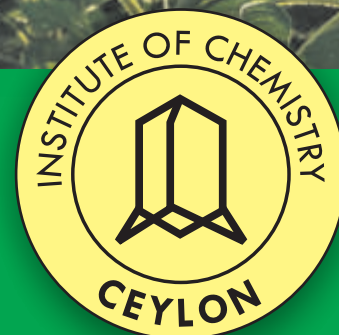


CHEMISTRY

I N S R I L A N K A



The Tri Annual Publication of the
Institute of Chemistry Ceylon
ISSN 1012-8999



September 2014 - Volume 31 No. 03

43RD ANNUAL SESSIONS OF THE INSTITUTE OF CHEMISTRY CEYLON



Prof. H D Gunawardhana delivering the Presidential Address.



Dr. Ariyadasa de Silva, Chief Guest delivering his address.



Prof. Manjula Vithanapathirana, Guest of Honour delivering her address.



section of participants



section of participants



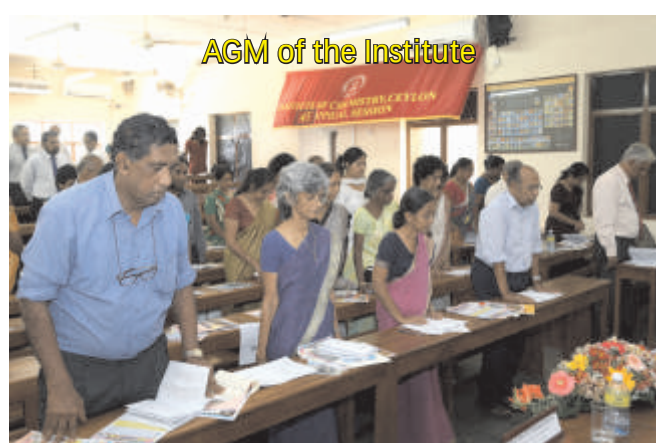
Runners up of the all Island Interschool Chemistry quiz competition 2013/14 - Maliyadeva Balika Vidyalaya, Kurunegala



Winners of the all Island Interschool Chemistry quiz competition 2013/14 - Vincent Girls High School, Batticaloa



Vote of Thank by Mr. K R Dayananda, President Elect



AGM of the Institute

Chemistry in Sri Lanka

ISSN 1012 - 8999

The Tri-Annual Publication of the Institute of Chemistry Ceylon

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

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

Vol. 31 No. 3

September 2014

	Pages
Outline of our Institute	02
Council 2014/2015	02
Chemistry in Sri Lanka	02
Committees 2014/2015	03
Guest Editorial: <i>Quality Biofuels – the key to sustainable fuel use</i>	04
Cover Page	04
Presidential Address: <i>Curricula and Evaluation in Chemistry for a Sustainable Economy</i>	05
Report on the 43 rd Annual Sessions and 73 rd Anniversary Celebrations 2014	18
Theme Seminar of “Curricula and Evaluation in Chemistry for a Sustainable Economy”	
<i>Curriculum and Evaluation in the Science Education in Sri Lanka: Learning points from global research</i>	19
Guest Articles	
<i>Tea - more than a nice cup</i>	24
<i>An Introduction to Cavity Ring-Down Spectroscopy</i>	25
<i>Protease Assays for Cancer Diagnostics</i>	29
<i>Green Diesel production from natural fatty acids by decarboxylation; An Overview</i>	34
<i>Molecular Docking</i>	37
Abstracts of Research Papers presented at the 43 rd Annual Sessions 2014	40
Call for Nominations for Institute of Chemistry Gold Medal 2015	41
Student Corner	
<i>Introduction and History of Chromatography</i>	43
<i>Nucleophilic Substitution Reactions of Alkyl Halides</i>	46
Benevolent Fund Benefits for Members	50
Graduate Chemists Welfare Fund	50
RSC News	51
Publications of the Institute of Chemistry Ceylon	52

Theme for the year -

“Chemical Sciences in Food Safety and Security”

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

Office ☎ : 2861231, 2861653, 4015230

 : 2861231, 2861653

E mail : ichemc@sltnet.lk

web page : www.ichemc.edu.lk

Outline of our Institute

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

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

Corporate Membership

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

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

Revision of Membership Regulation

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

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

Tech.I.Chem.C.

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

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

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

Membership Applications

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

Current Subscription Rates

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

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

Entrance Fee

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

*per application for admission/transfer to any grade

Headquarters Building Adamantane House

341/22, Kotte Road, Welikada, Rajagiriya
Telephone/Fax : 2861653, 2861231
Telephone: 4015230
e-mail : ichemc@sltnet.lk
web : www.ichemc.edu.lk

Council 2014/2015

President	: Prof. H D Gunawardhana
President Elect	: Mr. K R Dayananda
Vice President	: Mr. MRM Haniffa
Hony. Joint Secretaries	: Dr. R Senthilnithy Dr. A A P Keerthi
Hony. Treasurer	: Prof. M D P De Costa
Hony. Asst. Treasurer	: Dr. U S K Weliwegamage
Hony. Editor	: Prof. (Ms) Sujatha Hewage
Hony. Asst. Editor	: Dr. (Ms) H I C de Silva
Secretary for International Relations	: Prof. (Ms) Ramanee Wijesekera
Chairman / Academic Board	: Prof. J N O Fernando
Hony. Secretary for Educational Affairs	: Dr. C Udawatte
Chairman, Admission & Ethical Practices Committee	: Mr. E G Somapala
Secretary, A & EP Committee	: Mrs. D Seneviratne
Chairman, Board of Trustees	: Prof. H D Gunawardhana

Elected Members

Prof. (Ms) P A Paranagama	Dr. (Ms) L S R Arambewela
Prof. (Ms) Hema Pathirana	Dr. (Ms) Nandanie Ediriweera
Prof. Sudantha Liyanage	Mrs. Sakuntala Tennakoon
Prof. (Ms) Siromi Samarasinghe	Prof. K R R Mahanama
Prof. (Ms) Sagarika Ekanayake	Dr. Poshitha Premaratne

Editorial and Publicity Committee

Prof. (Mrs) S Hewage (Editor)
Dr. (Ms) H I C de Silva (Asst. Editor)
Prof. (Ms) Ramanee D Wijesekera
Dr. (Mrs) C Udawatte
Dr. (Mrs) R Kandiah

CHEMISTRY IN SRI LANKA

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

The editor invites from the membership the following items for publication in the next issue of the Chemistry in Sri Lanka which is due to be released in January 2015.

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

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

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

Committees 2014/2015

Admission and Ethical Practices Committee (A and EP committee)

Mr. E G Somapala (Chairman)
Ms. D Seneviratne (Secretary)
Prof. H D Gunawardhana
Prof. J N O Fernando
Prof. M D P de Costa
Prof. (Mrs.) S Hewage
Prof. K R R Mahanama
Prof. S Sotheeswaran
Dr. (Mrs) L S R Arambewela

House, Finance and Membership Committee

Prof. S Sotheeswaran (Chairman)
Prof. J N O Fernando
Prof. H D Gunawardhana
Prof. M D P de Costa
Prof. (Mrs) S Hewage
Dr. S Welwegamage
Dr. C Udawatte
Mr. K R Dayananda
Ms. P M Jayasinha
Dr. A A P Keerthi
Mr. NINS Nadarasa (Registrar)
Mr. J M R Banda (Deputy Registrar)
Mr. A M Jayasekara (Addl. Deputy Registrar)
Ms. A C Wijesuriya (Accounting Officer)

Board of Trustees

Prof. H D Gunawardhana (Chairman)
Prof. M D P de Costa
Prof. J N O Fernando
Prof. S Sotheeswaran
Dr. (Mrs.) L S R Arambewela
Prof. (Mrs.) S Hewage
Prof. E G Somapala

Awards Committee

Prof. K R R Mahanama (Chairman)
Prof. E Dilip de Silva
Prof. (Mrs.) S Hewage
Prof. (Ms.) H M K K Pathirana
Prof. S Liyanage
Mr. M R M Haniffa
Prof. (Ms.) S Ekanayake
Dr. A A P Keerthi
Dr. C Udawatte
Dr. (Ms.) Nandini Ediriweera

Library Committee

Ms. P M Jayasinha (Chairman)
Ms. Nalini De Silva (Secretary)
Prof. J N O Fernando
Prof. S Sotheeswaran
Dr. S Welwegamage
Dr. R Parthipan
Dr. C Udawatte
Mr. N I N S Nadarasa
Mrs. I HendaVitharana (Librarian)
Ms S Udawatha (Asst. Librarian)

Academic Board of the College of Chemical Sciences

Prof. J N O Fernando (Chairman)
Dr. Chandanie Udawatte (Secretary)
Mr. M R M Haniffa (Vice Chairman)
Mr. S C D Fernando (Asst. Secretary)
Ex-Officio Members:
Prof. H D Gunawardhana (President)
Mr. E G Somapala (Chairman, A & EP)
Prof. M D P de Costa (Hony. Treasure)
Dr. A A P Keerthi (Hony. Joint Secretary)

Committee Members:

Prof. (Ms.) R Wijesekera
Prof. (Mrs.) S A Deraniyagala
Prof. (Mrs.) S I Samarasinghe
Dr. (Mrs.) L S R Arambewela
Mr. K R Dayananda
Prof. (Mrs.) P A Paranagama
Ms. P M Jayasinha
Ms. M N K de S Goonatillake

Mr. N M S Hettigedara

Mr. H S M Pieris

Mrs. Nalini de Silva

Dr. Piyal Ariyananda

Co-opted Members:

Prof. (Mrs) S Hewage

Prof. E Dilip de Silva

Prof. S Liyanage

Prof. K A S Pathirathna

Prof. S Sotheeswaran

Dr. U S K Welwegamage

Prof. S P Deraniyagala

Dr. (Mrs) T Gobika

Prof. Hema Pathirana

Dr. M N Kaumal

Dr. V M Thadhani

Dr. Dinara S Gunasekera

Dr. R Parthipan

Dr. (Ms) H I C de Silva

Dr. (Mrs) R Kandiah

Dr. U K Jayasundara

Mr. P R K Fernando

Mr. N I N S Nadarasa

Mr. J M R Banda

Mr. A M Jayasekara

Ms. D Attanayake

Training Seminars / Workshop committee

Dr. (Mrs.) L S R Arambewela (Chairman)

Prof. (Mrs.) S Ekanayake

Dr. S Welwegamage

Ms. Nalini de Silva

Prof. (Mrs.) P A Paranagama

Prof. (Mrs.) S I Samarasinghe

Dr. (Mrs.) Nandanie Ediriweera

Mrs. Sakuntala Tennekoon

Interschool Chemistry Quiz Committee

Dr. A A P Keerthi (Chairman)
Dr. R Parthipan
Dr. R. Senthilnithy
Dr. (Mrs.) T Gobika
Ms. W K D V Dilrukshi
Mr. S C D Fernando

National Australian Chemistry Quiz Committee

Mr. N I N S Nadarasa (Chairman)
Prof. J N O Fernando
Prof. M D P de Costa
Mr. E G Somapala
Dr. S Wimalasiri
Dr. R Senthilnithy
Dr. M N Kaumal
Mr. A M Jayasekara

Monograph Committee

Prof. (Mrs.) S A Deraniyagala (Chairman)
Prof. M D P de Costa
Prof. (Ms.) R Wijesekera
Prof. E Dilip de Silva
Mr. M R M Haniffa

Social Affairs Committee

Prof. S Ekanayake (Chairman)
Prof. P A Paranagama
Dr. A A P Keerthi
Mr. K R Dayananda

Sponsorship Committee

Prof. H D Gunawardhana (Chairman)
Prof. J N O Fernando
Prof. S Sotheeswaran
Prof. M D P de Costa
Dr. A A P Keerthi
Mr. K R Dayananda
Mr. M R M Haniffa
Mr. H M S Pieris
Dr. R Parthipan
Mr. A M Jayasekara

Diploma in Laboratory Technology in Chemistry Committee

Mr. E G Somapala (Chairman)
Mr. K R Dayananda
Mr. P R K Fernando
Mr. R Vidanagamage
Mr. J M R Banda

Quality Biofuels – the key to sustainable fuel use

Professor S. Sotheeswaran

Dean, College of Chemical Sciences, Institute of Chemistry Ceylon

As fossil fuel reserves become ever harder to locate and extract, the world is looking for alternative energy sources. Biofuel provides compelling advantages and significant benefits. There are two main types of biofuels. They are bioethanol and biodiesel.

Biodiesel is obtained from vegetable oils by the transesterification process. As vegetable oils are much in demand in the food industry, waste cooking oil-once used, obtained from hotels, is mostly used in countries like Singapore to produce biodiesel.

- Thus, Biodiesel recycles waste oil back into fuel, eliminating the dangers of inefficient and often dangerous disposal and its re-entry in the food chain.
- The lifecycle of biodiesel emits 85% less CO₂ emissions than fossil fuel.
- Unlike other alternative energy sources, switching to biodiesel incurs no major infrastructure changes.

Governments around the world are setting ambitious targets for the reduction of CO₂ and more and more organisations are making the switch to biodiesel.

Bioethanol is produced by fermenting mainly sugarcane.

Brazil is the world's second largest producer of biofuels, and until 2010, the world's largest exporter of bioethanol. Together, Brazil and the United States lead the industrial production of ethanol fuel, accounting together for 87.8 percent of the world's production in 2010, and 87.1 percent in 2011. In 2011 Brazil produced 21.1 billion liters representing 24.9 percent of the world's total ethanol used as fuel.

However, the successful bioethanol production is sustainable in Brazil due to its advanced agri-industrial technology and its enormous amount of arable land.

Our neighbour, India, uses Jatropha oil to produce biofuels. Jatropha plant seeds, which are rich in oil (upto 40%) are cultivated and processed in India on a large scale for the production of biofuels. The government of India has identified 400,000 sq. Km of land where Jatropha can be grown. Why Jatropha? One might wonder. For that matter any seed oil can be used to produce biofuels as the researchers at the Institute of Chemistry Ceylon have shown by their research work on biofuels during the period 2009- to-date. However, popular seeds such as soyabeans and palm seeds can be used to obtain biofuels from their seed oils. But these are sought after in the food industry and should be avoided in producing biofuels.

Jatropha seeds contain the highly poisonous toxalbumin curcin, a lectin dimer. They also contain carcinogenic phorbol. Hence Jatropha oil is not used in the food industry. Apart from India, countries like Thailand and Philippines are using Jatropha seeds as the main feedstocks in biofuel production. One hectare of Jatropha plantation will give 400 to 600 litres of oil if the soil is average. The railway line between Mumbai and Delhi is planted with Jatropha and the train itself runs on 15-20% biodiesel.

As far as Sri Lanka is concerned the research work on Jatropha oil done at the Institute of Chemistry Ceylon should be taken to the next stage and larger research institutions such as the ITI and National Science Research Council should take an active interest in the promotion of Jatropha oil production in Sri Lanka for use as biofuels.

Unless we take the research results on biofuels seriously we will have to depend on fossil fuels and pay higher and higher fuel prices for our transport needs in the years to come.

Cover Page

As fossil fuel reserves become ever harder to locate and extract, the world is looking for alternative energy sources. Biofuel provides compelling advantages and significant benefits. Jatropha, rubber, palm, sunflower seeds and algae are used as feedstocks for biofuel production. For more details on biofuel production see pages 04, 34-37.

Curricula and Evaluation in Chemistry for a Sustainable Economy

Professor H. D. Gunawardhana

Emeritus Professor of Chemistry, University of Colombo and President, Institute of Chemistry Ceylon

1. Introduction

Economy of a country is dependent on the 'Quality' of Education. What is quality? It is to meet the predetermined requirements to the satisfaction of the users for a particular substance or a **service**. Education is a service. Users are the employers who employ the trained students. What are the predetermined requirements that an employer (mainly industry) expect from a student who has the training in the subject of Chemistry such that the trained student possesses, (i) the ability to understand the organization's chemical process and (ii) the ability to apply fundamental principles of Chemistry whenever a need arises in the industry. Economy is dependent on the availability of knowledge based industries which are responsible for the value addition to the resources of a country. The economy will progress if the employable human resources possess the above capabilities. Principles of chemistry → Technology → To fulfill the technological needs of a country → Development of Knowledge Economy. The application of the principles of science to technology becomes fruitful if there is a scientific culture in a country where Education in Science and Technology plays a vital role.

