancement of science and technology, including scientific research and development and transfer of technologies, to ensure improved quality and productivity so as to upgrade economic activities, which are essential for the economic and social development of Sri Lanka".

In order to achieve the Vision and the Mission of the Ministry, there are 12 Institutes functioning under the purview of the Ministry which engage in policy formulation, R & D, funding R&D, science popularization, accreditation, standards and system certification, and promotion of invention and innovations. The Institutes coming under the purview of the Ministry are given below-

1. Arthur C Clarke Institute for Modern Technologies (ACCMT)
2. Industrial Technology Institute (ITI)
3. National Institute of Fundamental Studies (NIFS)
4. National Engineering Research and Development Centre (NERD Centre)
5. National Science Foundation (NSF)
6. National Research Council (NRC)
7. National Science and Technology Commission (NASTEC)
8. Sri Lanka Accreditation Board for Conformity Assessment (SLAB)
9. Sri Lanka Standards Institution (SLSI)
10. Sri Lanka Inventors Commission (SLIC)
11. Sri Lanka Planetarium
12. Sri Lanka Institute of Nanotechnology (SLINTEC-Private Company)*

Research Priorities and National Development Focus of STI Sector

Any development initiative that takes place in the country should be aligned with the national and development priorities of the country. Considering this, the Ministry has given highest priority in making research relevant so as to contribute towards creating an innovation based economy. Accordingly, all R &D and STI initiatives of the Ministry are based on the following key initiatives of the government.

- National Research and Development Framework
- Sustainable Development Goals
- Nationally Determined Contributions proposed by the government of Sri Lanka in achieving Paris Agreement to address Climate Change issues
- Blue-Green Economy
- Enterprising Sri Lanka- budget speech 2018
- Innovating Sri Lanka

Based on the above, the Ministry and Institutes are focused on the following main thrust areas

- Nanotechnology
- Biotechnology
- Alternative and renewable energy
- Food and herbal
- Value addition to mineral resources
- Climate change and related impacts
- Space applications
- Environmental conservation
- Artificial intelligence
- Health related issues

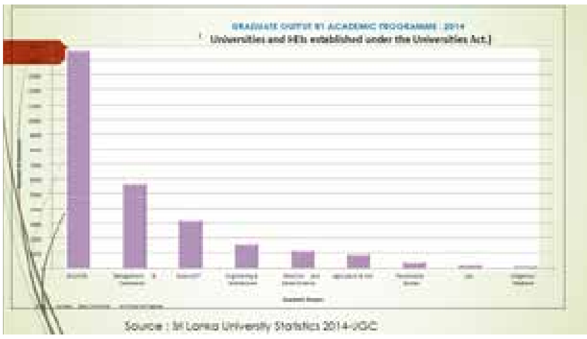
Major Challenges of the STI sector

Although the Ministry and research institutes are functioning with government funding and other facilities, in meeting the commitments of the Ministry, there are several challenges that hinder the performance of STI sector. They include

- Inadequate human resources with required qualification and brain drain
- Inadequate relevance to national priorities
- Unguaranteed funding
- Uncoordinated and fragmented approach
- Research duplication and lack of monitoring system
- Non availability of a system for outcome evaluation to measure impacts

Inadequate human resources and brain drain

According to recent statistics of the University Grant Commission, number of science graduates is reasonably low in comparison to management, arts and other graduates. On the other hand not all the science graduates engage in R & D or in relevant sectors. They often go on a battle of finding a job that provides a better remuneration. Finally they end up in a different field such as finance, administration etc. or migrating to another country leaving the STI sector of the country with inadequate human resources.



Similarly, the country also does not have adequate facility to accommodate more science and engineering graduates into an innovation based economy so as to engage those to contribute towards national development. Also, there is no attractive and continuous support for scientists and engineers especially for inventors and innovators to create an innovation based economy which will increase our economic growth. Therefore, it is all about system development and systematic approach to attract critical mass of scientists and researchers on STI.

Inadequate relevance to national priorities and uncoordinated and fragmented research approaches

As it is evident, all universities in the country and all Public Research Institutes (PRI) are engaged in research and development. However, their relevance to national priorities is in question. As a result majority of the research is limited to paper publications. Since all of these research institutes are funded by the government, it is important that the results of these R & D make an impact on national development. However, current research culture is mainly limited to basics and fundamental studies. Demand driven and industry based research culture is comparatively weak. This culture leads to lack of PRI-University-industry links where unique opportunities to meet industry needs are minimized.

Moreover, although there is demand driven or industry based research which is undertaken, commercializing them or making research into rupees is extremely low. The main reason for this is that PRIs do not invest in having a dedicated unit or a person to work with the business sector or industry to commercialize their prototypes. Subsequently, the scientists do not adequately have the marketing capacities. Thus, most often even though the research outputs are demand driven, they are not in the market.

Another main and threatening issue in the STI sector is uncoordinated and fragmented approaches. Each and every institute prefers to work in silo which leads to unproductive use of government resources and especially, financial resources. Most often majority of the research funding is spent on operational and administrative cost and research duplication is visible in almost all aspects. Since all of these research institutes are funded by the government, working together towards a common objective will provide more opportunities for productive results with limited funding while convincing the government with better outcomes which will definitely justify increasing government funding on R & D.

Unguaranteed funding

In developing an innovation based economy and creating a research culture, guaranteed funding is imperative. However, the current funding system of the government is not much supportive for STI sector. Since the results of research are not short term and tangible as in other sectors such as transport, housing etc., it is a complex task to convince the Treasury on intended outcomes of particular research. This leads to reduction in budgets regularly for not being able to show them results within a short period. Therefore, it is important that government provides guaranteed funding until the research is completed so as to yield the outcome. On the other hand, STI is not in the priority list of the government for funding and most often available resources are divided among so many institutes and universities while access to financial grants are popular only among a limited group .

Non availability of a system to measure outcome and impacts

Majority of the above issues could be resolved by having a proper monitoring and evaluation (M&E) system of research. Regular monitoring and evaluation is not done either by research institutes or research funding institutes. Most of the time, monitoring and evaluation is limited to output and not the outcome. As a result the government or the General Treasury tends to rethink about funding. Subsequently, evaluation gives important feedback and lesson learning for the next steps, specially for commercializing the R & D. The Institutes such as IChemC could join hands the government in evaluating the R & D outcomes.