The concept of '**sustainability**', implies meeting human needs while preserving the environment and natural resources needed by **future generations**. The technology can be considered as the output of scientific theories giving the final product needed for economic growth. An industry utilizes a technology or several technologies in its manufacturing stages. Any form of technology cannot survive without science. Technology may flourish for sometimes but ultimately die off if it is not supported by the science. The survival of a particular technology is dependent on the applications of the associated sciences required to improve the existing technology(ies) such a way that the manufactured product(s) will meet the present challenges in the market. i.e. 'Quality'. One could argue that ancient Sri Lanka had only the technology, which helped in the booming of the economy from time to

time with the assistance of good governance. It is clear that the ancient technology was based on some form of unwritten science surely *not the modern science*. Due to historical reasons most of the ancient unwritten sciences died off leaving us to apply the 'modern science' to ancient as well as modern technology. Therefore, the application of modern science to technology is essential since the sustainable development of a country is based on the improvement of the technologies.

In order to achieve the National Goals the curriculum at G.C.E. (A/L) should cater for 96% of the students who do not gain admission to Universities in Sri Lanka. The fundamental principles in chemistry should be taught thoroughly with at least one application of each principle. The evaluation should be based on testing the ability of the student to apply the principle to different situation which has not been taught. The credit given at examination should be merit of the competency to use the knowledge and not the ability to memorize the learnt materials. This is a difficult task for the examiners. However, it helps in the development of the economy of the country.

Teaching of scientific principles as applied to day to day life, laboratory and Environment and **EVALUATION** geared towards the testing of the ability to use the knowledge when the need arises will undoubtedly fulfill the above needs. Does the traditional Science Education in Sri Lanka provide the **TRAINING** to use the knowledge when the need arises? It mainly provides students to imagine the so called **SCIENCE** in **TEXT BOOKS**. There are several examples where the knowledge is confined to text books and not the applications to laboratory or day to day life.

2. The concept of 'sustainability' in the ancient (unwritten) science

Ancient Sri Lankans realized the importance of the conservation of water and constructed reservoirs (Wewa) to collect rainwater for the subsequent use in irrigation and other purposes. The first 'wewa' was

constructed by King Pandukabhaya (310 – 380 B.C.) presently known as the Basawakulama wewa at Anuradhapura. Since then hundreds of reservoirs have been constructed mainly to collect the rainwater. “Let not a drop of water be sent to the sea without utilizing it for the benefit of mankind” said King Parakramabahu the Great and constructed reservoirs. 'Wewa' and 'Dagaba' were the main theme of the ancient sociological village unit concept in Sri Lanka.

Two main objectives in the conservation of water are:

- (i) to provide water for irrigation during the dry season such that an uninterrupted agricultural activity with the production of food is maintained, -sustainable economy.
- (ii) to improve the health of the people by making the water available for domestic purposes. “Healthy nation is required for sustainable economy”. If the people are sick it affects the economy of the country. e.g. Chronic Kidney Disease of unknown etiology (CKDu)

It seems that an economic prosperity of ancient Sri Lankan was dependent on the conservation and subsequent continuous availability of water for human needs. Even though it is not the agricultural economy today, the conservation of water still plays a significant role in economy of the country through healthy living and food security. Therefore, the two terms “water” and “economic development” cannot be separated from one another. All ancient civilizations in the world were associated with water bodies such as rivers. Therefore, the three terms “Water Quality, Water Conservation” and “Food Security” cannot be separated from one another. In his book on “*Environmental Aspects of Sri Lanka's Ancient Irrigation System*”, Prof. C.G. Weeramanthri has stated that traditional **wisdom** has much to teach us. He further says that the concept of **sustainable development** was a part of our ancient culture associated with the irrigation agriculture. The modern international environmental law has only recently appreciated the necessity of this concept of sustainable development and often discusses the concept as it is a modern invention. In the Sri Lanka context, sustainable development is “a reinvention of the wheel”.

It is undoubtedly obvious that Science and Technology was directly responsible for the food security and thus the economic development of Sri Lanka during that era. Those who are not familiar with Science wrongly argue that ancient Sri Lanka had only

the Technology without Science. It is true that ancient Sri Lankans did not have the so-called **modern science** which is not more than 500 years old. The ancient technology was based on **unwritten science** and is not the modern science. The survival of the ancient technology was possible for several years due to its association with this unwritten form of science which would have been in some cases a kind of family secrets.

The survival of technology is dependent on science.

The economic development through food security in ancient Sri Lanka was due to the application of 'Sciences' to the technological needs during that period. Today, a need arises to apply modern science to ancient as well as modern technologies to meet the **current human needs** which are quite different from the human needs of our ancestors. The development of the so-called modern science during 19th and 20th centuries led to the changes of the human needs. The highest priority during this period was to meet the human needs at any cost. This was not the sustainable development. It was only during last two decades more emphasis was paid on the economic development by providing human needs without affecting the environment – sustainable development. The **sustainable development achieved during the ancient time** was completely ignored or disregarded. Often, the concept of sustainable development is taken as a modern invention. In fact, it is a concept regarded as a part of **our ancient culture**. It would be fruitful for us to have some understanding on the application of unwritten science to ancient technology in order to achieve economic development by the application of modern science which is familiar to us now for the existing technology.

The concept “*Respect Water*” helped the ancient Sri Lankans to re-use water without any adverse effect. It is still practiced in remote villages in Sri Lanka. It is now clear that the re-use of water today in domestic, agriculture and industrial spheres will lead to adverse effects. This is true for irrigation waters (the increase of SAR values and subsequent loss of soil permeability). It is also applicable to potable and industrial waters as well. A requirement thus arises to carry out continuous monitoring of water quality in all sphere of human activities. It is essential to incorporate 'Water Quality' in school curricula and the water quality testing can become a part of school projects.

3. Curriculum in Chemistry required to achieve sustainable economy

Two main aspects to be incorporated into the curriculum in Chemistry in order to achieve sustainable

economy are,

3.1 Education on Water Science- “Ancient wisdom on water”

“**Respect water**” is the concept introduced to me by my teachers in the village school in the early 1950's. This can be considered as the wisdom from the past relating to sustainable development - “Unwritten Science”. The term “respect” included not spitting or urinating on water, i.e., not to pollute water. This was practiced in Sri Lanka in the past 2,500 years in the domestic and agricultural use of water. The ancient design of toilets was based on the concept “respect water”, thus prevented the pollution of water in the past 2,500 years. Do we respect water today in our domestic usage? We have blindly followed the rest of the world in designing toilets without considering the **wisdom from the past**. The technology from elsewhere was copied without applying the science required to prevent the pollution of water. Urban population and also the village population today, disregard the ancient concept “**Respect Water**”. This concept helped the ancient Sri Lankans to re-use water without any adverse effects, thus achieving the sustainable development because water security is directly responsible for food security thus making us a healthy nation. It has also been reported in the Sunday Observer of 26th June 2005 that, water shortages and water pollution cause four million deaths per year around the world. **This means, one person dies every eight seconds**. The science education plays a vital role in the **preparedness** for such a disaster. Our school children are well aware of global warming, depletion of ozone layer, etc. There are no direct deaths due to these atmospheric effects, but these can affect developed (rich) countries. Therefore, developed countries ensure that these aspects are incorporated into teaching curricula by convincing the **'Educationalists' in Sri Lanka**. Though a Sri Lankan student is well aware of the depletion of ozone layer, global warming, **he is not aware of the quality of water he deals with**, in his day-to-day life. The water pollution does not affect the developed countries since they have very expensive modern methods to purify water. Since water pollution is a localised problem affecting us directly, our 'Educationalists' are not convinced by the 'Consultants' from developed countries to incorporate water into the teaching curricula. Can we have an indigenous curriculum suitable for Sri Lanka taking all our aspects into consideration? The only way to increase the awareness of water quality is to incorporate it to

school curricula disregarding the advice from so-called 'Consultants' from developed countries. The curricula of GCE (A/L) bear evidence for this.

Curricula – GCE (A/L)

Biology – Present Curriculum – not specific on water

Revised curricula – GCE (A/L)

Unit 2 – Photosynthesis – Photolysis of water

Unit 12 – Water pollution, pollutants, impact of pollution

Chemistry - Present curriculum -Unit 14- Chemical properties of water, Hardness of water, removal of hardness

Revised curricula – GCE (A/L)- Unit 16- Takes action to maintain the optimum composition of ground water and surface water. – identifies the variables that determine the quality of water. This includes Chemical Oxygen Demand (COD), Sodium Adsorption Ratio (SAR) etc. In the syllabus revision, some actions have been taken to incorporate aspects on water in the revised curricula – GCE (A/L). However, this is futile unless an extensive program is implemented to train the relevant teachers. The teachers find it difficult to teach these sections effectively. Why? The undergraduate curricula of many tertiary educational institutes do not have dedicated teaching aspects on water. Therefore, a graduate teacher needs an extensive training which is not effective today.

3.1.1 Education on Water Science – Potable Water quality:

The healthy living is directly related to the availability of potable water of suitable quality. Groundwater is the main source of drinking water for about 60% Sri Lankans. The water in the reservoirs, rivers and streams also provides drinking water for healthy life. River water is the main source of water in water supply scheme to many cities in Sri Lanka. In the past, the reservoirs (Wewa) also supplied drinking water during the long drought. Hydrogeological study shows that the nature of rocks affects the quality of ground water. Dissanayake and Weerasooriya (1985) have reported that the groundwater in the some areas of North-Central Province contains excessive amounts of fluoride. The health effects of these have been studied extensively. It is generally assumed that water is purified and becomes suitable for drinking by boiling. Boiling only makes the harmful pathogens inactive and occasionally reduces hardness due to the precipitation of calcium / magnesium carbonates.

However, boiling cannot remove the ions listed in the WHO guidelines.

Table1. Drinking water standards (WHO)

Criterion	WHO Recommended limit	International Acceptable limit	Tolerance limit
Total residue, mg dm ⁻³	500	1500	-
Turbidity, NTU	5	25	-
Alkyl benzene sulphate mg dm ⁻³	0.5	1.0	-
Arsenic (As) mg dm ⁻³	-	-	0.05
Barium (Ba) mg dm ⁻³	-	-	1.0
Cadmium (Cd) mg dm ⁻³	-	-	0.01
Calcium (Ca) mg dm ⁻³	-	200	-
Chloride (Cl) mg dm ⁻³	250	600	-
Chromium(Cr(VI)) mg dm ⁻³	-	-	0.05
Copper (Cu) mg dm ⁻³	1.0 – 2.0	1.5	-
Cyanide (CN) mg dm ⁻³	-	-	0.2
Fluoride (F) mg dm ⁻³	1.5	1.0 – 1.5	-
pH	6.5 – 8.5	6.5 – 9.2	-
Iron (Fe) mg dm ⁻³	0.3	1.0	-
Lead (Pb) mg dm ⁻³	-	-	0.05
Magnesium (Mg) mg dm ⁻³	-	150	-
Manganese (Mn) mg dm ⁻³	0.1 – 0.5	0.5	-
Nitrate (NO ₃) mg dm ⁻³	50	45	-
Phenolic compounds (as phenol) mg dm ⁻³	0.001	0.002	-
Selenium (Se) mg dm ⁻³	-	-	0.01
Sulphate (SO ₄) mg dm ⁻³	250	400	-
Zinc (Zn) mg dm ⁻³	3 - 5	15	-

The concept “*Respect Water*” helped the ancient Sri Lankan to re-use water without any adverse effect. It is now clear that the re-use of water today in domestic, agriculture and industrial spheres will lead to adverse effects. This is true for irrigation waters (the increase of SAR values and subsequent loss of soil permeability). It is also applicable to potable and industrial waters as well. A requirement thus arises to carry out continuous monitoring of the water quality in all sphere of human activities. It is essential to incorporate 'Water Quality' in school curricula and the water quality testing can become a part of school projects.

Evaluation on Potable waters:

1. Acid rains fall on (i) an area containing 60%

feldspars in the surface soil and (ii) a pond containing effluents from a battery factory.

$$E_{O_2/O^{2-}}^0 = +1.23V \quad E_{NO_3^+/NO_2^-}^0 = +0.94V \quad E_{SO_4^{2-}/SO_3^{2-}}^0 = +0.20V$$

In Colombo, (RT/F) ln X = 0.06 log₁₀ X

The surface wash off from the area containing feldspars was used for irrigation of paddy cultivation for about 10 years. Consequently, the paddy cultivation was affected leading to the abandoning of the paddy fields.

(a) Describe scientific reasons for the abandoning of the paddy fields.

(b) Sketch the pE Vs pH diagram and indicate the expected range of pE value of the pond water if the

pH of the pond water is reported as 9.0. Describe a method to treat black liquor to prevent water pollution.

2. It is proposed to establish a sulfuric acid manufacturing plant in the Dabulla area on a dolomite ($\text{CaCO}_3 \cdot \text{MgCO}_3$) deposit. If the emission (due to a leak) of the sulfuric acid plant increases the partial pressure of SO_2 in the atmosphere to 1×10^{-5} atm. For SO_2 , Henry law constant, $K_H = 1.25 \text{ mol dm}^{-3} \text{ atm}^{-1}$
 For H_2SO_3 $K_{a_1} = 1.27 \times 10^{-3} \text{ mol dm}^{-3}$
 $K_{a_2} = 6.24 \times 10^{-8} \text{ mol dm}^{-3}$
 $E_{\text{O}_2/\text{O}^{2-}}^0 = +1.23 \text{ V}$ $E_{\text{SO}_4^{2-}/\text{SO}_3^{2-}}^0 = +0.20 \text{ V}$
 - (a) Calculate the approximate pH of the rain water in the area.
 - (b) Write the reaction(s) which involves the oxidation within the rain drop giving the corresponding E^0 values.

3.1.2 Education on Water Science – Irrigation Water quality

The largest user of water in Sri Lanka is the irrigation agriculture. The irrigation water flows through a system of tunnels, streams, reservoirs (Wewa), canals etc. before it reaches the field where crop is grown. During this flow some soluble salts are always dissolved in and the water becomes saline containing high dissolved salts. Man's activities such as industries, deforestation etc. in and around water flow **enhance dissolution of salts**. In the fields, the water will undergo evapotranspiration resulting the accumulation of dissolved salts, which will affect the soil properties especially the soil permeability and subsequently crop growth. It has been reported that in countries such as Afghanistan, Pakistan, Egypt etc. **millions of hectares** of irrigated lands have been abandoned due to the loss of soil permeability which affected the crop growth. The previous example is the abandoning of about 100 hectares of paddy fields in Sri Lanka due to the loss of soil permeability. This may be possible in all the other irrigation schemes if the priority is given only for the quantity rather than the quality. Therefore, it is essential to take adequate precautionary measures, especially in the areas irrigated by Mahaweli waters, in order to prevent any such salt danger caused by the increased utilization of irrigation water resources. **Prevention is better and less expensive than cure.**

The Mahaweli irrigation project involves utilization of water of the Mahaweli river to irrigate an

extensive area of dry zone. When complete, the Mahaweli Development project was expected to supply water for the irrigation need of 900,000 acres for two crops a year. The master plan also envisages the generation of 2,037 million kilowatt hours of hydroelectric energy. The phase 1 of the project, (Kala Oya, Abanganga) covered 132,000 acres of existing lands and 91,000 acres of new lands. A monitoring programme was initiated in 1978 to check the quality of irrigation water in the system H of the Mahaweli diversion scheme. The block 302 of the system H of the Mahaweli development scheme was selected for this purpose. It was reported that there was a remarkable increase of Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) values especially in the drainage waters in April and in November. This coincides with the Maha and Yala harvesting seasons of the system H. Usually, a heavy rainfall leads to the decrease of these values significantly. Balalu Wewa is the reservoir which supplies irrigation water to Block 302 through the left Bank Canal (L.B.C.). Seasonal variation of the filterable residue and total residual contents of water from Balalu Wewa, Left Bank Canal and at the beginning of D₁ Channel of Block 302 showed similar trends. It was seen that there was an increase in the filterable residue as well as the total residue of the irrigation waters in April 1978 and 1979. The Maha harvest starts in March and ends in April. During this period the water supply to the field being completely cut off and consequently, as a result of rapid evaporation of existing water, the filterable residual content increases.

The knowledge of the quality of irrigation water is important in judging its suitability for irrigation. Suitability of irrigation water depends upon several factors associated with characteristic of water, soil, plant and climate, and can be expressed by the following relationship.

$SI = f(QSPDC)$ where,

SI = Suitability of irrigation water,

Q = Quality of water i.e. the total salt concentration, cationic and anionic composition

S = Physico-chemical properties of the soil profile

P = Salt tolerance characteristics of the crop plant at different stages of growth

D = Drainage conditions

C = Climatic parameter

It is difficult to suggest a single water quality criterion because of the interaction of several factors.

The degree of adverse effects on soil properties is mainly related to the chemical composition of irrigated water. The adverse effect of a particular quality water on soil-plant system depends upon the total salt concentration, relative proportion of sodium to other cations, boron concentration and bicarbonate content. Waters of low electrical conductivity are generally composed of higher proportion of calcium, magnesium and bicarbonate ions whereas those of high electrical conductivity contain mostly of sodium and chloride ions. The relative proportion of sodium to other cations is determined by the sodium adsorption ratio (SAR). Any increase in the SAR of irrigation water increases the SAR of the soil solution, which ultimately increases the exchangeable sodium by the soil leading to the loss of soil permeability by replacing calcium (and/ or magnesium) ions on the surface by sodium ions.

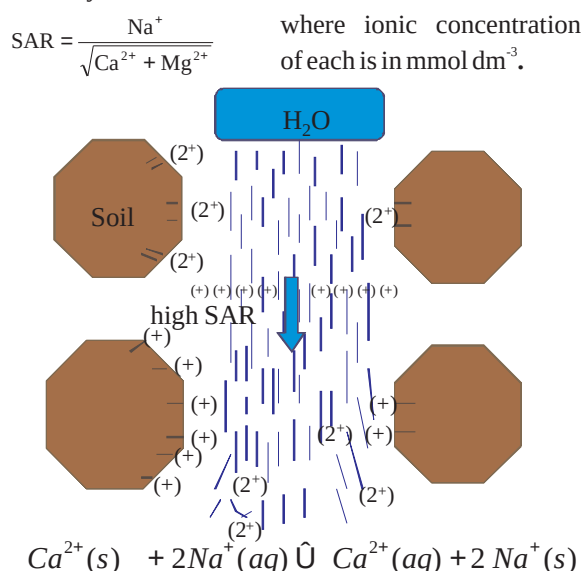


Figure 1. Illustration of the loss of soil permeability when waters of high SAR values are used for irrigation

Table 2. FAO Guideline for interpretation of water quality for irrigation

IRRIGATION PROBLEM	DEGREE OF PROBLEM		
	No. Problem	Increased Problem	Severe Problem
Salinity tolerance (water quality index) (0-100 mmol/L)	<0.75	0.75-3.0	>3.0
Permeability (effects of infiltration rate into soil) (mm/day)	>0.5	0.5-0.2	<0.2
EC _e SAR (mmol/L)	<6	6-9	>9
Montmorillonite (2:1 type of clay)	<6	6-10	>10
Illite/smectite (2:1 type of clay)	<6	6-21	>21
Kaolinite (1:1 type of clay)	<6	6-21	>21
Specific tolerance (water quality index)	<1	1-9	>9
Sodium (mmol/L)	<4	4-10	>10
Chloride (mmol/L)	<0.75	0.75-3.0	>3.0

The history of the conservation of water in Sri Lanka could be traced to the reign of King Pandukabhaya (380 – 310 B.C.) who constructed the first reservoir (Wewa) at Anuradhapura. Thereafter, several hundred of reservoirs have been constructed mainly to conserve the rainwater. Very little evidence could be gathered on the construction of reservoirs by building dams across flowing streams or rivers. In such instances a **forest cover** was maintained in an around the streams carrying water to the reservoirs and also the canals which supplied water to paddy fields. The belief such as divine being living in trees assisted to preserve the forest cover. In addition, powerful dictatorship and good governance prevented people even to clear a forest. One method of **achieving sustainability** in the ancient irrigation projects is to maintain the forest cover. The modern science reveals that clearing of forest increases the sodium ion concentration of irrigation waters thus making the water unsuitable ultimately leading to loss of soil permeability. The ancient water management was based on this type of ancient scientific views (unwritten science).

Kalawewa is one such reservoirs constructed by King Dathusena (6th Century A.D.) by building a dam across a stream (presently Dambulu Oya – Kala Oya). He may have constructed this to fulfill his wishes and may have gone against the opinion of his advisors in making the decision. Three or four hundred years after the continuous use of Kala Wewa waters for irrigations, the Anuradhapura kingdom was shifted to Polonnaruwa. One could attribute reason for the shift is a crop failure due to the lost of soil permeability. The administrative failure during the period 6 – 9 century resulted the poor water management which ultimately led to the crop failure. The continuous irrigation with poor quality water and consequent crop – failure affected the agricultural economy in the Anuradhapura area resulted the shift of the kingdom to Polonnaruwa in the 10th century.

The recurrence of large scale crop – failure can not be ruled out today. However, it is now impossible to shift the population in the affected area unlike in the 10th century. A possible crop failure today will lead the disaster and the destruction of the development achieved during last two decades. A proper water management programme guided by the results of continuous monitoring programme and water quality criteria undoubtedly, prevent such disasters.

In the case of a natural resource such as water it was revealed that the per capita availability has declined to alarming levels affecting the future generations. To

maintain the sustainability without curtailing the current human needs it is essential to develop technologies on the reuse or recycling of water, effluent treatment processes etc. The development of such technology is impossible without the scientific knowledge on the water bodies. The immediate requirement is to assess the water quality and its seasonal variation by monitoring programmes and subsequent use of scientific principles to monitor the sustainability without a decrease in the per capita availability.

The historical records reveal that there were no human settlements in the central hill country over 800 hundred years ago (Figure 2). The hill country was the reservoir of water feeding most of the man made wewas even during a severe drought.

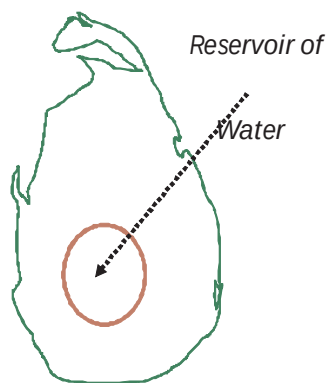


Figure 2. Central hill country was kept as a reservoir of water in the ancient times

Should we reconsider the history for continuous availability of suitable quality water leading to uninterrupted food security? It is possible for us to export good quality water and earn much needed foreign exchange since Sri Lanka is the country blessed with the highest rainfall in the region.

It is also important to impose rules and regulations on the recycling of the water used by industries. In the case of a natural resource such as water, it was revealed that the per capita availability has declined to alarming levels affecting the future generations. To maintain the sustainability without curtailing the current human needs, it is essential to develop technologies on the reuse or recycling of water, effluent treatment processes, etc. (Figure 3). The development of such technology is impossible without the scientific knowledge on the water bodies. The immediate requirement is to assess the water quality and its seasonal variation by monitoring programmes and subsequent use of scientific principles to monitor the sustainability without a decrease in the per capita

availability. The recycling of water should be a law. In the long run this will help in the maintenance of the food security.

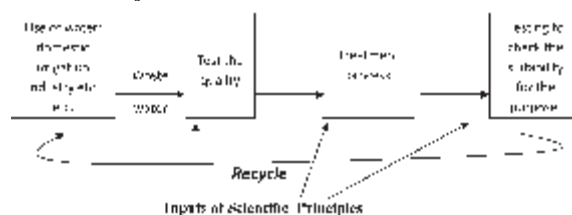
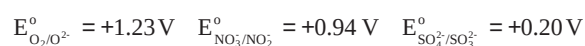


Figure 3. Recycling of water

It is also important to impose rules and regulations on the recycling of the water used by industries. In the case of a natural resource such as water, it was revealed that the per capita availability has declined to alarming levels affecting the future generations. To maintain the sustainability without curtailing the current human needs, it is essential to develop technologies on the reuse or recycling of water, effluent treatment processes, etc. The development of such technology is impossible without the scientific knowledge on the water bodies. The immediate requirement is to assess the water quality and its seasonal variation by monitoring programmes and subsequent use of scientific principles to monitor the sustainability without a decrease in the per capita availability. The recycling of water should be a law. In the long run this will help in the maintenance of the food security.

Evaluation:

Acid rains fall on (i) an area containing 60% feldspars in the surface soil and (ii) a pond containing effluents from a battery factory.



In Colombo, $(RT/F) \ln X = 0.06 \log_{10} X$

The surface wash off from the area containing feldspars was used for irrigation of paddy cultivation for about 10 years. Consequently, the paddy cultivation was affected leading to the abandoning of the paddy fields.

- Describe scientific reasons for the abandoning of the paddy fields.
- Sketch the pE Vs pH diagram and indicate the expected range of pE value of the pond water if the pH of the pond water is reported as 9.0. Describe a method to treat black liquor to prevent water pollution.

3.1.3 Education on Water Science - Water quality for Industrial needs:

Water quality for industrial needs is highly

variable. For food industry, water used should be free from pathogens. Chlorination, ozonation and irradiation with γ etc. are used in water treatment process. Water used for boilers should be soft water, i.e. it should be free from calcium and magnesium ions. This is generally achieved using cation exchangers. In addition, the effluent from the industry should conform to the standards (Table 3).

Table 3. Tolerance limits for industrial effluents to be discharged into the environment

No.	Determinant	Tolerance limits for effluents discharged into surface waters	Tolerance limits for effluents discharged into marine coastal waters	Tolerance limits for effluents discharged on land for irrigation purpose.
1	pH	6.0 - 8.5	6.0 - 8.5	5.5 - 9.0
2	Temperature, $^{\circ}\text{C}$	40	45	35
3	BOD, mg dm^{-3}	60	100	250 (100)
4	COD, mg dm^{-3}	400 (250)	400 (250)	650 (300)
5	Chloride, mg dm^{-3}	1000	Not applicable	
6	Chromium(VI), mg dm^{-3}	0.5	0.5	0.5
7	Chromium(Total), $\mu\text{g cm}^{-3}$	2.0	2.0	2.0
8	Sulfide, mg dm^{-3}	2.0	5.0	-

Chemical Oxygen Demand (COD) is the amount of oxygen (mg dm^{-3}) required for the oxidation of organic matter in polluted water.



Amount of oxygen in mg dm^{-3} required for this oxidation is the COD value.

Evaluation

- You are requested to determine following parameters in a sample of water with suspended matter, COD (TOC), Nitrate(V), Total alkalinity and Phosphate.
Describe the methods of sampling and preservation if the water body is
(i) a canal (ii) a drinking water well.
Calculate and describe a method of preparation of a solution of 800 mg dm^{-3} (ThOD) using pure solid potassium hydrogen phthalate.
- An industrial effluent contains 0.10 mol dm^{-3} of a toxic anion X^{2-} . The tolerance limit of the anion to

be discharged into inland surface waters is $1 \times 10^{-4} \text{ mol dm}^{-3}$. The solubility product of a precipitate MX is $1 \times 10^{-12} \text{ mol}^2 \text{ dm}^{-6}$.

For an acid H_2X , $\text{p}K'_{a_1} = 0.5$ and $\text{p}K'_{a_2} = 9.0$

- Describe the method of sampling you used.
- With calculations and deduction, describe a method that you would use to achieve the tolerance

3.2 Education on mineral resources of Sri Lanka

During the progress of the Samanala wewa project the ruins of ancient blast furnaces have been found. It is evident that the manufacture of iron ('pig iron') was carried out about 2000 years ago with the help of monsoon wind to operate the blast furnace. It was found that pig iron does not possess necessary strength to be used for the manufacture of tools (e.g. swords). In the 5th century A.D. with the use of the Open Hearth process steel was manufactured in Sri Lanka even for export. Today, the manufacture iron is not carried out in

Sri Lanka.

Since “Education determines the economy of a Country” there is a need to educate our children or even all stake holders including teachers on the sustainable consumption of the mineral resources.

Sri Lanka is endowed with industrial mineral resources such as, Apatite, Clay (kaolin), Ilmenite, Monazite, Mica, Quartz, Granite, Silica sand, Gemstones Feldspar, Graphite, Rutile etc. (Figure 4).

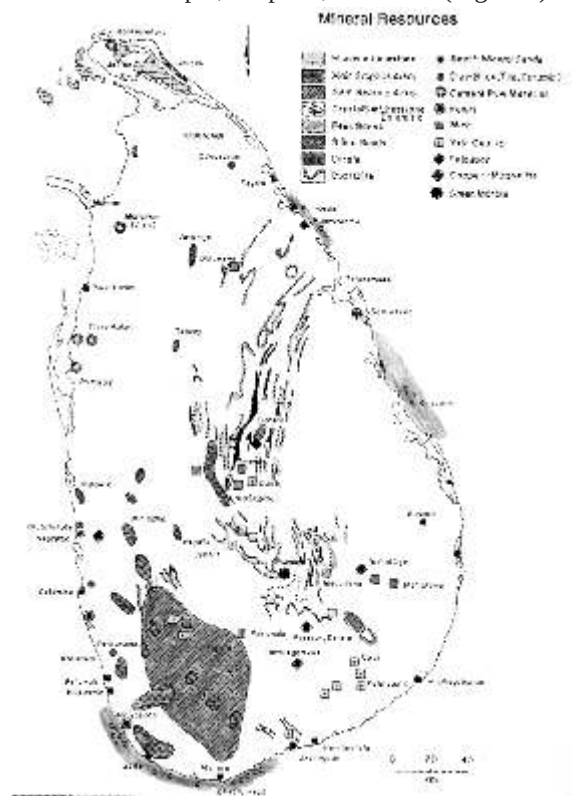


Figure 4. Mineral Resources of Sri Lanka

The mineral resources are mostly **non renewable**. Graphite and mineral sands (mostly rutile, monazite) are mainly exported. The country also exports geuda (pale white or colorless sapphire), loose gemstones, and jewelry. The Government owns apatite, graphite, and mineral sand mines; the remainder of the country's mines are owned and operated by the private sector. The essential step is the search for an appropriate and common paradigm for resource availability based upon a sustainable development where future generations are likely to be better off than the current generation. The education for sustainable consumption of especially on non renewable natural resource should be introduced at all levels of teaching in Sri Lanka.

A brief account on the sustainable consumption of mineral resources of Sri Lanka is given below

3.2.1 Lime stones-

- (i) Miocene Lime stone – mainly calcium carbonate
- (ii) Crystalline lime stone – dolomite, calcite, magnesite etc.
- (iii) Shell, Coral (Animal origin)

Some uses of lime stones are: Cement (Miocene Lime stone), Construction industry (Calcite, Dolomite), Paint (Shell), Food industry (Coral) etc.. Coral is a very pure form of calcium carbonate. Coral was used for construction industry where such purity is not required, “Not a sustainable consumption”.

The Administrators of Sri Lanka should also know something about Mineral Resources. Why? With foreign assistance it was planned to establish a Cement Factory in the Central Province. **The foreign** consultant has been informed that “Limestone” is available in the Central Province to Manufacture Cement. At a meeting I attended, I told the foreign consultant that the area contains dolomitic limestone (dolomite) which is not suitable for the manufacture of cement due to its high magnesium content. This was the end of the planned projects!

Secondary level: Deposit, location, composition, different types of limestone in Sri Lanka and their locations. Usefulness of limestone in industry.

Tertiary level: Principles of the manufacture Portland cement.

Secondary level:

1. Can you use limestone available in the Central Province (Kandy, Digana) to manufacture Portland cement?

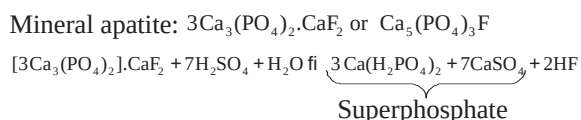
Tertiary level:

1. The chemical behavior of all types of limestone is different. Why?
2. Calcined limestone from shell can be used as a paint but calcined coral cannot be used as a paint. Why?
3. Cracks appear when calcined dolomite is used as a finishing coat in masonry. Why? How would you overcome this?

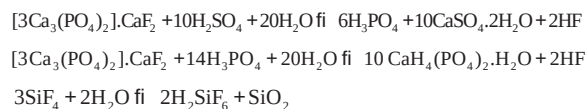
3.2.2 Apatite - Eppawala apatite

It is estimated that this deposit (discovered in 1971) contains 60 million tons which is adequate for sustainable consumption as a phosphate fertilizer required for several generations. Despite this discovery, it is unfortunate that Sri Lanka still imports triple super phosphate (TSP) spending several million

rupees annually. The technology for the conversion of apatite to super phosphate and TSP is well known.



With excess sulphuric acid Triple Superphosphate (TSP) is formed.



Evaluation:

Secondary level:

- How do you manufacture superphosphate using Eppawala apatite as the raw material?

Tertiary level:

- The phosphorus solubility of apatite is determined in 2% Citric acid and in 2% maleic acid media. Why?
- Can Sri Lanka be self-sufficient with phosphorus fertilizers? How?

3.2.3 Silica based minerals- quartz, granite etc.

Reserves of quartz were estimated to be adequate at more than 20 million metric tons

Evaluation:

Secondary Level:

- What are the raw materials used for ceramic industry?
- Give an account of the types of silicate minerals in your area.

Tertiary level:

- Can we produce silicon chips in Sri Lanka? Give the possible process.