Role of Chemists in STI sector and Collaboration with the Ministry

To conclude, in line with above context, chemists could engage with the Ministry and all other public research institutes in so many aspects. They mainly include the following;

- Engage in joint research programmes
- Contribute to research proposal reviews so as to undertake nationally important research
- Facilitate research outcome evaluation
- Provide inputs for policy making through existing systems such as Social Innovation Lab
- Obtain the services of government incubation centres in undertaking R & D
- Advise the government on policy and programme needs for better STI culture

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Role of Industrial Technology Institute in Product Development

Dr. (Ms.) Ilmi G N Hewajulige

Senior Deputy Director / Research Fellow, Food Technology Section, Industrial Technology Institute

Vision 2025, the Government's vision is to make Sri Lanka a rich country by 2025 transforming Sri Lanka into the hub of the Indian Ocean, with a knowledge-based, highly competitive and social-market economy. However, Science, Technology and Innovation are the key drivers of knowledge based economical growth of any country. Therefore, scientific innovations, new product development and technology commercialization in national and international level are important for better economic growth. The 'Global Innovation Index Report 2017' ranks Sri Lanka at 90 out of 127 nations worldwide indicating lack of scientific innovative culture within the country. This could be due to low investment in R&D in terms of less annual GDP contribution (0.11% in 2017). Low investment in R&D in return will result inadequate human resources and poor R&D infrastructure leading less visibility of R&D outputs such as less number of patents and commercialized products, ad-hoc R&D and less focused programmes and low level industry oriented R&D in the country. Therefore, no significant contribution of R&D for wealth creation of the country is observed with very low amount of manufactured high tech exports.

Industrial Technology Institute (ITI- Successor to CISIR) is a multidisciplinary R & D Institution by its mandate. ITI was established in 1955 under the Parliament Act No. 15 of 1955 (CISIR Act) in order to support the Industrial Development in the country. ITI functions under the preview of the Ministry of Science, Technology and Research, with a vision of becoming a center of excellence in scientific industrial research for national development. The institute is geared by its mission to conduct innovative R&D and provide internationally competitive technical services to accelerate industrial development for the benefit of the people of Sri Lanka. ITI and private industries of the country shares a rich history of research collaboration. To facilitate the industry, the ITI needs research which are in applied nature, aiming a market ready solution as the end product. The commercialization strategies of ITI include collaborative and contract research projects with industry, consultancy services, and direct technology transfers on exclusive or non exclusive basis via technology transfer agreement with or without royalty payment according to the ITI Intellectual Property Policy. With this intervention ITI was able to introduce many successful products related to food, herbal, chemical, biotechnology and material technology to local and international markets in the recent past. To cater the immerging market needs, ITI laboratories are equipped with expert staff, state-of the art equipment and pilot scale machinery. The testing laboratories of ITI are accredited with ISO/IEC 17025: 2005 while R&D laboratories are complied with ISO 9001:2015 quality management system.

The contribution of chemists in scientific R&D inventions, product development and technology commercialization is substantial in terms of the economic growth of the country. Their contribution in product and process standardization and laboratory accreditation in terms of providing data to set up limits in specific standards or validate measurement standards, implementing standardized measurements methods to provide reliable and acceptable data is invaluable. In addition, the chemists also contribute in metrology with special reference to chemical metrology by providing appropriate measurement support in quality management systems. The laboratory or test parameter accreditation which is the main pillar of conformity assessment and quality infrastructure system inevitably uses the chemical data and limits originated by chemists. The role of chemists in achieving the sustainable development goals 2015 - 2030 introduced by the United Nations Development Programme (UNDP) is also significant in terms of safe
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food product development by detection of adulteration and contaminants, medicinal food to combat with Non Communicable diseases (NCDs), herbal based new drug discovery, medical breakthroughs for diseases and ailments, enabling people to live longer and healthier lives, to supply safe drinking water, sanitation including disinfectants that kill germs and prevent disease etc. More than 95% of the manufacturing goods are touched by chemistry / chemists in different forms and therefore Chemists' contribution for innovation and economic growth is significant.

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Unveiling of the Portrait of Distinguished Service Awardee, Senior Professor Samitha P. Deraniyagala

The Institute of Chemistry Ceylon organized a ceremony for unveiling the portrait of the distinguished service awardee, Professor S. P. Deraniyagala which was held on 3rd of August 2018 at 3.30 pm at the council room of Adamantane House located at Rajagiriya.

Professor S. P. Deraniyagala being a fellow of the Institute of Chemistry Ceylon and a Charted Chemist, has contributed immensely to the advancement of the Institute by holding the key positions such as Honorary Rector, Dean of the College of Chemical Sciences and visiting Senior Professor in Chemistry. He served as the President of the Institute in 2009/2010 prior to which he was the Vice President and then the President Elect.

The citation for the above award was read by Prof. Ramani Wijesekara, Department of Chemistry, University of Colombo. The portrait was unveiled by Prof. Ajit M. Abeysekara, Prof. Emeritus, Department of Chemistry, University of Sri Jayewardenepura.

The ceremony was attended by Prof. Sudantha Liyanage, President of the Institute, Honorary Rector, Dean CCS, Past Presidents, Members of the Council and academic and non-academic staff of the Institute and several other distinguished guests including Mrs. Mandrupa Fernando and Mrs. S. Ramakrishna.

Prof. S. Liyanage welcoming the guests

Prof. Ramani Wijesekara reading the citation

Prof. Emeritus Ajit M. Abeysekara unveiling the portrait of the awardee Prof. S. P. Deraniyagala

Prof. S. P. Deraniyagala addressing the gathering
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International Chemistry Olympiad (IChO) 2018

The 50th IChO competition was held in Bratislava, Slovakia and Prague, the Czech Republic from July 19 to 29, 2018 Sri Lanka was represented by Dr Chinthaka Nadun Ratnaweera as an Observer and his comments are included herein.

IChO was initially formed in 1968, exactly 50 years ago in Czechoslovakia. Hence, the IChO celebrated their 50th anniversary along with this competition and interestingly, it was held in the same country where it was originated. The opening ceremony was held in Bratislava, Slovakia where all the participating countries were introduced. During the opening ceremony, Sri Lanka was recognized as a first-time observer country. After the welcome gathering held on the same day afternoon, the students and mentors (and observers) were separated where upon students and mentors were not able communicate among themselves until the examinations were over.

There were two parts in the IChO examination consisting theory and practical and mentors and observers were accompanied to the university laboratories to inspect the practical examination setup. Mentors verified whether all the required items such as glassware, apparatus, and chemicals were placed in the correct order at the student's workstations. Following the laboratory inspections, a draft practical examination paper was presented to review. Mentors thereafter had an opportunity to discuss the issues involved in the exam problems with the authors. After resolving the related issues IChO Jury approved the exam questions. Next day was assigned for the translation of the practical examination which was carried out by the mentors and observers representing each country. Even the representatives of the English speaking countries did the required language adjustments to the question paper.

After completing the practical examination, copies of the draft theoretical problems were given to mentors for reviewing. Similar to the practical examination, mentors discussed the issues with the authors before the final paper was approved by the Jury. The Jury meetings were held for a few hours to address all the issues raised by the mentors. When there were contradictory views the judges had to go for the majority vote. On the following day mentors and observers did the translations and any language adjustments that were necessary. Doing translations were a very tedious task and time consuming work for the non-English speaking countries since the questions were lengthy and quite elaborative.

After the theoretical examination, answer scripts were marked by the authors according to an approved marking scheme. All the countries were given copies of the marking scheme and copies of their students answer scripts. Subsequently, the mentors marked their student's answer scripts and compared them with examiners (authors) marks and did any arbitrations that were found necessary.

Students did both practical and theory examinations in Bratislava, Slovakia where as both mentors and observers stayed in Prague, 300 km away. After all the examinations were over, a reunion gathering was held in Prague. Students were given a considerable time for relaxing after completing their hectic examinations.

Finally, the IChO judges decided about the cutoff marks for awarding Gold, Silver, and Bronze medals and also for granting honorable mentions. According to this year's criteria, gold medals were awarded to 8-12%, silver medals to 18-22%, and bronze medals to 28-32%. Approximately 70% of students received a medal or an honorable mention. Award winners were rewarded at the grand closing ceremony held in Prague.

During the event, I gained a valuable experience as an Observer. As per the request made by IChO steering committee, I presented a brief description of our current status and plans for participating at the 2020 IChO. They were very satisfied with our progress. During the event, I exchanged our views with several steering committee members including Dr Peter Wothers, who visited IChemC a few years back and advised us to clarify certain issues prevailed at that time. Also, I talked with many mentors from different parts of the world and learned their selection process and methods of training. I participated in all the Judges meetings during the event, thus understood their current regulations and the proposed amendments for achieving their future aspirations. In addition, they discussed about the syllabus revisions which are expected to be implemented during the forthcoming year.

Altogether 76 countries participated at this year IChO and 6 countries represented as observers. More than 300 students from many parts of the world competed in this event and it was well organized and conducted in a highly professional manner.

I wish to thank the IChemC sincerely for giving me this opportunity to participate and initiating the first step towards sending a team from Sri Lanka to compete at the IChO in 2020. Participation at IChO probably benefits Sri Lanka in terms of uplifting the standards of Chemistry education in this country and also to promote the recognition of the Institute of Chemistry both locally and internationally. As the Chairman of the Chemistry Olympiad Sri Lanka committee, I look forward to make the necessary arrangements to send an effective team who would be capable to compete with students from countries and to win many medals.

Call for Nominations for Institute of Chemistry Gold Medal 2019 by 31st March *(Under Revised Rules)*

This Gold Medal was the very first of such awards to be donated to the Institute and was made possible through a generous donation made by **Mascons Ltd** in memory of their founder, **Mr A Subramanium** in 1978/79. It recognised contributions made to National Development through research and development involving Chemical Sciences. The Gold Medal Fund was supplemented recently through a further contribution from Mascons Ltd. This criteria governing the award were changed in 2011 since there were no applicants since 2007 in order to enable the award to be made to a mid-career Chemist in recognition of honorary services to the Institute.

Nominations are now being invited for the 2019 Award from amongst **Corporate Members** of the Institute who have fulfilled the following minimum criteria;

Nominees should be not more than 55 years of age and should have been Corporate members of the Institute for at least 10 years on 1st of June 2019

Nominees should have made significant contributions towards the activities of the Institute through yeoman services in an honorary capacity during the period of membership. These activities could include holding office, membership in committees, coordination of events such as workshops, social events *etc*.

Nominations could be made by any **Corporate Member** of the Institute and should include the consent of the nominee and details of the contributions made by the nominee in accordance with the above guidelines. The Award will be presented at the 48th Annual Sessions.

(**Nominations should be forwarded to reach the Hony. Secretary, Institute of Chemistry Ceylon not later than 31st March 2019**.)

Benevolent Fund Benefits for Members

i. Long life benefits:
Amount provided will be as follows:
a. Over 70 yrs : Rs. 12,000 b. Over 75 yrs : Rs.18,000 c. Over 80 yrs : Rs. 25,000.

ii. Critical illness benefits: up to Rs. 60,000

iii. International travel for conferences (with presentation of a paper):
a. Passive members : Rs. 30,000 (international travel only)
b. Active members : Rs. 60,000 (international travel and/or accommodation).

Any member who has paid membership fees for life (after 3 years of such payment) is entitled for these benefits. All members are advised to pay the membership fee for life and become beneficiaries.

Appreciation
Dr. Suppiah Senthi Shanmuganathan

Dr. Shanmuganathan was awarded BSc (Special Degree) with First Class Honours in 1950 from the University of Ceylon. He was recipient of the Bhikaji Framji Khan Gold Medal for the best performance at the Special degree examination in Chemistry, University of Ceylon. He joined the Medical Research Institute (MRI) in 1951 and proceeded Sheffield University, UK for his PhD degree. He returned to Sri Lanka and assumed duties at the Biochemistry Section of the MRI.