3.2.4 Mineral sands- rutile, ilmenite, zircon, monazite etc.

Beach sand is containing Ilmenite, Rutile, Magnetite, Zircon, Monazite and Silica. The resources based at Pulmoddai is replenished annually (15%) with the advent of the north-east monsoon season. Utilising around 150,000 tons per annum for an upgrading plant, the reserve can last for over 25 years. Four million tons of heavy mineral sands (grades of over 60% heavy mineral) are available in Pulmoddai. **This deposit rates among the best known in the world**, especially due to its heavy mineral contents of between 60% to 70%. India is looking to buy more rutile and ilmenite mineral sands from Sri Lanka, a media report said quoting Kerala state industries minister Elamaram Kareem. Sri Lanka's *The Sunday Times* newspaper in a Kerala dateline report said two state-run firms Kerala

Minerals and Metals Ltd and Travancore Titanium Products Ltd was looking to import more mineral sands from Sri Lanka. The newspaper report said there was not enough ilmenite to feed the full capacity of the Titanium plant. Ilmenite and rutile is used to produce Titanium metal used in the aerospace industry, and Titanium dioxide pigment, used in paints. In 2008, China was the biggest buyer of Sri Lankan mineral sands, followed by India, according to data released by the island's geological survey office. Large mineral resources are found in the eastern coast of Sri Lanka, where a 30-year war ended this year. The sands are extracted by state-run Lanka Mineral Sands.

Table 4. Composition of the Beach Sand

Mineral	Composition
RUTILE	TiO ₂ 95% MINIMUM MOISTURE 0.50% MAXIMUM
ZIRCON	TiO ₂ 11.25% SiO 38.01% ZrO ₂ 26.5
ILMENITE	TiO ₂ 53% MINIMUM MOISTURE 2% MAXIMUM

TiO₂ pigment is used in paint industry and titanium metal is used in Aircraft industry (Figure 5).

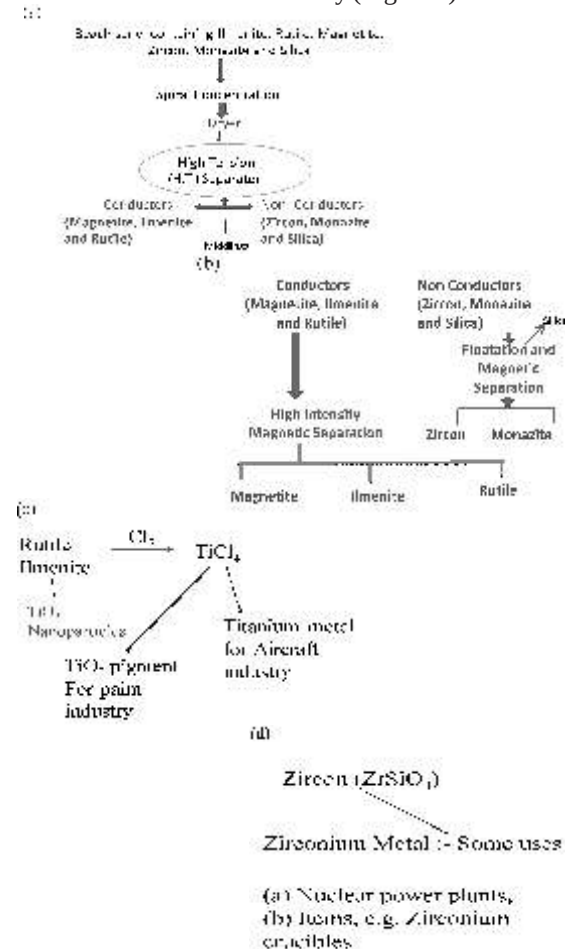


Figure 5. Beneficiation of the beach sand- (a), (b): Separation of minerals from beach sand; (c), (d): Uses

of minerals such as rutile, limenite and zircon

Evaluation:

Secondary level:

1. Name the mineral which contains oxygen, titanium and iron.

Tertiary level:

1. TiCl_4 is volatile. Give one reason.
2. Metal chelates of titanium can be extracted from acid medium. Why?
3. Prior to electrostatic separation drying of mineral sands is essential. Why?
4. The chemical behavior of zirconium is similar to Hafnium. Why?
5. Zircon is a non conductor. Why?
6. Which of the following ions undergoes hydrolysis easily, give one reason.
(i) Titanium(IV) (ii) Zirconium(IV)

3.2.5 Monazite- A reddish-brown phosphate mineral containing rare-earth metals, (Ce, La, Y, Th) PO_4 , important as a source of cerium and thorium found in Bentara Ganga Area. Thorium can be converted into a nuclear fuel Uranium -233 (^{233}U).

Evaluation:

Tertiary level: Principles of the extraction of thorium metal from monazite. Future use of Th as a nuclear fuel.

Discovery of nuclear fission as a source of energy.

Ideas on cold fusion!!!

3.2.5.1 Nuclear fuel is a material that can be consumed to derive nuclear energy



3.2.6 Clay, Feldspars - Large quantities of two dimensional alumino silicate (Clay) and three dimensional alumino silicate (Feldspars) are available in Sri Lanka. The country has substantial deposits of, alluvial clay, ball clay, bloating clay, china clay, clay ochre, kaolin, non bauxite clay and shale. Ceramics industry is the largest mineral-based sector in Sri Lanka. The Government sought to exploit the export market for ceramics used in electronic goods and roof tiles and to achieve an annual growth rate of 5% for the industry. To boost clay production and identify additional clay reserves, the industry hoped to locate new good-quality feldspar and kaolin deposits. No new ball clay deposits had been identified in the recent

past. The Clay Reserves that were being mined at Boralesgamuwa and Meetiyagoda were expected to run out during the next 2 to 3 years.

3.2.7. Graphite -The mineral graphite is one of the **allotropes of carbon**. It was named by Abraham Gottlob Werner in 1789 from the Greek γραφειν (graphein): "to draw/write", for its use in pencils, where it is commonly called lead, as distinguished from the actual metallic element lead.

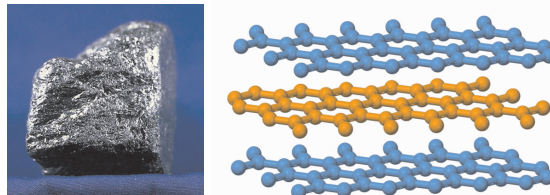


Figure 6. Graphite

Some uses of graphite are,

Electrodes: An estimate based on USGS data indicates that graphite electrode consumption was 197,000 tonnes in 2005. **Foundry facing and lubricant:** An estimate based on USGS graphite consumption statistics indicates that 2,200 tonnes was used in this fashion in 2005. **Neutron moderator:** Special grades of synthetic graphite also find use as a matrix and neutron moderator within nuclear reactors **Brake linings:** US natural graphite consumption in brake linings was 6,510 tonnes in 2005.

Mica is a generic term applied to a group of rock-forming complex aluminosilicate minerals having a sheet or plate like structure with varying chemical composition and physical properties. Crystals of Mica are characterised by highly perfect basal cleavage in the direction of large surfaces permitting it to split or delaminate into extremely thin and flat films.

3.2.8 Quartz, Silica sands & Granite

Major Forms of Silica:

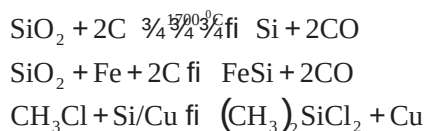
Quartzite- This occurs in many parts of the country. The usefulness of this is low due to the presence of impurities such as iron.

Vein quartz (Silica quartz)- The vein quartz is known for its high grade (purity i.e. 99.9% SiO_2)

Silica sands- These are found in Madampe, Nattandiya and Mrawila areas.

Granite, the durable and elegant material, is not easy to come by as it comes deep within the earth. Its character reflects the creative forces of nature - the patterns of each block of granite tell a story of gigantic pressures, the searing heat of the earth's core, and its violent birth in the volcanic eruptions of bygone millennia. Granite brings grace to the gardens, homes, palaces and

temples of Sri Lanka's ancient royalty and adds a timeless and lasting beauty that has survived for centuries. Sri Lanka has four major types of granite deposits (granite proper, gneissose granite, pegmatite and graphitic granite) in substantial amounts, suitable for processing into cut and polished stones. The colour, grain structure, hardness and strength of Sri Lankan granite is suitable for the international market.



Education on Minerals



Curricula – GCE (A/L)

Biology –

Present Curriculum - not specific on minerals.

Revised curricula - GCE (A/L) - not specific on minerals

Chemistry-

Present curriculum - Unit 15.2 Depletion of non-renewable resources such as Mineral sands, Gems, Calcium carbonate, Apatite, Graphite, Dolomite and Clay.

Revised curricula - GCE (A/L) - Unit 15.6 - Investigates some chemical industries based on mineral resources. Production of glass, cement, detergents, rutile, ilmenite and crude oil.

This indicates that the Secondary Education does not provide adequate knowledge in Mineral resources of Sri Lanka.

N.B. Metal ion chelation ability of *Begonia* 'looking glass' leaf extract, showed promising results with the metal ion Al(III). The metal ions of Aluminium in the presence of extract showed a different wavelength at 560 nm, aside to the original wavelength of *Begonia* 'looking glass' leaf extract solution which was at 518 nm. Stability of the metal ion-extract complex against pH was discovered in the range of pH 2 to pH 5. These results reveals that, the *Begonia* 'looking glass' leaf extract can be used as a metallochromic indicator against Aluminium ions. In addition, this *Begonia* 'looking glass' leaf extract revealed positive results for different strengths of Hydrogen ion concentrations.

The curricula of tertiary education Institutions may sometimes not have education on Water Science and also education on Minerals but may be available as optional courses. Therefore, some students may be

awarded B.Sc. degrees with Chemistry as a subject without any knowledge on Water Science and also on Mineral Resources required to achieve sustainable economy.

Tertiary level: Principles of the extraction of copper metal from copper pyrites (copper sulphide) Alloys of copper and their applications.

Secondary level:

1. Name the mineral which contains oxygen, copper and sulphur.
2. What is Karat 22 Gold?

Tertiary level:

1. The chemical behavior of copper(I) ($3d^{10}$) is different from silver(I) ($4d^{10}$). Why?
2. Pyrometallurgy is not generally used for the extraction of copper. Why?
3. Which of the following ions undergoes oxidation easily? Give one reason.
 - (i) Copper(I)
 - (ii) Silver(I)

4. Process of Evaluation

This is to test the ability to use the knowledge when the need arises. This was discussed with model questions.

References:

1. A statement of the World's Scientific Academies, May 2000, *Transition to Sustainability*.
2. Weeramantry, C.G. (2000) *Environmental Aspects of Sri Lanka's Ancient Irrigation System*, A Sarvodaya Vishva Lekha Publication.
3. "Silica Based Industries – Future Prospects" NARESA Publication, 1996
4. Rupasinghe, M.S., Gocht, W. and Dissahayake, C.B. *J. Natn.Sci. Coun. Sri Lanka*, **1983**, 11, 99 – 110
5. S. B. Suslick; I. F. Machad (2003) *Non-Renewable Resources* - Industrial Minerals.
6. Geiger, W. "Mahavamsa – The Great Chronicle of Ceylon" Buddhist Cultural Centre – Sri Lanka
7. Arumugam, S. Ground water observation in the Kala Oya basin. *Proceedings of Sri Lanka Association for the Advancement of Science*, December 1976.
8. Sri Lanka Standards Institution- Guidelines for the Surface & Groundwater Quality for Designated Uses of River Basins in Sri Lanka- Part 1: Kala Oya Basin (Draft Standards for Public Comments) December 2005.
9. Central Environmental Authority- Guidelines for

- Water Quality, 2003.
10. EML Consultants- Kala Oya Bio Diversity Study: Section 5: Water Quality Assessment – December 2005.
 11. Ayers R. S.; Westot, D. W. (1976 and 1986) Water for Agriculture -FAO Irrigation & Drainage
 12. Dissnayake, C.B.; Weerasooriya, S.V.R., (1985) *Hydro-geochemical Atlas of Sri Lanka*
 13. Ashgar, A.G.; Puri, A.N.; Taylor, E.M. (1936) *Soil; deterioration in irrigated areas of Punjab, Part I-II*. Irrigation Res. Inst. Memoirs, Amitsar.
 14. Bower, C.A.; Ogata, G.; Tucker, J.M. *Soil Science*, **1968**, 106(I), 29-34.
 15. Golterman, H.L. (1971) *Methods for chemical analysis of fresh water*. Oxford; I B P Book No. 8 Blackwell Scientific Publishers.
 16. MAB – Programme, (1976). Final report, 24 – 27 February 1976.
 17. Mahaweli Development Board, (1977) Mahaweli Ganga Development, Sri Lanka Summary Reports on Projects.
 18. Paliwal, K.V. (1972), *Irrigation with saline water*. Water Technology Centre, Indian Agricultural Research Institute, New Delhi.
 19. Paliwal, K.V.; Yadav, B.R. (1976) *Irrigation water quality and crop management in the Union Territory of Delhi*. New Delhi, Water Technology Centre, Indian Agricultural Research Institute.
 20. Paliwal, P.V.; Gandhi, A.P. (1976) *Soil Science*, 122(2), 85
 21. Svendsen, Mark T. (1976) – *Investigating agricultural waterlogging and salinity problems* M.Sc. Thesis, Colorado State University, Colorado, U.S.A.
 22. Raiswell, R.D. Brimblecombe, P. and Liss P.S. (1980). *“Environmental Chemistry”* Edward Arnold (Publishers) Ltd, London.
 23. Gunawardhana, H.D. *Chemistry in Sri Lanka*, **1985**, 2(1), 11.
 24. Gunawardhana, H.D. *Chemistry in Sri Lanka*, **1989**, 6(1), 18.
 25. Gunawardhana, H. D. *Chemistry in Sri Lanka*, **1993**, 10(2), 37.
 26. Gunawardhana, H.D.; Sugathapala, P. M. *Analyst*, **1989**, 114, 619.
 27. Gunawardhana, H.D. (1988) *“Some aspects of the chemistry of the environment of Sri Lanka”*, edited by C.B.Dissanayake and Leslie Gunatilake, P. 169. SLAAS Publication.
 28. Gunawardhana, H.D.; Adikari, A.M.; Kumudini, R. J. *Natin. Sci. Coun. Sri Lanka*, **1981**, 9(2), 12
 29. Weeramantry, C.G. (2000) *Environmental Aspects of Sri Lanka's Ancient Irrigation System*, A Sarvodaya Vishva Lekha Publication.
 30. Gunawardhana, H.D. (1990) “A possible Reason for the shifting of the Anuradhapura Kingdom to Polonnaruwa”. *National Archaeological Congress* July 1990, Colombo.
 31. Far Eastern Economic Review, 2003.
 32. Gunawardhana, H.D. and Dias, P.P.S.P. *J. Natn. Sci. Counc. Sri Lanka*, **1987**, 15(1), 1-10.
 33. <http://www.nie@lk>
 34. Ramakrishna, R.S.; Gunawardhana, H.D. “Use of Titanium(IV) chelate of Salicylic acid for the selective Absorptiometric Determination of Titanium” *Talanta*, **1973**, 20, 21 – 26.
 35. Ramakrishna, R.S.; Gunawardhana, H. D. “Solvent Extraction Studies of iron(III) –titanium(IV) System,” *Proc. Ceylon Assoc. Advt. Sci.* **1970**, 26(1), 104.
 36. Ramakrishna, R.S.; Gunawardhana, H. D. “Synergic effect of Pyridine on the Extractibility of the Titanium(IV) – salicylic acid chelate”, *Proc. Ceylon Assoc. Advt. Sci.*, **1971**, 27(1), 89.
 37. Ramakrishna, R.S.; Gunawardhana, H. D. “Extraction of the Pyridine adduct of Titanyl salicylate in Chloroform,” *Proc. Sri Lanka Assoc. Advt. Sci.*, **1972**, 28(1), 110.
 38. Gunawardhana, H.D.; Perera, A.C.S.; Fernando, M.S.B. “Studies on the use of Coconut oil based Ligands for the Extractive separation of Titanium(IV)”, *Trans. Indian Inst. Metals*, **1979**, 119.
 39. Gunawardhana, H.D.; Wikramanayake, D. N. “Extraction of Titanium using a Castor oil based Ligand” *Indian J. Chem.* **1982**, 21(A), 88 – 90.
 40. Gunawardhana, H.D.; Asiriwatham, D. “Extraction of Titanium with Coconut oil based N-Phenylhydroxamic acid” *Indian J. Chem.* **1982**, 21(A), 338 – 340 (1982).
 41. Gunawardhana, H.D. “Extraction and Spectrophotometric determination of Titanium(IV) with N-Phenylhydroxamic acid and Phenylfluorone” *Analyst*, **1983**, 108, 952 – 958.
 42. Abeyratne, N.; Gunawardhana, H. D. “Extractive Spectrophotometric determination of Titanium(IV) by Ternary complex formation”, *Chemistry in Sri Lanka*, **1996**, 13(1), 7.
 43. Gunawardhana, H.D.; Wijesoma, W.S. S. “Studies on the Use of Sesame oil based Hydroxamic acid ligand for the Extractive separation of Titanium” *Proc. Inst. of Chemistry, Ceylon*, **1981**, 10(1), 26.
 44. Fernando, L.N.; Gunawardhana H. D. “Solvent Extraction studies with a Soya oil based N-phenylhydroxamic acid type ligand” *Proc. Sri Lanka Assoc. Advt. Sci.*, **1988**, 44(1), 185.