It was felt that middle level technical personnel in many institutions do not have opportunities for further education and training. Dr. Shanmuganathan recognized this gap and pioneered the initiation of the Laboratory Technician Certificate Course (LTTC) in 1972. Subsequently, this was upgraded Diploma in Laboratory Technology in Chemistry (DLTC). This course was conducted at Aquinas College of Higher Education until it was moved to the Institute of Chemistry Ceylon building, "Adamantane House" at Rajagiriya. As tribute to Dr. Shanmuganathan, I am pleased that the annual intake for this course is over 100. The course assists private sector laboratory personnel to obtain training and qualification for accreditation of the respective laboratory for accreditation under ISO/IEC 17025. He created a bursary at the Institute of Chemistry Ceylon to encourage and provide opportunities for many students to pursue their education.

Dr. Shanmuganathan was a visiting lecturer in Biochemistry at University of Ceylon. In the academic year 1969/1970 he supervised my seminar topic which was on "Colorimetry". At that time this was a new topic because the laboratory courses were on gravimetry and titrimetry only. He requested me to carry out references at the library of MRI. After the Seminar presentation I was inspired by Dr. Shanmuganahan and was interested in practicing colorimetry with my colleague Dr. S Hettiarachchi. We found an old Hilger machine at the Physical Chemistry Laboratory. We tried this to obtain colorimetric results but failed. We went to CISIR and mentioned our failure to Dr. M A V Devanathan. He said that the machine is a fluorimeter and not a colorimeter!

May lord rest his soul in peace!

H.D. Gunawardhana
Professor Emeritus, University of Colombo

Appreciation

Mr. Lakshman Perera B.Sc. (Hon.)

It was with great sorrow that I pen my thoughts here to celebrate the life of Mr. Lakshman Perera.

He was born on the 28th of June, 1955, and attended St. Joseph's College, Colombo 10. He was selected to complete his special honours degree in chemistry at the University of Colombo. He graduated with a second class in 1978. Upon graduation, he began his employment in the industrial sector. As a true chemist, he was more interested in the application of chemistry to solve real-life problems, instead of simply obtaining a PhD, of which he was clearly extremely capable.

My first encounter with Mr. Perera was when he taught me mathematics for a very short period in the sixth grade. I can vividly remember his teaching and how much I enjoyed his teaching style. He was a quick-thinker, and whilst his teaching style may not have been traditional, it was truly wonderful. My next meeting with him was shortly after leaving my first place of employment, and joining a company where he was my boss. My one and a half-year employment under his guidance was a huge learning curve. I vividly recall, one day, listening to him explain to one of his customers about a range of analytical techniques. His explanations were thorough, yet straightforward. He had the ability to understand various problems and suggest solutions that were simple and economical. I have seen only a handful of people who had such inherent abilities during my time in academia and the industry. He impressed me very much during my employment under him, to the extent that I have acknowledged his influence in my success in my early books.

I was fortunate to have reconnected with him in the past four years. He was a partner of one of my ventures in the education sector in Sri Lanka until his untimely death.

Mr. Perera was the CEO of C&T Worldwide, which is now run by his family. He was the recipient of the 2011 Presidential Award from former President Rajapakse for his original patented work on, "The method of manufacturing Low Aromatic White Spirits (LAWS)." In addition to this novel method of manufacturing LAWS, he also developed Termon S - a disinfectant approved on international grounds (effective against the bird flu virus H5N1), Decolor CT - a bleaching agent for rubber, and many other innovative products. Mr. Perera was a member of the Institute of Chemistry, Ceylon from 1986 to 2017 and became a fellow in December of 2016. During his time, he helped the Institute of Chemistry and the University of Sri Jayewardenepura by sponsoring various events, workshops and seminars, and also the Polymer Symposium, which was held once in three years.

Mr. Perera also made time to guide and refine the final year undergraduates of the University of Colombo, University of Sri Jayewardenepura, University of Peradeniya, and the Institute of Chemistry in their training in the field of industrial chemistry at his company and laboratory.

His only two daughters, who are both doctors, are the clear success stories of Mr. Perera's teaching and direction. He had always declared his pride about the achievements of his daughters, and his love for his wife who supported him throughout his life.

His family and friends will always miss him. In both a professional and social sense, we will remember him as a man of his word, and an eternal supporter of good causes. He will always be remembered by the chemists at the Institute of Chemistry, Ceylon, who are passionate in applying chemistry to solve real-life problems.

Of course, I will miss him as one of the great men whose influence helped to shape my formative years.

May he rest in peace.

Prof. Eugene de Silva
Fellow of the Institute of Chemistry, Ceylon
CEO - Virginia Research Institute, USA

Guest Articles

The 'Big' Deal about Those 'Small': The Global Perspective

Dr. Lahiru Wijenayaka

Senior Research Scientist, Sri Lanka Institute of Nanotechnology (SLINTEC), Mahenwatta, Pitipana, Homagama

The focus of nanotechnology is utilizing material in the nanoscale in imparting improved or superior properties on technological products that are difficult or even impossible to realize otherwise. Nano-enabled advanced products are increasingly becoming prominent in the local and international consumer market. Hence, with the advent of this novel and disruptive technology and its protuberant popularity in many fields of technology, there is an increased need for understanding why this emerging field has become an important part of our routine lives.

'Nano' labelled products are already flooding the shelves, especially in the more developed parts of the globe. Evidently, some products use the prefix 'nano' purely in a marketing perspective, with no reference to nanotechnology being used in their products, or even the preceding manufacturing processes as a whole. For example, Apple Corporation's iPod Nano© and the TATA Nano© automobile use the term 'nano' to signify the smaller dimensionality of their products, while no reference has been made for using nanomaterials and/or nano-scale engineering processes.[1] However, akin to any other emerging field, this relatively new field of technology has gone through a steady initial phase over the last few decades, and following the current and extrapolated trends in the marketplace and in scientific research, nanotechnology is expected to enter into a rapid growth with many actual nano-enabled technologies in the pipeline expected to enter the mass market within the next few years.

The Next Industrial Revolution

Technology has always been a key driving factor in determining the state of the human civilization. Having witnessed the massive societal progression subsequent to the first three industrial revolutions, today, the humans are on the brink of experiencing the fourth industrial revolution, soon to transform our perspectives on technology all together. According to Professor Klaus Schwab, Founder and Executive Chairman of the World Economic Forum, "the fourth industrial revolution will affect the very essence of our human experience", and clearly highlights its anticipated technological eminence. Notably, the fourth industrial revolution, or 4IR as more commonly known, is characterized by the fusion of technologies that is blurring the lines between the physical, biological and the digital spheres, while nanotechnology is known to strongly influence the above phenomena from both physical and biological perspectives as shown in Figure 1. Therefore, with the abundance of industries adopting nanotechnology and its governing principles, alongside the strong intervention of nanotechnology into advanced biomedical applications, it is undoubtable that nanotechnology is among the key globally emerging technologies today, hence driving the technologies of tomorrow.

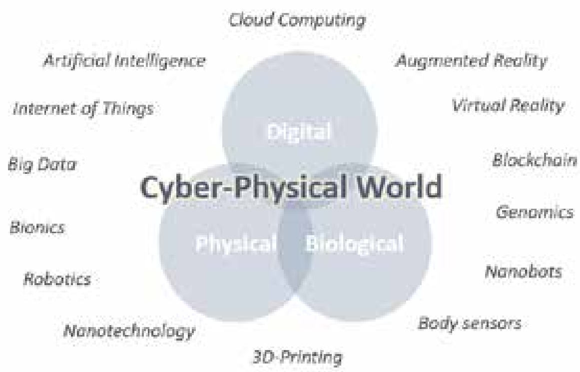

Figure 1: Blurring the lines in the cyber-physical world: An inevitable reason for the 4IR

The Sustainability Perspective

At the same time, with the steady rise in the world population, both observed and anticipated to continue, mankind is facing elevated challenges in meeting the rising demand for basic commodities and services, while minimizing the ensuing impact of human activities on the environment. Recognizing this need, the United Nations (UN) has proposed the Sustainable Development Goals (SDGs); a list of challenges the mankind has to face, while ensuring minimal intrusion into environmental and societal wellbeing. These 17 goals, summarized in Figure 2, address issues concerning climate change, economic inequality, sustainable consumption, and innovation among others, while 'sustainable development' in the context of these challenges is defined as "that which meets the needs of the present without compromising the ability of future generations to meet their own needs".[2]

Figure 2: Sustainable Development Goals (SDGs) proposed by the United Nations

Amidst the abundance of scientific research conducted in determining improved ways in which the human needs could be met, it is evident that many conventional scientific approaches are reaching their theoretical limits, hence being inadequate in meeting the escalating needs of the society. This, in turn, is where nanotechnology comes into the picture. Following the inception of the National Nanotechnology Initiative (NNI) of United States, it was envisioned that nanotechnology could provide sustainable solutions to many global challenges including (1) crop intensification, (2) efficient and economical water treatment and desalination technologies, as well as (3) clean and renewable energy sources including high-efficiency solar cells.[2] Today, as many may see, most of those above have become a reality in the light of contemporary nanotechnological research.

For example, the use of nano-enabled agrochemicals has indicated significant potential in making agriculture more efficient and sustainable, leading to improved food security that is imperative in meeting the needs of the growing human population.[3] At the same time, desalination of sea water is a strategy that is critical in meeting the potable water requirement of the growing human population. Remarkably, the nanometer-scaled pores in single-layer freestanding graphene can efficiently filter ions from sea water,4 while requiring significantly lower pressures and extremely lower energies in comparison to conventional reverse osmotic approaches. Furthermore, energy, is yet another overarching challenge to humans, where efficient solar energy harvesting is among the most widely explored solutions. Nanotechnology has indicated the promise to deliver benefits in the above, in terms of both efficiency and cost, allowing improvements in energy harvesting that would be unrealistic via any other conventional approaches adopted herein.

It is important to note that the SDGs will govern the policy and funding of the United Nations Development Program (UNDP) until 2030 in 170 countries and territories world over. Therefore, with the promise of nanotechnology in achieving many of the scientifically influenced SDGs, this emerging technology will continue to be in the forefront in terms of funding trends within the predictable future. According to many recent and ongoing scientific research, nanotechnology continues to advance scientific research, seeking to answer, (1) can nanotechnology help address the challenges of improving global sustainability in energy, water, food, shelter, transportation, healthcare and employment? and (2) can nanotechnology be developed and implemented in a sustainable manner with maximum societal benefits and minimum impact on Earth's global environment and climate?.2 Hence, the key role of nanotechnology in achieving sustainable development demarcates yet another strong reason as to why nanotechnology has attracted much attention globally during recent times.

Scientific Output Standpoint

Additionally, as a scientific discipline, it is worthwhile assessing the success of nanotechnology in terms of the funding attracted for research and development activities, as well as the eventual output, or more precisely the publications, patents and the market products ensued. It is clear that a major portion of federal as well as other research funding, specifically in the developed parts of the world, have been concentrated on nanotechnology based research and development work. Forecasting from the apparent trends, this inclination is expected to continue into the foreseeable future, with many prominent world leaders expressing their commitment in this regard. For instance, the US President's 2019 budget will provide nearly $ 1.4 billion for the NNI, an investment in support of innovation promoting America's interests, including competitiveness, economic growth, and national security. Nevertheless, this clearly indicates their continued trust on nanotechnology in guiding the economy and the well-being of the nation.

Notably, the temporal trends in both publications and patents in nanotechnology indicate a continuous and exponential growth, with no signs of exhaustion in the short run. Many researchers continue to work on nano-related disciplines, seeking to answer questions that clearly could not be approached via alternate means. Remarkably, there are more than 1500 nano-enabled products already in the market, and it is anticipated that 100's of new nano-enabled products are entering the consumer market each year. Hence, observed trends in the publications and patents, as well as the number of nano-enabled products flooding the shelves is yet another clear factor that highlights the globally perceived significance of nanotechnology.