Theme: “Curricula and Evaluation in Chemistry for a Sustainable Economy”

The 43rd Annual Sessions of the Institute of Chemistry Ceylon were held on 18th and 19th June 2014 at the Adamantane House, the headquarters of the institute. The theme of this year was “**Curricula and Evaluation in Chemistry for a Sustainable Economy**”. The annual session was inaugurated on 18th June by the Chief Guest **Dr. Ariyadasa de Silva**, Retired Professor, Faculty of Education, University of Colombo. A large number of participants including guests, members and students attended this ceremony. The president, Professor H. D. Gunawardhana warmly welcomed all the participants.

The Chief Guest **Dr. Ariyadasa de Silva** thanked the institute for selecting this valuable theme for this year annual sessions. In his speech he mentioned that the offering a specially planned curriculum and subjecting it to regular and effective evaluation enabling necessary revision and renewal is an essential component of the educational effort to attain economical sustainability.

The Guest of Honour was **Professor (Mrs.) M. Vithanapathirana**, Professor, Faculty of Education, University of Colombo. She discussed some key aspects on curriculum and evaluation trends in chemistry towards sustainable economy. She further stated that it is necessary to review our curricular, formulate priorities, and identify commitments and resources towards a valued curriculum goal and outcomes towards ensuring sustainability.

Prizes and scholarships were awarded to the students following the Graduateship program in Chemistry at the College of Chemical Sciences, Institute of Chemistry Ceylon. Further, prizes and certificates were awarded to the winners of the All Island Interschool Chemistry Quiz competition 2013/2014.

The closure of the inauguration ceremony was followed by the vote of thanks by Mr. K. R. Dayananda, the president elect.

The 43rd annual general meeting (AGM) of the Institute was held at Adamantane House after the inauguration ceremony. A new council was elected for the year 2014/2015.

Five research papers were presented on different areas in chemistry during the technical session held after the AGM. The Annual Dinner was held on 18th June at OPA premises. Professor M D P de Costa was the Chief Guest of this event.

The theme seminar on “**Curricula and Evaluation in Chemistry for a Sustainable Economy**” was held on 19th June at Adamantane House. The Keynote address was delivered by **Mr. Sterling Perera**, Vice Chairman, National Education Commission and Former Commissioner – General Examinations on “**Curricula and Evaluation in Science subjects for a Sustainable Economy**”. Professor (Mrs) Manjula Vithanapathirana delivered a speech on “**An overview of Science Education in Sri Lanka**”. Professors H. D. Gunawardhana and K. R. R. Mahanama delivered the guest lectures on “**Curricula and Evaluation in Chemistry for value addition to some mineral resources**” and “**Curricula and Evaluation in Chemistry for Environmental studies-Air**”, respectively. Drs. P. A. N. Punyasiri, L. M. K. Tillekeratne and Jayantha Gunatilleke delivered their speeches on “**Curricula and Evaluation in Chemistry for value addition in Tea industry, in Rubber industry, and in Coconut industry**”, respectively. Messers L. P. R. J. Wijesinghe and R. P. Samarakkody, and Ms. Sangheetha Sriskandarajah delivered guest lectures on “**Curricula and Evaluation in Chemistry for Environmental studies -Water, -Soil, and for value addition in Palmyrah industry**”, respectively. All these guest speakers mentioned how the school level and graduate level chemistry curriculum address the above mentioned topics and how the evaluation should be done to assess students' knowledge.

Curriculum and Evaluation in the Science Education in Sri Lanka:

Learning points from global research

Professor Manjula Vithanapathirana
Faculty of Education, University of Colombo

Learning science has important implications for human society and the future of our planet. With the emergence of a highly competitive and integrated global economy with rapid technological innovations, a growing scientific knowledge base is a necessity to have a profound impact on our lives. Investment in science, technology and innovation is an important driver of economic growth and social development. Science must respond to societal needs and global challenges. Towards this the public understanding of science and citizen participation in science needs to be improved. The phenomenon 'science education for citizenship' is accepted across the world.

There are three dimensions of science education. The first is the content of science incorporating the basic concepts, and scientific knowledge. The other two important dimensions of science are the science processes and attitudes. Learning science processes becomes a tool to learn and understand science, as well as an important aim in science education. Not only the scientists, but also all individuals in the society should have these skills in order to be scientifically literate, and to solve the problems encountered in daily life. Attitudes towards science consist of a large number of sub-constructs such as the perception of the science teacher; anxiety toward science; the appreciation of the value of science; self-esteem at science; motivation towards science; enjoyment of science; attitudes of peers and friends towards science; attitudes of parents towards science; the nature of the classroom environment for science learning; achievement in science; and fear of failure in science.

Across the world there is a concern about the decline of interest in scientific studies while the demand for science graduates is growing. Science education studies from developed countries eg. United Kingdom, raises alarm that low uptake of science and the negative attitudes towards science poses a serious threat to economic prosperity. A recent UNESCO report on current challenges on science education (2009) highlights some reasons for losing interest in learning science. They are as follows:

- Science teaching is predominantly 'transmissive' and students are expected to absorb knowledge as

it comes from the teacher or from the textbook.

- Science knowledge is rigid and unchanging.
- The content of school science is highly abstract and uninteresting as there is very little relevance to everyday lives.
- Science in films and in the media is often exciting, but the science topics in school curriculum are not.
- Learning science is relatively difficult, when compared with many other subjects and also, many non-science careers are more financially rewarding.

It can be observed that the above reasons are affiliated to the quality of the content and process standards of science curricula. Most of these reasons seem to be applicable to Sri Lankan context as well. Similar findings related to status and issues related to Science Education in Sri Lanka have been highlighted by recent studies conducted or reported by NASTEC, World Bank, NEREC and also Institute of Chemistry.

In my presentation I would like to focus on research based international trends on the content and process standards of science learning and teaching and highlight a few aspects that would be worthwhile to be considered during a science education reform in Sri Lanka.

Determining curriculum content standards

The trend in 'constructivist approach' to creating science curriculum is continually emphasized across the globe. Constructivist philosophy aligns curriculum, pedagogy and assessment. Constructivist curricula build on major science concepts by revisiting them with increasing sophistication at various levels. This may encourage a logical developmental sequence of knowledge, skills and attitudes that promotes science learning in secondary and post secondary levels.

In a science curriculum, the content standards outline what students should know and be able to do in science. With the current thinking on content standards, internationally there is a trend to decrease the number of topics that are studied in science and to take a more “depth” rather than “breadth” approach.

In-depth understanding of science concepts enables students to have a solid basis on which to build and acquire new knowledge and solve problems. However, the broadening of school curricula is a common observation and a problem encountered in systems of education. This is due to the fact that school curricula are focused to form the foundation for the higher education specializations of various science subjects. International literature provides evidence to show that, too often, the school chemistry curriculum is designed with the future stages of learning in chemistry in mind. Thus, honours chemistry requirements determine first year university courses which, in turn determine the senior school curriculum which then defines what should be taught at earlier stages. This means that the school chemistry curriculum is determined largely by the needs of a *minority* who might become chemists.

A school science curriculum must be re-thought in terms of the whole group - who will become citizens. It is necessary to identify the needs of the learners at different levels such as secondary and higher education levels in curriculum construction. It has been demonstrated that those with more or less no chemistry from school can still do well in a first year university course. If the said mismatch can be addressed, the curriculum designers will seek to define the kind of chemistry which the wider population will need. Syllabuses then can be planned around these major themes, the themes that are significant for the majority. One of the main concerns reported regarding the Sri Lankan curricula is the vastness of the content in science curricula. To avoid this situation it is necessary that we identify the core knowledge in the scientific disciplines and increase their emphasis in school science curricula. The education structured around a limited number of core ideas allows the time necessary for students to explore ideas at a greater depth at each grade level and engage in the full range of practices. It is recognized that curriculum standards that cover many details are too broad to provide guidance about priorities.

Identifying learning outcomes continue to be of high importance for teaching and learning. Once the content is identified articulating the learning outcomes define precisely what pupils will be able to do by the end of the lesson. With carefully worded learning outcomes it is possible to get a clear idea of what the pupils are expected to achieve and how the teacher is going to assess it. In the formulation of learning outcomes, the Blooms Taxonomy (1956) becomes useful. Benjamin Bloom identified three domains of

learning, the cognitive, the affective and the psychomotor. In the cognitive domain six levels of cognitive function corresponding to learning tasks are identified. In the recent past slight changes have been done by students of Bloom and a new hierarchy of cognitive categories of the cognitive domain levels range from simple recall of factual information up to the creation of new information. Specifically the categories are memorizing, understanding, applying, analyzing, evaluating and creating. Students should be provided with opportunities at all levels of the hierarchy with a proper balance. It is necessary to ask the question whether these learning outcomes are realistic to students. Research suggests that cognitive acceleration tasks in science education aiming longer-term outcomes, several months later, are better than immediate outcomes. The affective domain developed by Bloom and others includes the manner in which we deal with things emotionally, such as feelings, values, appreciation, enthusiasms, motivations, and attitudes. The five major categories are listed from the simplest behavior to the most complex. The psychomotor domain (Simpson, 1972) includes physical movement, coordination, and use of the motor-skill areas. Perception, readiness to act, guided response, practice, skillful performance, adaptation and origination of new skills are the seven major categories are listed from the simplest behavior to the most complex and learning is achieved through the hierarchical progression of levels of more simple to more complex.

Implementing curriculum process standards

Learning is constructing knowledge through a personal process undertaken by the individual. *Knowledge is not passively received, but is built up by the cognizing subject.* According to this principle it is not possible to transfer ideas into students' heads intact. The learners construct their own meanings from what they experience and words or visual images they hear or see. To prepare students to live and work in tomorrow's world, emphasis on scientific inquiry should be increased while decreasing the emphasis on teaching science in a sequence of lectures and reading assignments. What the learners already know is of key importance in this construction process.

Only when teachers become more comfortable with both science content and the processes will they be able to maintain the quality of science education. Pedagogical Content Knowledge (PCK) is a widely used concept to examine the professional, often implicit teaching knowledge of teachers. PCK is

constituted by a profound knowledge about subject connected with knowledge about how the students learn this respective subject matter and how to create a supportive learning environment. PCK development is rooted in reflected teaching practice. As in any area of the curriculum, learning with understanding in science involves the development of ideas and concepts through both mental and physical activity. It is important that science lessons are as much 'minds-on' (thinking skills) as they are 'hands-on' (psycho-motor skills).

As talking and listening play a crucial role in supporting thinking and reasoning, classroom strategies which promote teacher-pupil and pupil-pupil dialogue are ideal for developing children's thinking skills. Teaching science for understanding, instead of rote memorization, classroom dialogue helps the students to be active participants who are engaged in asking questions, observing and inferring, collecting and interpreting data, and drawing conclusions. Such active learning pedagogies that promote higher order thinking skills play an important role in effective learning outcomes. Further to this cooperative learning is also a vibrant pedagogy which goes beyond whole group discussions. The nature of interactions in the cooperative groups has been found to be very promising for learner-centred classrooms. It has been found that as a pedagogical method it might overcome the decline in attainment and motivation in secondary science. Knowledge construction although traditionally has been recognized as an individual activity, at present it is considered as a collective cognitive responsibility. Cooperative learning is a generic term. It has been defined as 'small groups in which students have to jointly organize their time and resources to work toward some specific goal'. Cooperative learning methods promote positive interdependence and social interaction between students that result in psychological well-being while constructivist peer learning. However, the quality of implementation of the strategy may yield different outcomes.

It is impossible to raise interest in science without practical work with different substances or organisms. The practical skills are those that enable pupils to use appropriate methods and equipment accurately and safely, assessing risk as they get along. They should be able to plan and carry out investigations individually and with others. The mastery over the concepts learnt enables the students to build the ability of designing the experiments. In a traditional laboratory course, the

students perform experiments with the help of a laboratory manual, where each step of the experimental procedure is described. The major limitation of this approach is the gap between the specific learning outcomes and their relevance to knowledge construction and application. In contrast the post-laboratory sessions which are designed in such a way that there is a progressive development of the concepts, techniques and skills. This is to maximise the potential for learning and connect higher order cognitive skills such as analysis, synthesis and evaluation. A post-laboratory session can be conducted in the form of a questionnaire based on the pre-laboratory and laboratory sessions for each experiment. Performance during the post-laboratory session ensures that deep learning and the development of critical thinking has taken place, in those students who have performed well both in the laboratory and post laboratory sessions.

Another aspect that extends PCK is the integration of technology to the science learning and teaching. Technology has changed our world. But our classrooms have not changed much. Students spend most of their daily lives outside school interacting with 21st century technology, but too many classrooms seem stuck in the 19th century. At a minimum, using ICT for evidence gathering, analysis of data and communicate findings is essential in science teaching and learning. Technology must be perceived as a means of helping students explore topics in more depth and in more interactive ways. Integration of technological content knowledge (TCK), technological pedagogical knowledge (TPK) depends on the synthesized knowledge of technology, pedagogy, and content (TPC). Further, beyond this basic level, technology integration could take place as a pedagogical approach, a strategy for social interaction in a learning environment or as a technological design with the use of an easy-to-use advanced system. Not only PCK, teachers' self efficacy also influences student motivation and learning. Self efficacy is a belief about the level of competence that a person expects to display in a given situation. Teachers with a strong self efficacy tend to more planning and organized, open to new ideas, willing to experiment new methods, and have greater enthusiasm for teaching.

These active learning approaches in science education will certainly contribute to the development of 'transversal competences' highlighted as communication, literacy, numeracy and digital competences. These are identified as new skills required for the competitive global marketplace. These

approaches will develop the ability to learn-to-learn in order to support the development of self regulating persons who are motivated to shift towards entrepreneurship, creativity and innovation.

The Sri Lankan national curriculum adopted the 5E model widely across the entire subject curriculum and the implementation of this approach became controversial and challenging. The 5E Learning Cycle, first created by Robert Karplus in the late 1950s and early 1960s, has been regarded as a general philosophy of teaching and learning with strong constructivist foundations, consisting of five phases: engagement, exploration, explanation, elaboration, and evaluation. However, there is research evidence to show its effectiveness as an inquiry based methodology.

Assessment for learning, Assessment of Learning and Assessment as Learning

No lesson is complete without assessment and evaluation. Assessment capabilities of science teachers include their understanding and application of generic assessment concepts as well as science-specific assessment knowledge. Hence, knowledge of assessment of science learning has also been identified as an important component of science PCK.

Assessments that support learning should be prioritized above other assessments. 'Assessment for learning' (AfL) is any assessment that is designed and practiced for the purpose of promoting pupils' learning. Learning is not a linear process. The main objective of AfL in science is to know what students know, what students do not know and student misconceptions. 'Assessment conversations' are considered as a useful tool in formative assessment. Teachers must progress with sequential steps such as challenging students and leading them towards generation of better ideas. A crucial aspect of such dialogue-based teaching is to give students a voice, and help them realise that their teacher wants to know what they think, so that they will feel free to express even half-formed or confused ideas. Teachers can then use this information accordingly to guide the next activities. The main purpose of assessment conversations is to make students' thinking explicit so that teachers can recognize and act on it to promote learning. Assessment conversations make evident what and how students are thinking, enabling teachers to recognize their students' conceptions, mental models, strategies, language use, and/or communication skills. Another essential requirement

in assessment for learning is interactive feedback on written work. Teachers have to annotate students' work with comments designed to guide them in making improvements, and then provide opportunities for them to use this guidance. Students then come to see their work as a step in improving their learning. Existing practices emphasise marks, so that pupils see the exercise merely as a test. Assessment practice may communicate what knowledge is valued and equated with achievement in a particular context. By choosing what to assess (and what not to assess) teachers are communicating messages of the relative values of particular aspects of curriculum to their students.

Further, it is also useful to involve students in working in small groups to assess each other's work. The point here is not to trust students with generating marks, but to make them help each other so that they understand the aims and criteria of learning activities. Students are explicitly and systematically taught to help, support, and challenge one another as part of building community in their classroom. Student-led conferences are also an excellent way to deal with demonstration of learning and growth using individual goal setting, portfolios, and alternative assessment.