Driving the Global Innovations

Another forte of nanotechnology is its distinctive emphasis on innovation. According to the United Nations Educational, Scientific and Cultural Organization (UNESCO), nanoscience and nanotechnology is a priority field for today's innovation leaders. Switzerland, for instance, topped both the European Union's Innovation Scoreboard and the Global Innovation Index, and had the highest output in nanotechnology: 198 scientific articles per million population in 2013. Remarkably, with sustained focus on nanotechnology driven research, Switzerland has continued to top the Global Innovation Index up until the present. The Global Innovation Index published by the Cornell University, European Institute of Business Administration and the World Intellectual Property Organization (WIPO) is an annual ranking of countries by their capacity for, and success in, innovation, thus highlighting its significance in terms of global stewardship. Hence, looking at the success story of Switzerland, it is clear that this mere number strongly highlights the significance of nanotechnology in driving the innovations perspective, and hence the economical and societal development of a nation as a whole.

So why would all this matter to us Sri Lankans? Based on the information presented above, it is not an exaggeration to say that for any nation, the knowledge and application of Nanotechnological principles in science and in industry is important to ensure that the local perspectives and priorities align with the international or global trends. Nevertheless, it is clear that there is a rich abundance of nanotechnology based opportunities in Sri Lanka that is yet to be explored. For instance, the design, manufacture and export of textiles and apparel products is one of the biggest industries in Sri Lanka, whereas there is a strong felt need for high-tech solutions and products for the textile and apparel industry world over. At the same time, Sri Lanka is home to a vast variety of minerals with high economic value spread throughout the country, indicating promising potential for technology based value addition. Hence, although beyond the scope of this narrative, it should be stated that the potential of our country would be endless, if we can effectively couple nanotechnology into our scientific and societal framework.

Most of those discussed above was what we have witnessed thanks to the pioneering work of nanotechnology within a relatively short tenure. But what does the future of nanotechnology promise? With the success of the ongoing nanotechnological research, a nanoparticle-based universal flu vaccine may one day provide immunity against all known strains, advance textiles with piezochromic nanowires may allow us to harvest energy simply through movement, artificial, self-heating muscle may allow amputees to better control their prosthetics, and nano-enabled miniscule devices that one can simple ingest may one day let doctors diagnose and treat diseases without the need for any invasive surgery. According to the NNI, "after more than twenty years of basic nanoscience research and more than fifteen years of focused research and development, applications of nanotechnology are delivering in both expected and unexpected ways on nanotechnology's promise to benefit society". Hence, with the multitude of reasons summarized here as to why the simple term 'nano' has garnered much attention globally, it is clear that there is certainly a 'big' deal about those 'small'.

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Computer Aided Drug Design

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Introduction:

Computer Aided Drug Design (CADD) is a multidisciplinary science that comprises chemistry, biology, physics, mathematics, biology, computer science and information technology in which the computational techniques are applied in drug discovery and development. Computational methods have become a vital part of the modern drug discovery since its origin in the late 19th century. Different terms such as: computer-aided drug design (CADD), computational drug design, computer-aided molecular design (CAMD), computer- aided molecular modeling (CAMM), rational drug design, in silico drug design, computer-aided rational drug design are being used to refer to this area. Rapid expansion and increased accumulation of large volumes of genomic, biological and chemical data involved in drug discovery and the advances in software and hardware i.e. computational power and its sophistication are the main reasons for the seamless merging of these two fields: computer science and drug discovery. CADD plays pivotal roles in almost all the preclinical steps of modern day drug discovery process, and hence, it enhances and accelerates the whole process. The conventional drug discovery is a costly process in terms of time, money and manpower. Bringing a new drug to the market can take an average of 10–15 years with an approximate cost of US$800 million to US$1.8 billion. This is simply due to the high failure rate of the novel drugs at the various stages of the drug discovery process. Therefore, CADD techniques are used by top pharmaceutical companies and other research groups across the globe to circumvent the high failure rates. CADD provides the drug discovery scientists a massive "trial-and-error" forecourt at a trifling cost. This definitely has opened more doors for "experimenting" with new ideas in terms of molecular structures of the new drugs.

High-performance Computing and Artificial Intelligence in Drug Discovery

Artificial intelligence (AI) enables the computers to skilfully perform intelligent tasks, without explicitly being programmed for them. The first application of AI in chemistry is dated back to 1960's where it was use in compound design in medicinal chemistry. However, even today there is no single AI that can autonomously design a new drug; instead, there are many different forms of AIs in the dicey game of drug discovery. Artificial Intelligence enables better understanding and design of new inputs, throughout the drug discovery process from target selection, hit identification, lead optimization to preclinical studies and clinical trials. In AI-based structure generation, the models are trained on large datasets (training sets) of molecular structures from exemplified medicinal chemistry space (i.e. with proven drug-likeness), such as ChEMBL. These AI generative models learn a distribution over the molecules in the dataset. From this distribution, the AI algorithms permit the sampling of novel molecules from the chemistry space that has been learned to be more 'drug-like'. While sampling the entire possible chemical space remains an extremely difficult task, the ability to predict reliable properties, such as biological activity is particularly challenging even with the help of AI. To address this problem, AI-based predictive-modelling has been introduced. Today we have access to large quantities of chemical structure data together with measured end points of relevance and it allows us to generate predictive models. Furthermore, it allows application of techniques such as deep learning to these large datasets. Deep learning chemical property prediction is now a very active area of research. Current applications of AI in drug discovery is not limited to molecular design and property prediction; it also is currently being used to predict the synthetic routes.

Having "smart" computers loaded with AI only is not sufficient in the modern drug discovery due to the large size and the high complexity of the chemical systems of interest. Fast computers with high processing power and storage capacity are essential in CADD. Such a supercomputer is a really a "superman" version of a general-purpose computer. The IBM Blue Gene/P supercomputer "Intrepid" at Argonne National Laboratory (US) has 164,000 processor cores compared to 4 processer cores in a home computer. These supercomputers have highly enhanced performances and therefore their usage is known as High Performance Computing (HPC). As of 2017, there are supercomputers which can perform up to nearly a hundred quadrillion FLOPS (Floating point operations per second). Employing high performance computers have dramatically cut down the calculation and simulation time in CADD. Therefore, HPC has become an essential component in computer aided drug discovery.

CADD Strategies

In CADD, there are few major approaches to design a novel drug. Among them, Structure-Based Design (SBD), Ligand-Based Design (LBD), Compound Library Design, High Throughput Screening (HTS) and Transition State Analogue Design (TSAD) are the most common strategies.

In SBD, the target protein's structure is known, and the drug is to work through a competitive inhibition mechanism. Structure-based drug design protocol incorporates both experimental and computational techniques. This is generally the preferred method of drug design, because it has the highest success rate due to the available knowledge about the target structure and its functionality. There are various computational tools that can be readily employed in the major steps of SBD: Initial Hits selection, Compound Refinement, and ADMET. The most popular computational tools in initial hits selection are pharmacophore search methods, 3D QSAR analysis and molecular docking calculations. In compound refinement, various quantum mechanical calculations, molecular dynamics simulations and various other molecular modeling techniques are used. In pharmacophore search methods, several computational screening techniques are used to select matching pharmacophores from large molecular libraries. Toxicity calculation (ADMET) is done computationally by using QSAR-based methods.

In Ligand-Based Design (LBD), a vast array of computational tools are used to design high potent ligands (based on a given active ligand) and determine their efficacy and toxicity; furthermore, computational tools are even used to identify the potential biological targets for a given ligand and this is a particularly interesting scenario as in LBD where the target information is initially unavailable. Compound Library Design and High Throughput Screening techniques can be considered as special cases of ligand-based drug discovery. In compound library design, various algorithms are employed to auto generate large libraries (of millions of entries) of drug-like molecules based on a given ligand structure. To filter the initial hit molecules from such libraries, the high throughput screening (HTS) techniques are applied. As the output of HTS, a large number of hit molecules will be presented, further filtering is essential for hit to lead (H2L), i.e. for lead generation.

One of the most promising strategies in CADD is transition state analogue (TSA) design. Currently, elucidating the complete electronic structure of the transition state of an enzyme catalyzed reaction is only possible in computer simulations called reaction dynamics simulations. This is a tremendous advantage in CADD where it allows one to design transition state analogue (TSA) inhibitors where those molecules are stable molecules that mimic the electronic structure and geometric properties of the corresponding transition state. Since the transition state (TS) has the highest binding affinity to a given catalytic protein, the corresponding TSAs will be its best inhibitors. There are several drugs in the current market that have emerged through this process.

CADD has saved millions in money and years in time in the modern drug discovery process. It is truly a multidisciplinary science that augments and expedites the drug discovery pipeline. In the current pharmaceutical industry, CADD is extensively used in all preclinical phases. State-of-the-art CADD techniques have immensely helped the humanity by making the discovery process faster and economical.

CVD and ALD: The Chemistry of Thin Film Growth for Modern Day Microelectronics

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The miniaturization of silicon microelectronics has revolutionized the speed, performance, and proliferation of consumer electronics and high-tech devices during the last five decades. In this aspect, continuous scaling of transistors and interconnects to smaller dimensions plays a major role and leads to increased transistor switching speeds and allows increased transistor densities in integrated circuits. The microelectronics industry has been facing two major technological hurdles in the process of device miniaturization. Primarily, ultra-thin films of conventional materials reach fundamental limits of their bulk material properties and the industry requires the introduction of novel materials with superior properties and better performance at a thickness of a few nanometers. Additionally, conventional film deposition techniques can no longer meet the thickness, conformality, and uniformity requirements posed by ultra-thin films and thus the manufacturing processes require new deposition techniques with improved performance.

The growth of thin films is a crucial step in microelectronics fabrication. The thickness, purity, and conformality requirements of thin films, as well as the film growth technique to be used, vary depending on the material and the level of integration. The thickness requirement of a film can vary from a few atomic layers up to tens of nanometers. Sophisticated deposition techniques which are capable of applying thin films in complex three-dimensional substrates and high aspect ratio features are required for current and future innovations of microelectronics.

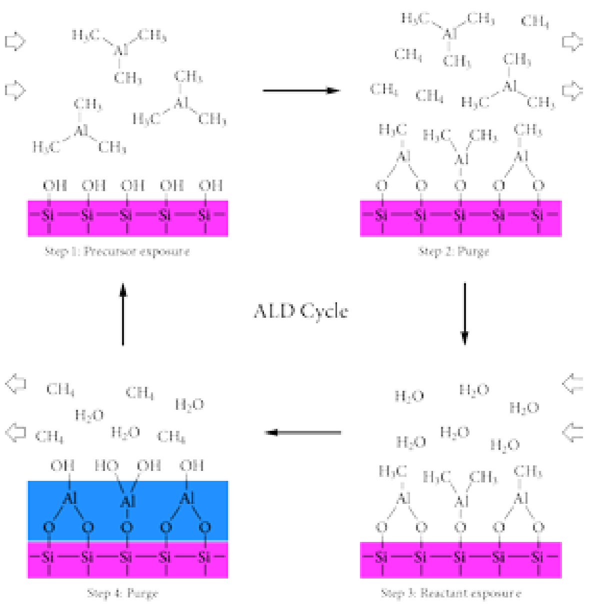
The deposition of thin film materials involves a variety of techniques. Superior performance is achieved using gas phase deposition techniques in which deposition occurs at the gas-substrate interface from the material transported in the form of a gas. Such deposition routes are classified on the basis of the physical form of the gaseous matter used and the mechanism of the deposition process, and include physical vapor deposition (PVD), chemical vapor deposition (CVD), and atomic layer deposition (ALD). As feature sizes in microelectronics devices decrease, and aspect ratios increase, the growth of extremely thin, conformal films relies on CVD and ALD.