Research into current summative assessments or evaluation has exposed many problems. Recent literature refers to this concept as 'assessment of learning'. Assessment of learning is the assessment that becomes public and results in statements or symbols about how well students are learning. It often contributes to critical decisions that will affect students' futures. They include the excessive burden of assessment procedures and their failure to assess the full range of skills and competencies that should be the goals of science education. Current evaluation methods narrow students' learning experiences. Most evaluations are based on achievement tests. Quality assessment practices need to include consideration of the 'fitness for purpose' of an assessment task or an activity. Development of a reliable and valid tool to make objective evaluations has to be mastered by all evaluators.

'Assessment as learning' is another concept in assessment. Through this process students are able to learn about themselves as learners and become aware of how they learn. They become metacognitively active (knowledge of one's own thought processes). Self-assessment is essential if students are to carry-on being effective learners in their higher education or in their professional life. Students in effective classes are constantly engaged in reflection on their own learning.

Teachers would gather students into groups and ask them questions that called for open-ended, reflective responses, rather than questions calling for a 'right answer'. This could take place individually, in small groups, and as part of whole class instruction. With appropriate teacher scaffolding of responses, students are encouraged to use a critical, reflective stance in their work on projects, reading, writing, and more. This approach seems effective in helping to deepen understanding and enhance memory. Assessment as learning helps students to take more responsibility for their own learning and monitoring future directions.

Finally,

In conclusion it can be said that the science curriculum of Sri Lanka must be closely matched to the purposes of 'science education for citizenship'. A re-orientation of teaching and learning practices towards constructivist approaches would change a person's unsustainable way of thinking, being and acting. Such a shift would facilitate the understanding about the humans and the environment, entrepreneurship, life styles, peace and joy and possibilities of social justice. The assessment of what has been learned must be closely matched to the purposes of that curriculum. These changes to the science education should lead students to develop a more realistic understanding about the nature of science and how it operates. How it connects with other curriculum subjects and with the lives of the students in and out of school and their communities. They will be able to see science as part of the rich heritage that previous generations have handed over to us and it is subject to change as new observations and ways to interpret them emerge. Such a science is not an unchanging body of truth but a science that offers us powerful knowledge, understanding and methods to look at the world. Such a view of science would certainly match with the interests of the students and encourage them to continue studies in science.

Bibliography

1. Drew, V.; Mackie, L. (2011). Extending the constructs of active learning: implications for teachers' pedagogy and practice. *The Curriculum Journal*, 22(4), 451-467.
2. Edwards, F. (2013). Quality assessment by science teachers: five focus areas. *Science Education International*, 24(2), 212-226.

3. Erlikh, G.V. (2011). What Chemistry Should Be Taught in Modern Schools? *Russian Journal of General Chemistry*, 83 (4), 794-805.
4. Lin, T.C.; Tsai, C.C.; Chai, C.S.; Lee, M.H. (2013). Identifying Science Teachers' Perceptions of Technological Pedagogical and Content Knowledge (TPACK). *Journal of Science Education and Technology* 22 (3), 325-336.
5. Liu, T.C.; Peng, H.; Wu, W.H.; Lin, M.S. (2009). The Effects of Mobile Natural-science Learning Based on the 5E Learning Cycle: A Case Study. *Educational Technology & Society*, 12 (4), 344-358.
6. Liversidge, T.; Cochrane, M.; Kerfoot, B.; Thomas, J. (2009). *Teaching Science: Developing as a reflective secondary teacher*. SAGE
7. Mbajiorgu, N.; Reid, N. (2006). *Report of a Literature Review. Factors Influencing Curriculum Development in Chemistry*. Royal Society of Chemistry, Tertiary Education Group. www.heacademy.ac.uk/. Retrieved on 1.3.2014
8. Osborne, J.; Simon, S.; Collins, S. (2003). Attitudes towards science: A review of the literature and its implications, *International Journal of Science Education*, 25 (9), 1049-1079.
9. Pellegrino, J.W.; Wilson, M.R.; Koenig, J.A.; Beatty, A.S. (Eds.) (2014). *Developing assessments for the next generation science standards*. National Academy of Sciences
10. Thoonen, E.E.J.; Slegers, P.J.C.; Peetsma, T.T.D.; Oort, F. J.(2011) Can teachers motivate students to learn?, *Educational Studies*, 37(3), 345-360.
11. Topping, K.J.; Thurston, A.; Tolmie, A.; Christie, D.; Murray, P.; Karagiannidou, E. (2011). Cooperative learning in science: intervention in the secondary school, *Research in Science & Technological Education*, 29(1), 91-106.
12. UNESCO (2009). Current challenges in basic science education.
13. Wang, Q. (2008): A generic model for guiding the integration of ICT into Teaching and learning, *Innovations in Education and Teaching International*, 45(4), 411-419
14. Williams, D. (2011). What is assessment for learning? *Studies in Educational Evaluation*, 37. 3-14.

TEA—MORE THAN A NICE CUP

Professor S. Sotheeswaran

Dean, College of Chemical Sciences, Institute of Chemistry Ceylon

The dried leaves and shoots of the ever green shrub, botanically describes as *Camellia sinensis* of the plant family Theaceae, when infused with boiling water, yield a popular beverage known as tea. The plant is native to some Asian countries and is a major export commodity in Sri Lanka, formerly known as Ceylon. The tea exported from Sri Lanka is well known as Ceylon Tea.

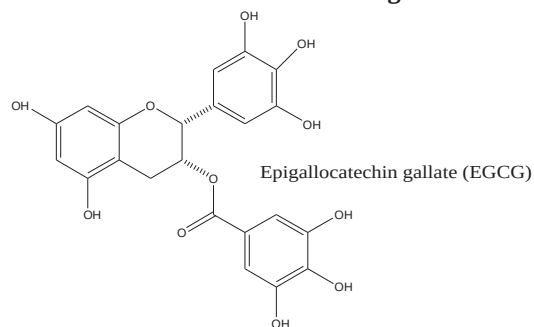
Tea is not just a stimulating drink containing about 3.5% caffeine; it is also more than that—it has medicinal properties. A fifteen year study on humans in the age range of 50-69 years, most at risk from heart disease, has revealed that a regular intake of tea may protect them from fatal heart attack. It is now known that a class of natural products known as flavanoids found in tea have good antioxidant property and these protect the human body against damage by the very reactive chemical species known as organic free radicals, which are implicated in diseases such as cancer, atherosclerosis and the debilitating neurological disease known as Parkinson's disease. It is also now known that tea flavanoids inhibit the oxidation of low density lipoprotein (the so called 'bad cholesterol') and prevent it from causing damage to the blood vessels.

In another series of experiments it has been demonstrated that some tea flavanoids have the ability to protect animals against tumours. A cancer research institute in Nagoya, Japan, has also reported that two flavanoids and their oxidation products in black tea have potent anti-HIV activity.

Black tea is the common tea drunk in many parts of the world, but recently green tea is also becoming popular among health conscious people. Green tea contains more of the antioxidant compounds, which become destroyed when tea leaves are processed to manufacture black tea. Green tea, the older form, is favoured mainly in Japan and China. Here the tea leaves undergo less processing; being heated and dried, they retain their green colour. Green tea is known to contain the flavanoid EGCG (epigallocatechin gallate).

Epigallocatechin gallate is one of the four major catechins in green tea. Catechins belong to the flavan-3-ol class of flavanoids. All catechins including EGCG are polyphenolic substances. Black tea leaves have a

much lower content of these catechins. Because tea leaves undergo extensive fermentation during the manufacture of black tea, the majority of the catechins are enzymatically oxidized to the major pigments of black tea—**theaflavin** and **thearubigen**.



Tea catechins make up approximately thirty percent of the dry weight of green tea leaves. Of the catechins, EGCG is the most abundant in green tea leaves. Green tea continues to be a popular beverage in the Orient, especially in China and Japan. In this region it is thought to have a number of health promoting benefits, and it is used in the management of various disorders. Clinical studies suggest that green tea may prevent cancer as well as the deposition of lipids and calcium in the **arterial lumen**. The catechins in green tea are responsible for the purported health benefits of tea.

It has also been shown that tea flavanoids inhibit blood platelets from clumping, preventing the dangerous clots that lead to almost all heart attacks and strokes.

Since tea also contains fluoride, it can strengthen tooth enamel and help prevent tooth decay. In laboratory studies, Japanese researchers found that tea also prevents dental plaque formation and kills some oral bacteria that can cause gum disease.

Ceylon tea is grown in the central highlands of Sri Lanka. Nestled in the salubrious hills is the world famous Tea Research Institute (TRI) situated at Talawakelle. The scientists there have been striving hard to improve the quality and yield of Ceylon Tea. They are also developing new products for the ready-to-drink tea market. A liquid tea concentrate has been perfected.

Sri Lanka's share of the world tea market is about 18-20% and Sri Lanka ships more than 300 million kg/year of tea.

An Introduction to Cavity Ring-Down Spectroscopy

Dr. Udaya K. Jayasundara

Ms216 Department of Chemistry, University of Nevada Reno, Reno Nevada, 89557 USA
(Senior Lecturer, College of Chemical Sciences, Institute of Chemistry Ceylon, Rajagiriya)

Introduction

In a conventional absorption spectrophotometer (e.g. Ultraviolet visible) the path lengths are in the order of centimeters hence the effectiveness of absorption or sensitivity is limited to concentration of parts per thousand or more. The Beer Lambert law which governs the relationship between the absorption and the path length is shown below:

$$A = \epsilon c l \quad (1)$$

Where, A is the absorption, ϵ is the molar absorption constant, l is the path length in centimeters, and c is the concentration of the sample solution in g/mL.

This law can also be written as shown below.

$$A = \ln \frac{I_0}{I} = S l N \quad (2)$$

where A is the absorbance, I_0 is the initial light intensity, I is the transmitted light intensity, S is the absorption cross section, l is the path length of light through the absorber, and N is the number density of absorber molecules (per unit volume).

The absorption cross section refers to the active area of absorption which is a very important factor in reaction dynamics. For example the absorption cross section of a regular ultra violet absorption experiment can be shown as follows,

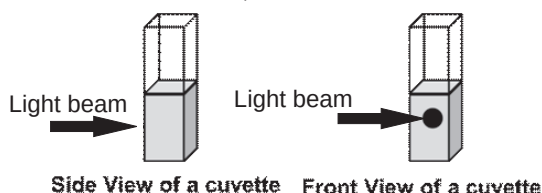


Figure 1. The active area of sample in a conventional single or double beam experiment.

There are several disadvantages of conventional UV-visible absorption spectrometer sample cells (cuvettes). According to the Figure 1, relatively a very small area of the sample (this depends on the diameter of the light beam) will be actively participating the absorption process. On the other hand, these cuvettes need considerable amount of the solution in order to get the absorbance of a solute. In other words this can be resembled to a weighing of airplane pilot's weight by subtracting the weight of airplane from weight of (pilot+ airplane).

Because of these issues, the S is small and hence

detectable absorbance can be attained by two methods either increasing the concentration of absorber molecules or by increasing the physical absorption path length using long pass absorption spectroscopy. Even though the concentration may be controlled with limitations, increase of effective path length may not be practical in most of the situations. To solve this problem the scientists have introduced a new absorption technique called Cavity Ring-Down Spectroscopy (CRDS), also known as cavity ring-down laser absorption spectroscopy (CRLAS), which takes into account the rate of absorption instead of the magnitude of the absorption which can easily measure absorptions on the order of parts per million.^{1,2,3} Because of this super sensitivity, molecules which have relatively small absorptions can be detected by this method.

CRDS is a laser absorption technique which takes advantage of the improved analytical sensitivity which is possible during absorption measurements with extremely long path lengths of light beams. The path length of a typical CRDS setup can easily lengthen up to a few kilometers (km) which can never be achieved by any commercially available absorption instrument. This can be achieved by using two highly reflectivity mirrors ($R > 99.9\%$) to literally "bounce" a pulsed laser back and forth through the absorbing species on the order of about 10,000 times. Here R indicates the reflectivity of mirrors. The light that transmits through the exit mirror (Mirror 2) on each pass is measured vs. time. This procedure is shown in Figure 2.

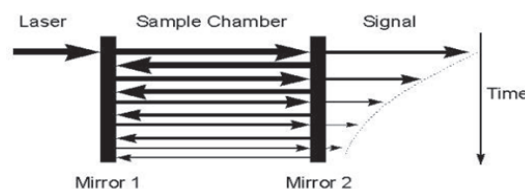


Figure 2. The transmittance of trapped light between mirrors.

The intensity of the transmitted light through Mirror 2 is proportional to the intensity of light in the cavity. Over time, the amount of light reaching the detector decays exponentially which is called "ringdown," named such because of the similarity to the sound decay of a ringing bell. The decay time will

be dependent upon the reflectivity (R value) of mirrors, the distance between mirrors, the speed of light, and the molecular absorption coefficient of any absorbing species in the cavity.

Calculation of Absorption in CRDS

There may be other ways to lose the intensity of the light inside the cavity. If an assumption is made such that the only way of losing the intensity of light just by leakage from Mirror 2, then the ringdown can be characterized by

$$I = I_0 \exp\left(-\frac{t}{t_0}\right) \text{ with } t_0 = \frac{t_r}{2(1-R)} = \frac{l_{\text{cavity}}}{c(1-R)} \quad (3)$$

where t_r is the roundtrip time for light in the cavity, R is the mirror reflectivity, l_{cavity} is the distance between the two mirrors (usually this is set to 1 m to make calculations simple), c is the speed of light, and t_0 is the 1/e decay time of the light (called the ringdown lifetime).

Above equation is valid only if there is no absorbing materials presence in the cavity. Someone can claim this is similar to the case of “blank or reference sample” in the conventional absorption spectroscopy. In the presence of an absorber, the ringdown time will become small and is denoted by t as shown in the following expression.

$$I = I_0 \exp\left(-\frac{t}{t_0}\right) \text{ with } \frac{1}{t} = \frac{1}{t_0} + (sl_{\text{abs}}N) \frac{c}{l_{\text{cavity}}} \quad (4)$$

where l_{cavity} is the path length of the absorber and t is the 1/e decay time for light in the presence of the absorber.

Since the absorption is the parameter of interest as in the equations (1) and (2), equations (3) and (4) can be combined to calculate the absorption as follows.

$$A = \frac{l_{\text{cavity}}}{c} \left(\frac{1}{t} - \frac{1}{t_0} \right) \quad (5)$$

This is the key equation used in CRDS and can be modified depending on the absorbing material. Further, the equation (5) is valid for comparison of a cavity in the presence of chemical absorbers (with ringdown time) to a cavity in a reference state without the chemical absorbers (with ringdown time t_0). The reference state does not necessarily be the empty cavity. For an example, in gas phase CRDS experiment, the reference state is chosen to be the cavity filled with reactant gases. By choosing this reference state, we effectively subtract out any background absorption from the absorbing material of interest.

The ringdown time is independent from the initial laser intensity which translates to improved sensitivities. The high sensitivities attainable with CRDS make it competitive with popular “absorption-like” methods such as laser-induced fluorescence (LIF), resonance enhanced multi photon ionization (REMPI), and photoacoustic spectroscopy (PAS). These three methods are all sensitive laser-based methods, which indirectly measure absorption features of the analyte. The primary advantage that CRDS has over these methods is that the absorption of photons by the analyte is detected directly which increase the applicability as a quantitative absorption technique. In general, CRDS is most applicable in making highly sensitive and quantitative measurements of trace molecular gas phase species, performing time resolved kinetic studies on short lived or low concentration molecular species, and investigating weak molecular transitions from the UV to mid-IR spectral range.