In a typical CVD process, one or more precursor compounds are vaporized into a flow of inert carrier gas and introduced onto a heated substrate in a deposition chamber. The gaseous precursors can react and/or decompose in the gas phase above the substrate and/or on the surface of the growing thin film to afford the desired thin film. Gaseous byproducts are flushed out with the carrier gas.

$$2Al(CH_3)_3(g) + 3H_2O(g) \longrightarrow Al_2O_3(s) + 6CH_4(g)$$

CVD film growth precursors should be sufficiently volatile at temperatures below 200 °C for efficient vapor phase transport. They must be reactive enough on the surface of the growing thin film at the deposition temperature but should not be too reactive, since this leads to gas phase reactions resulting in the production of particles. Gas phase reactions could be restricted by using low precursor pressures and less reactive precursors. Moreover, highly reactive precursors tend to form islands and thus less conformal films. CVD film growth rate is dependent on the substrate temperature and precursor flux. Thick films are deposited at high substrate temperatures with long exposure time. Optimized CVD processes are capable of depositing thin conformal films over large areas of substrates at moderate temperatures. However, due to difficulty in precise thickness control and poor step coverage in ultrathin (<10 nm) films due to the extensive gas phase reactions between two or more complementary film growth precursors, CVD may no longer endure as a viable technique for growth of ultrathin films for certain applications.

ALD is a variant of CVD, in which precursor vapors are delivered to the substrate surface as alternating pulses, thereby eliminating gas phase reactions. Each precursor pulse is separated from the next precursor pulse by an inert gas purge. Thus, ALD growth process operates as a four step process known as ALD cycle (Scheme 1). First precursor, often a metal precursor, is chemisorbed on the substrate surface. Excess precursor and byproducts (i.e. protonated ligand) are purged away to afford a monolayer of the first precursor. Adsorption of a second precursor (or reactant) and subsequent reaction of the two precursors at the substrate surface, followed by purging of reaction byproducts and any excess of the second precursor completes one ALD cycle. Repetition of the ALD cycle then leads to film growth. Since the growth rate (measured in Å/cycle) is constant in the optimized ALD process, precise film thicknesses can be achieved by adjusting the number of deposition cycles. ALD is recognized as a method of forming very thin films with atomic precision, but it is not practical for formation of very thick films due to the slower growth rates compared to other techniques such as PVD and CVD.



Scheme 1: ALD cycle for the growth of Al_2O_3 film from trimethylaluminium and water

ALD film growth precursors should fulfill a series of tightly controlled physical and chemical requirements. High volatility of the precursors allows rapid delivery of high doses of precursors at relatively low temperatures. Additionally, ALD precursors must be thermally stable on the surface of the substrate at the deposition temperature. Otherwise, precursor decomposition could lead to extensive non-self-limiting, CVD-like growth. In addition, the metal precursor should be highly reactive toward a second precursor as well as toward the surface groups of the substrate. The second precursor, which is the oxide, nitride, or reducing source precursor, can be chosen from a series of available options such as H_2O, H_2O_2, or O_3 for metal oxide films; NH_3 or hydrazines for nitride films; and formaldehyde, silanes, or H_2 for pure metallic films. The non-metal precursor selection solely depends on the reactivity between the two precursors at the deposition temperature; however, mild and non-hazardous precursors are preferred. Metal precursors that form corrosive byproducts are undesirable due to corrosion and etching of the growing thin film as well as the interior surface of the ALD reactor.

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48th Annual Sessions of the Institute of Chemistry Ceylon 2019

Theme:

Steering Chemical Industries Towards a Smarter Nation

Date: 10th - 12th June, 2019

CALL FOR ABSTRACTS AND EXTENDED ABSTRACTS

Last date for receiving abstracts and extended abstracts is **15th February 2019**

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The following awards will be presented at the Annual Sessions 2019 of the Institute of Chemistry Ceylon.

- **Dr. C L de Silva Gold Medal Award**
  Awarded for an outstanding research contribution in any branch of Chemical Sciences and/ or the use of such research for National Development during the last five (5) years in Sri Lanka. Credit will be given for the utilization of local raw materials, and where the contribution has already resulted in (i) a publication in a Citation Indexed Journal or (ii) Registering a Patent or (iii) where the contribution has already resulted in a positive impact in the development and innovation in the industry.

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- **INSTITUTE OF CHEMISTRY BRONZE MEDALS**
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  Awarded for the best research contribution in Chemistry carried out by a postgraduate student registered for a postgraduate degree by either course work or/ and research at a Higher Educational Institute in Sri Lanka and for work carried out in Sri Lanka, with the exception of special analysis that cannot be done in the country. Such results should be less than 20% of the findings from the work. Sandwich programs carried out partially abroad do not qualify for the award.

  Kandiah Award for Basic Chemistry
  For research predominately in basic Chemistry (Organic, Inorganic, Physical, and Analytical).

  Kandiah Award for Applied Chemistry
  For research in Chemistry related areas such as polymer, food, biochemistry, biotechnology, where interdisciplinary research is involved and provided that chemistry has a central role and comprises at least 50% of thecontent.

  Kandiah Memorial Graduateship Award
  For the best piece of research in the Chemical Sciences carried out by a Graduate Chemist of the College of Chemical Sciences/Institute Chemistry Ceylon registered with a Higher Education Institute for a Post Graduate Degree.

- **Professor M. U. S. Sultanbawa Award for Research in Chemistry**
  Awarded for the best research paper presented at the Annual Sessions of the Institute of Chemistry Ceylon, for work carried out and completed in Sri Lanka.

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Further information could be obtained from the Registrar, Institute of Chemistry Ceylon or www.ichemc.edu.lk

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ROYAL SOCIETY OF CHEMISTRY | SRI LANKA LOCAL SECTION

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	09
FRSC	03
Chem, MRSC	07
MRSC	27
AMRSC	18
Affiliate /Under Graduate.	10
Total Membership as at July 2018	**74**

2. Committee of Management

The following were elected to the Committee at the 57th Annual General Meeting held in July 2018.

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Hony. Secretary - Mrs. Aruni Wickramanayake
Hony. Treasurer - Dr. P Iyngaran

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3. Activities

- 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 Graduateship Examination in Chemistry Levels 3/4 Theory Examination

- All - Island Inter School Chemistry Essay Competition.
- Inter University Chemistry Essay Competition
- Book donation programme
- A/L Teacher training workshop
- Advanced Level Chemistry Seminar
- ndustrial Visit for B.Sc. Special degree students, M.Sc. students and RSC Members
- Collaboration with SLAAS E-2 workshop and seminars
- Supporting Chemical Societies of Universities in Sri Lanka

Mrs. Aruni Wickramanayake
Hony Secretary

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