Experiment Setup

The author has developed a CRDS setup at the Department of Chemistry at the University of Nevada Reno, Reno USA in 2008 which can be operated by using visible light. The experimental setup is shown in the Figure 3 which is the same Figure published in Chemistry in Sri Lanka volume 31(02) in May 2014.⁴

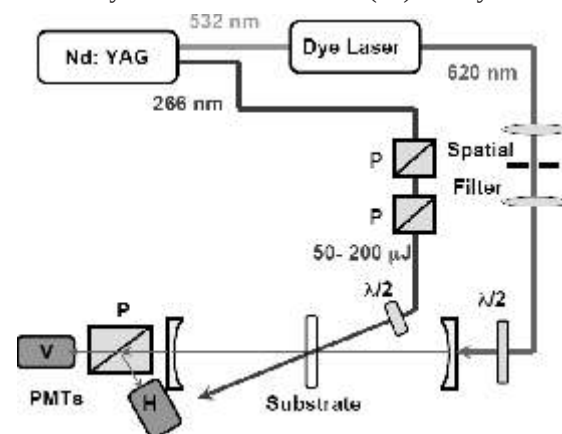


Figure 3. CRDS setup designed to study photochromic dyes using the visible light as the probe beam and the visible light as the pump beam. P: polarizer, PMT: photomultiplier tube, V: PMT for vertically polarized light, H: PMT for horizontally polarized light, $\lambda/2$: half wave plate to generate linear polarized light

The laser light was generated by Neodymium Yttrium Aluminum Garnet (Nd:YAG) laser which is a pulsed laser with a frequency of 10 Hz. Nd:YAG laser primarily generates 1064 nm, 532 nm (second

harmonics), and 266 nm (fourth harmonics). Since the setup was designed to cope with visible light and the goal was to obtain 620 nm light for the cavity, a separate dye laser has also placed behind the YAG laser which uses 532 nm as the input beam which was filtered with UV filters to make sure it is free from 266 nm. The 532 nm wavelength light beam was passed through a solution of 4-(Dicyanomethylene)-2-methyl-6-(4-dimethylaminostyryl)-4H-pyran (DCM) laser dye solution which can be adjusted to generate 620 nm. This color was selectively chosen such that the molecules interested in studying have a significantly higher absorption between 600 nm and 640 nm.⁵

The laser light consists of several transverse electrical modes (TEM).⁶ Figure 4 depicts some of the TEMs generated during this type of laser experiment.

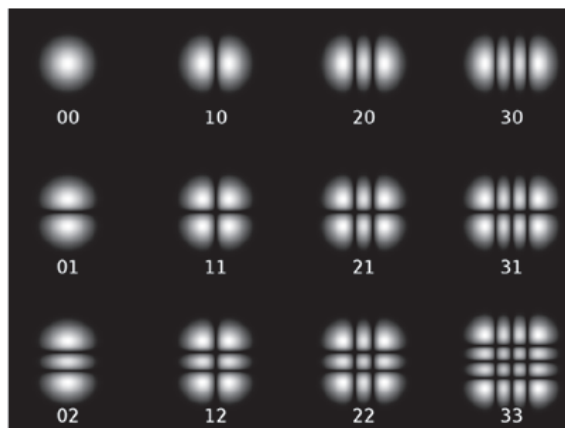


Figure 4. Different laser cavity modes

It is extremely important to filter the light beam before it is used for any experiment because of this mixing of TEM. For the experiments designed by the author required to separate the modes with TEM₀₀ only in the probe beam because that mode will directly affect the final result. This was done by placing a spatial filter as shown in Figure 3 and a closer view is shown in Figure 5. The spatial filter consists of two concave mirrors of focal length of 10 cm and are placed 20 cm apart in a cage where the pinhole is located at the focal point.

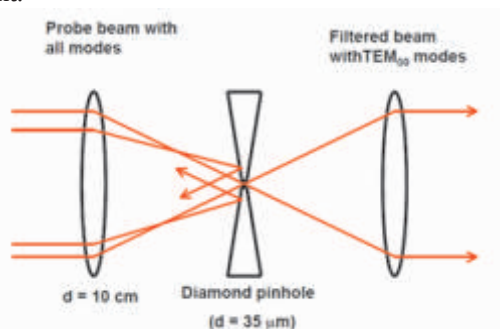


Figure 5. The spatial filter with a diamond pinhole with a diameter of 35 μm .

According to Figure 5, it clearly shows that only a fraction of light goes through the pinhole and that consists of TEM₀₀ mode. The lenses and the pinhole must be required to finely adjust in order to obtain a highly intense beam and greater laser alignment is required at this stage. The transmitted light through the second lens will be used as the input beam for the CRDS. Even though the original laser light has a definite polarization it is a good practice to place a wave plate (specially designed lens) to make sure the output consists of one polarization. For this experiment a half wave plate ($\lambda/2$) was placed and adjusted to obtain both horizontally polarized light (HPL) and vertically polarized light (VPL). This light was used as the probe beam for the experiment.

Initially, the cavity was aligned by placing the Mirror 2 and then realigned by placing the Mirror 1. The signals obtained from photomultiplier tubes (PMTs) are due to the empty cavity. Once the cavity functions well, the spin coated substrate with Poly(methyl methacrylate) (PMMA) was placed in the cavity (usually the center) with the help of a rotational stage (See Figure 6) such that its orientation can be adjusted.

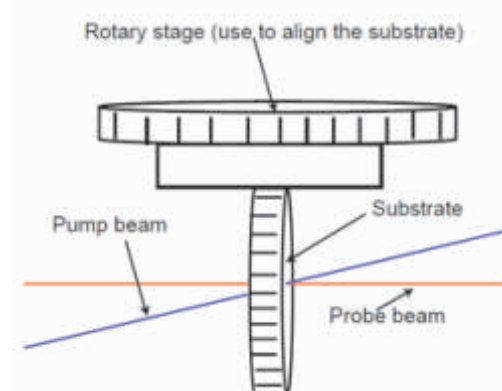


Figure 6. The rotational stage used to align the substrate in CRDS.

Then the cavity was re-aligned and this cavity was used as the blank for the rest of the experiments. The ringdown time (t_r) can be now calculated. The sample is prepared in PMMA solution and it was spin coated to a glass substrate. This was placed in the cavity. These experiments were performed as pump-probe experiments (these will be discussed in detail in future publication). Therefore, the orientation of the pump beam is also important. The half wave plate aligned as in Figure 3 which functions to give the correct orientation of the beam. For these experiments the pump beam was kept either vertical (V) or horizontal (H) as shown in Figure 7.

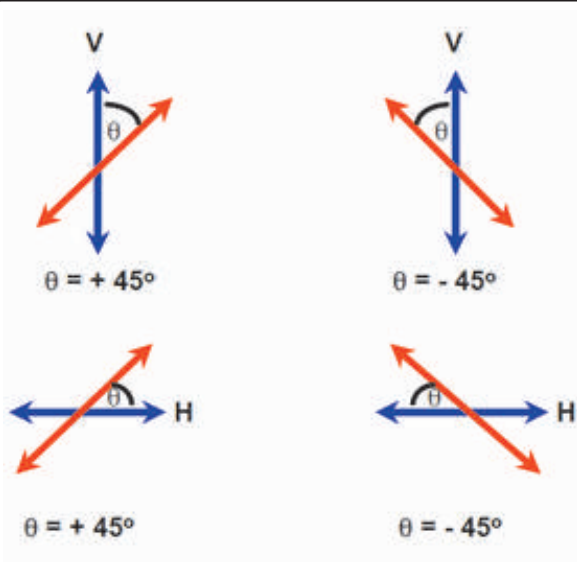


Figure 7. The possible orientations of pump and probe beams. Pump beam is in red and the probe beam in blue color. The angle between those beams was set to 45° .

Result and Discussion

Figure 8 shows the UV-visible absorption spectra of the open and closed forms of photochromic dye molecules of interest along with possible structures. These are special type of molecules which have two different forms which can interchange in the presence of UV light and in visible light. For this article, behavior of one such example in CRDS will be discussed in detail here.

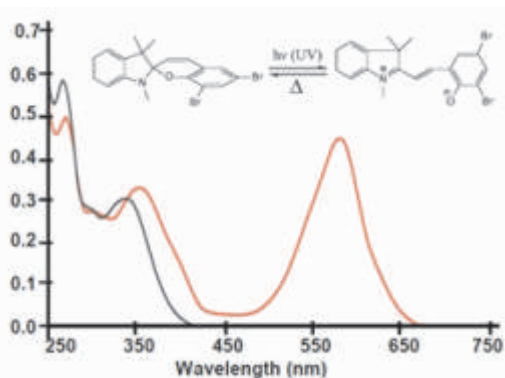


Figure 8. The UV-visible absorption spectra for Photochromic dye molecule (open and closed configurations). The peak around 620 nm is due to the open form. Red: open form of the molecule, Black: closed form of the molecule.

The ringdown time variation of the cavity in the presence of above molecules can be shown as follows.

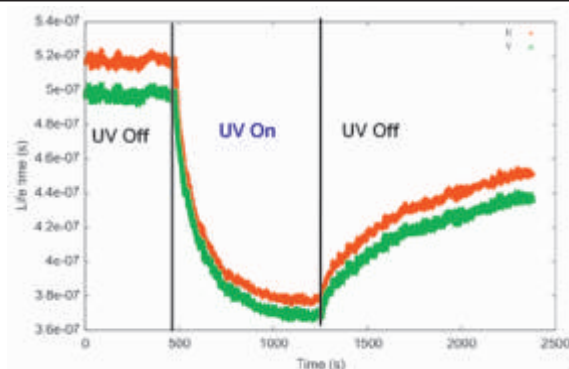


Figure 9. The variation of ringdown time. The green curve is due to the signal from vertically polarized light and the red curve is due to the signal from horizontally polarized light.⁵

Figure 9 indicates the life time during the first 500 seconds of the experiment (i.e. when there is no probe beam available) is 520 ns and 500 ns for horizontal and vertical probe beams, respectively. The lifetime of the empty cavity is in the microsecond scale. The first 500 second region can be taken as the back ground signal. These data can be used to obtain the absorption spectrum of the above molecule using the equation (5) and is shown as follows.

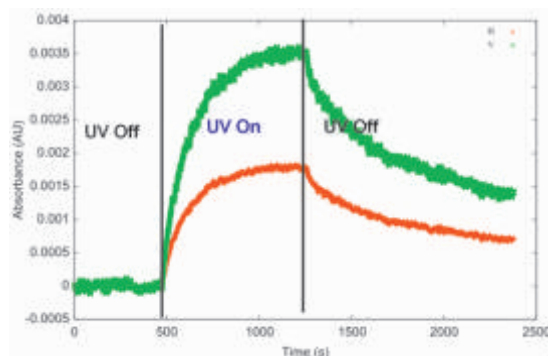


Figure 10. The variation of absorption. The green curve is due to the signal from vertically polarized light and the red curve is due to the signal from horizontally polarized light.⁵

According to Figure 10, once the pump beam was turned on (UV on) the absorption increases. That was because, the originally closed form of the molecules were opened due to the active pump beam. Thereby the closed form molecules were converted to the open form which absorbs light from probe beam (visible region) and hence caused the ringdown time loss as shown in Figure 9 and increase of absorbance as in Figure 10. After some time, the ratio of number of open molecules to number of closed molecules did not change and hence the absorption remained unchanged

due to the equilibrium showed in Figure 10. Once the UV light was turned off the equilibrium was disturbed and reverse process became possible and hence absorption decreased. This can be done repetitively and it has been found out the initial ringdown time (absorption at 500 seconds) cannot be achieved. This may be due to decomposition reactions which were not studied.

Applications

Here one of the applications of CRDS discussed and there is large number of applications of CRDS found in different fields and those will be discussed in a future article.

Conclusion:

The goal of this article is to give an introduction to

the CRDS. One of its applications in terms of a pump-probe experiment has been discussed using an example.

References:

1. O'Keefe, A; Deacon D. A. G. *Rev. Sci. Ins.* **1988**, *9*, 2544.
2. Romanini, D., Kachanov A. A. *Chem. Phys. Let.* **1997**, *264*, 316-322.
3. Wheeler, M. D., Newman, S. M. *J. Chem. Soc., Faraday Trans.* **1998**, *94*(3), 337-351.
4. Jayasundara, U.K, *Chemistry in Sri Lanka*, **2014**, *31*(02), 19-22.
5. Jayasundara, U.K, *University of Nevada Reno, Unpublished Results* (2008- 2011).
6. Okamoto, K. *Fundamentals of Optical Waveguides*, Elsevier Academic Press, 2006, pp.71-79.

~~~~\*~~~~

## Protease Assays for Cancer Diagnostics

Dr. Dinusha Udukala

*Department of Chemistry, Kansas State University, USA*

*(Full Time Academic, College of Chemical Sciences, Institute of Chemistry Ceylon, Rajagiriya)*

### Introduction

Diseases in which abnormal cells divide without control and are able to invade other tissues are known as cancer.<sup>1</sup> Blood and lymph systems are the chief vectors in spreading cancer. The causes for cancer can be divided into two major divisions: external factors and internal factors. Tobacco, infectious organisms, chemicals, and radiation are so-called external factors. Inherited mutations, hormones, immune conditions, and spontaneous mutations that occur from metabolism are so-called internal factors.<sup>2</sup> Cancer is a major cause of death in the world, especially in USA, where it is the second major cause of death.

There is a variety of treatment methods available in order to treat cancer. Most common methods are surgery, radiation, chemotherapy, hormone therapy and biological therapy. Before any treatment of cancer can be attempted, a correct diagnosis has to be performed. Therefore, developing robust methods for diagnosing cancer in the earliest disease stages is the key to overcoming this often fatal disease. The early cancer detection methods are so important, because the cancer survival rates can be significantly increased if it is detected at an early stage. Screening and detection methods differ from one type of cancer to the other, because there are significant biochemical differences between the types of cancer (e.g. brain, breast, lung,

pancreas, prostate etc.). Most of these differences arise, because different types of cancer develop from different types of cells.

### What are the currently used cancer detection methods?

To detect breast cancer Mammography, Ultrasound Detection, Magnetic Resonance imaging and Molecular Breast Imaging techniques are well known.<sup>2</sup> Tests of Sputum, Chest X-rays and Spiral CT Scans are the most commonly used techniques to detect lung cancer.<sup>2</sup> Most of these methods are expensive. Recently Bossmann group has developed a blood test, known as protease assay to detect cancer.<sup>3</sup> It is a simple technique. If that technique can be developed from laboratory scale to industrial scale, it would be very beneficial for people as they can get a breast cancer test done with a low cost. Also anticancer drugs which are enzyme activatable can be developed using that technology.

### What is a Protease Assay?

Proteases are a class of enzymes that catalyze the cleavage of a specific peptide bond in other proteins. They are also called proteolytic enzymes or proteinases.<sup>4</sup> There are six different catalytic classes of proteases named as aspartic, metallo-, cysteine,

serine, threonine and glutamic. This classification is based on the group performing the nucleophilic attack at the carbonyl group. The nucleophile differs from one group to the other. Cancer-related proteases have the potential to become reliable biomarkers for the detection of solid tumors in early stages.<sup>5,6,7</sup> Quite a few proteases are known to be necessary for cancer development and progression including Matrix Metallo-proteinases (MMPs), urokinase plasminogen activator (uPA) and Cathepsins (CTSs). They are critical cofactors during cancer progression. These proteases don't function individually. They do act in a cascade-like manner. Also these proteases are very stable in tissue and blood serum. Therefore, they are suitable biomarkers.

Main purpose of a protease assays is to determine the activity of proteases. Different kind of protease assays are used in different applications. Depending on the type of the interesting protease and the type of detection technique, there are several protease assays which have been developed. The protease assay which Bossmann group has developed is based on the analytical technique, fluorescence. As a result these specific protease assays are known as light switches.

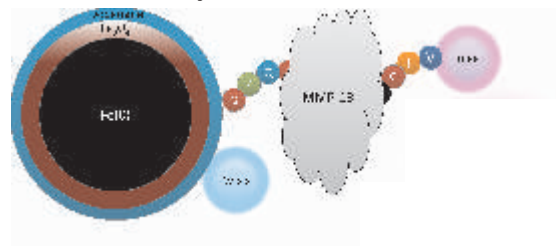
### Motivation for the Development of a “Light Switch”

Most of the studies in cancer diagnostics have been performed using enzyme linked immunosorbent assays (ELISA).<sup>8</sup> It is impossible to determine the activity of the proteases when the concentration of them is measured using ELISA. The reason behind that is, these proteases occur as inactive precursors (zymogens), active enzymes or enzyme inhibitor complexes. They are activated through an activation network. Unfortunately, cancer does not show significant symptoms in early stages. Consequently, the detection of cancer at stages where treatment is feasible with established technologies is very challenging. If we can identify cancer by performing a blood test of a person, that would be a significantly early cancer detection method. This should be done during the annual checkup of a person.

This research is based on the paradigm that monitoring the protease signature of the patient provides the basic concept for early cancer detection and detecting cancer recurrence. This is, principally, the motivation behind developing nanoplatfroms for cancer detection based on the “nanoparticle based light switch” technology. They have used fluorescence detection for the quantitative monitoring of active proteases (not zymogens!) using highly protease-

selective nanoplatfroms. Fluorescence detection methods have the advantage of being more sensitive than ELISA measurements, electrochemical methods and UV/Vis absorption methods.<sup>9</sup> They have tested 12 proteases using this nanoparticle - based system (Light switch).

### Consensus-Sequence Based Fluorescence Detection of Protease Activity

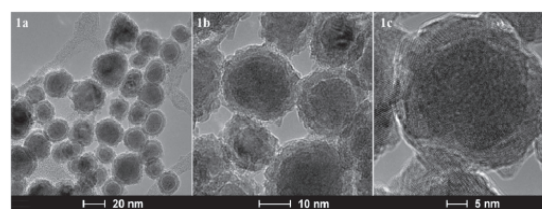


**Figure 1.** Nanoplatfrom for protease detection (Eg: MMP13)

Figure 1 shows the nanoplatfrom for protease detection. It consists of four main components. They are iron core/ iron oxide shell nanoparticle, specific peptide sequence, fluorophore and fluorescence quencher. One Fe/Fe<sub>3</sub>O<sub>4</sub>-nanoparticle is linked in average to 35 $\pm$ 3 TCPP-molecules via consensus sequence (one type of sequence per nanoplatfrom) and 50 $\pm$ 4 cyanine 5.5 molecules via amide linkages. These four components will be discussed briefly with the next sections.

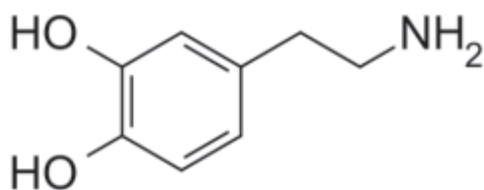
#### 1. Iron core / iron oxide shell nanoparticle

First is the dopamine coated iron core / iron oxide shell nanoparticle. They can be synthesized with very low polydispersity.<sup>10,11</sup> Figure 2 shows the transmission electron microscopy (TEM) images (1a, 1b) and high-resolution transmission electron microscopy (HRTEM) image (1c) of the obtained nanoparticles. These nanoparticles have a well-defined core/shell structure, with the average Fe(0) core diameter of 13 $\pm$ 0.5 nm and the Fe<sub>3</sub>O<sub>4</sub> shell thickness of 2.0 $\pm$ 0.5 nm, respectively. The HRTEM image reveals polycrystalline nature of the nanoparticles. Dopamine (shown in Figure 3) forms robust organic coatings with binding constants of the order of 10<sup>15</sup> L mol<sup>-1</sup>. It also increases the water solubility of the resulting nanoplatfroms to > 5 gL<sup>-1</sup>.<sup>12</sup>



**Figure 2.** TEM (1a, 1b) and HRTEM (1c) Images of Fe/Fe<sub>3</sub>O<sub>4</sub>- Core/Shell Nanoparticles that are Forming the

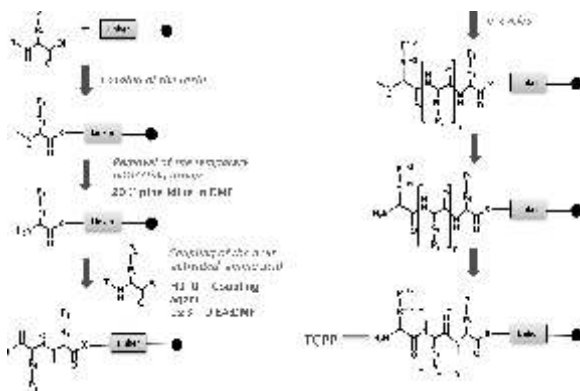
## Inorganic Core of the Nanoplatforms for Protease Detection



**Figure 3.** Chemical structure of dopamine

## 2. Specific peptide sequences

Second is the specific peptide sequence for the protease which is linked to the dopamine of the nanoparticle through amide linkages. As shown in the example in Figure 1 the peptide sequence for MMP 13 is GPQGLA-GQRGIV. Similarly depending on the protease that needs to be detected different peptide sequences should be used. Peptide sequences can be synthesized using solid phase peptide synthesis method as shown in Scheme 1.<sup>13</sup>



P: permanent side chain protecting group

T: temporary protecting group    ■: solid support

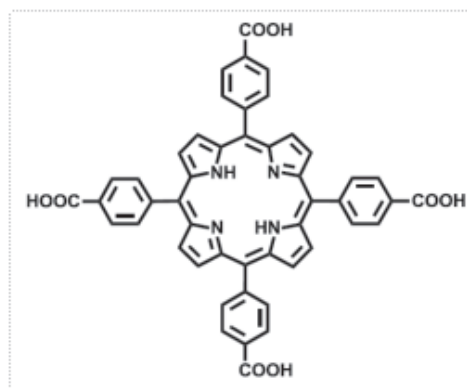
A: activating group    X: NH or O

**Scheme 1.** Principles of Solid Phase Peptide Synthesis

## 3. Fluorophore

Third is the fluorophore. Tetrakis(4-carboxyphenyl)porphyrin (TCPP) (shown in Figure 4) is the structure which is acting as the fluorophore in this system. Porphyrins are naturally occurring organic compounds. The most important porphyrin is heme, which is the pigment in red blood cells. They are aromatic molecules. Porphyrins have a planar macrocyclic structure of four pyrrole rings connected by methine bridges.<sup>14</sup> There are several applications of porphyrins. Main application with this research work is the capability of working as a fluorophore. Other than that catalysis, photosynthesis, photodynamic therapy<sup>15</sup> and sensors<sup>16</sup> are the other applications of porphyrins. Porphyrins have a strong absorption in the

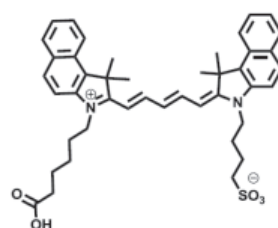
400-450 nm region (Soret band) and absorptions in the 500-700 nm region (Q-bands).<sup>17</sup> Among the porphyrins they have chosen the TCPP. Peptide sequences can be synthesized using solid phase peptide synthesis method. Then taking advantage of solid phase peptide synthesis method, TCPP can be conjugated to the N-terminal of peptide sequence using standard coupling conditions as shown in Scheme 1. TCPP is tethered via consensus sequence to dopamine, which is bound to the  $\text{Fe}_3\text{O}_4$  layer at the  $\text{Fe}/\text{Fe}_3\text{O}_4$  surface.<sup>18</sup>



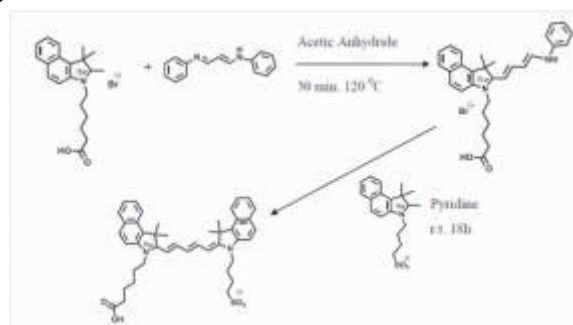
**Figure 4.** Chemical structure of Tetrakis(4-carboxyphenyl)porphyrin (TCPP)

## 4. Fluorescence Quencher

Forth is the fluorescence quencher. Cyanine 5.5 (shown in Figure 5) is acting as the fluorescence quencher in this system. Cyanine dyes are highly conjugated, fluorescent molecules. They have the absorption and emission wavelengths in the near red and infra-red region (600–900 nm). They are known as near Infra red (NIR) fluorescent dyes. Cyanine dyes have been used in many fields of science, for instance as photosensitizers, phototherapeutic agents and studies of nucleic acids. Some other important features of cyanine dyes are large molar extinction coefficients, and moderate fluorescence quantum yields.<sup>19,20</sup> Cyanine 5.5 possesses overlapping absorption/fluorescence spectra with the fluorescence spectrum of TCPP, and it is permanently attached via dopamine-anchors to the nanoparticle's surface without using an enzyme-cleavable tether. Consequently, Cy 5.5 remains permanently bonded to the nanoparticle during the protease detection process. By following the reactions shown in Scheme 2 cyanine 5.5 can be synthesized.



**Figure 5.**  
Chemical  
Structure of  
Cyanine 5.5

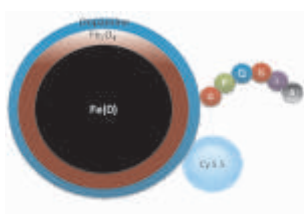


**Scheme 2.** Synthesis of Cyanine 5.5

### Logic of the Light Switch

The logic behind this light switch technology is that it can be switched “on” in the presence and activity of the enzyme. This process is as follows: A specific consensus sequence can be cleaved by its specific enzyme, which will lead to fluorescence of the attached fluorophore. Before we introduce the specific protease that is able to cleave the consensus sequence to the system, the fluorescence of the fluorophore is quenched as shown with Figure 1. This is the OFF situation of the light switch. Quenching of TCPP-fluorescence occurs via two pathways. The first is plasmonic quenching by the nanoparticle.<sup>21,22</sup> The second is singlet to singlet energy transfer from TCPP to cyanine 5.5 also known as fluorescence resonance energy transfer (FRET).<sup>21</sup> Both pathways are necessary to ensure significant quenching of TCPP as long as it is tethered to the Fe/Fe<sub>3</sub>O<sub>4</sub>-nanoparticle.

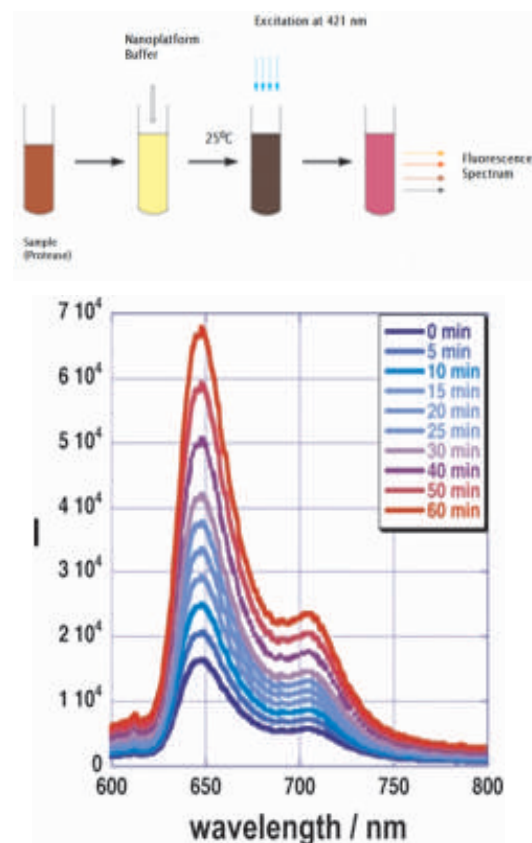
After the introduction of the protease, it will cleave the consensus sequence and then the fluorophore is free to move away from the nanoplatfrom. Consequently, both quenching mechanisms become inefficient with increasing distance as shown in Figure 7. Then TCPP can fluoresce well. That is the ON situation of the light switch. This explains the process of the light switch.



**Figure 7.** Nanoplatfrom for protease detection after the action of the protease (Eg: MMP 13)

Many state-of-the-art analytical methods, such as immunoassays<sup>23</sup> or electrochemical detection methods<sup>24,25</sup> can quantify the protease concentrations occurring in cancer tissue, but they are not (yet)

sensitive enough to measure protease activities that are observed during early stages of cancer development. These tests have to be performed in blood (serum) to have any value in early diagnostics as shown in Figure 8. This requirement leads to significant dilution effects. The development of nanoplatfroms for the diagnostics of solid tumors, such as breast cancer or lung cancer, in early stages, is based on the paradigm that the concentration of each proteolytically active cancer-related protease is typically below  $10^{-13}$  mol L<sup>-1</sup> in the blood serum of healthy human subjects.<sup>9</sup> It is anticipated that one or several proteases are overexpressed in early cancers and that, therefore, their concentrations in blood serum increase to  $10^{-12}$  mol L<sup>-1</sup> to  $10^{-10}$  mol L<sup>-1</sup>. The concentration of selected proteases will then further increase in late stage cancer patients.<sup>9</sup> It is noteworthy that virtually all proteases are biosynthesized as zymogens (inactive precursor enzymes), which require enzymatic activation. Zymogens are usually not indicative of tumor progression.<sup>26</sup> Therefore, it is of great importance to measure the activity, and not the concentration, of cancer-related proteases.<sup>9</sup> In stark contrast, immunoassays rely on the presence of epitopes, which are present in active and inactive proteases alike.<sup>23</sup>



**Figure 8.** Procedure of the Protease Assay

## Conclusion

Nanoplatfoms for ultrasensitive detection of cancer-associated proteases have been successfully developed. They consist of dopamine-coated Fe/Fe<sub>3</sub>O<sub>4</sub> core/shell nanoparticles to which the fluorescent dye TCPP and the FRET-acceptor cyanine 5.5 are co-attached. The consensus sequences between TCPP and the central nanoparticle are hydrolytically cleaved by their respective proteases, which are highly selective. Due to the very small experimental error, the detection of protease concentrations down to  $1 \times 10^{-16} \text{ mol l}^{-1}$  is achieved for MMP1, MMP2, MMP3, MMP7, MMP9, MMP11, MMP13, uPA, CTS B, CTS D, CTS L, and CTS K after 1 h of incubation. (Results are not discussed here) These nanoplatfoms are sensitive enough for future use in routine clinical diagnostics for the early detection of solid tumours and enable the recording of “protease signatures”, which may be patient- or tumour-specific.

## References

1. <http://www.cancer.gov/cancertopics/>
2. American Cancer Society. Cancer Facts & Figures 2013. Atlanta: American Cancer Society; **2013**.
3. Wang, H.; Udukala, D. N.; Samarakoon, T. N.; Basel, M. T.; Kalita, M.; Abayaweera, G.; Manawadu, H.; Malalasekera, A.; Robinson, C.; Villanueva, D.; Maynez, P.; Bossmann, L.; Riedy, E.; Barriga, J.; Wang, N.; Li, P.; Higgins, D. A.; Zhu, G.; Troyer, D. L.; Bossmann, S. H. Nanoplatfoms for highly sensitive fluorescence detection of cancer-related proteases. *Photochem. Photobiol. Sci.* **2014**.
4. Duffy, M. J. Proteases as Prognostic Markers in Cancer, *Clin. Cancer Res.* **1996**, *2*, 613-618.
5. Mandhare, M. N.; Patil, P. H.; Jagdale, D. M.; Kadam, V. J. Targeting matrix metalloproteinases: an important strategy in cancer therapeutics, *Int. J. Pharm. Sci. Rev. Res.* **2012**, *12*, 27-39.
6. Rabbani, S. A.; Xing, R. H. Role of urokinase (uPA) and its receptor (uPAR) in invasion and metastasis of hormone-dependent malignancies, *Int. J. Oncol.* **1998**, *12*, 911-920.
7. Vasiljeva, O.; Turk, B. Dual contrasting roles of cysteine cathepsins in cancer progression: Apoptosis versus tumor invasion, *Biochimie*, **2008**, *90*, 380-386.
8. Schmitt, M.; Sturmheit, A. S.; Welk, A.; Schnellendorfer, C.; Harbeck, N. Procedures for the quantitative protein determination of urokinase and its inhibitor, PAI-1, in human breast cancer tissue extracts by ELISA, *Methods in Molecular Medicine*, Brooks, S. A.; Harris, A. L.; Humana Press Inc., Totowa, New Jersey, **2006**, pp 245-265.
9. Bossmann, S. H.; Troyer, D. L. Point-of-care routine rapid screening: the future of cancer diagnosis, *Expert Rev. Mol. Diagn.* **2013**, *13*, 107-109.
10. Lacroix, L.-M.; Huls, N. F.; Ho, D.; Sun, X.; Cheng, K.; Sun, S. Stable Single-Crystalline Body Centered Cubic Fe Nanoparticles, *Nano Lett.* **2011**, *11*, 1641-1645.
11. Wang, H.; Shrestha, T. B.; Basel, M. T.; Dani, R. K.; Seo, G. -M.; Balivada, S.; Pyle, M. M.; Prock, H.; Koper, O. B.; Thapa, P. S.; Moore, D.; Li, P.; Chikan, V.; Troyer, D. L.; Bossmann, S. H. Magnetic-Fe/Fe<sub>3</sub>O<sub>4</sub>-nanoparticle-bound SN38 as carboxylesterase-cleavable prodrug for the delivery to tumors within monocytes/macrophages, *Beilstein J. Nanotechnol.* **2012**, *3*, 444-455.
12. Xu, C.; Xu, K.; Gu, H.; Zheng, R.; Liu, H.; Zhang, X.; Guo, Z.; Xu, B. Dopamine as a robust anchor to immobilize functional molecules on the iron oxide shell of magnetic nanoparticles, *J. Am. Chem. Soc.* **2004**, *126*, 9938-9939.
13. Amblard, M.; Fehrentz, J. -A.; Martinez, J.; Subra, G. Methods and protocols of modern solid phase peptide synthesis, *Molecular Biotechnology*, **2006**, *33*, 239-254.
14. Jeong, E.-Y.; Burri, A.; Lee, S. -Y.; Park, S. Synthesis and catalytic behavior of tetrakis(4-carboxyphenyl) porphyrin-periodic mesoporous organosilica. *J. Mater. Chem.* **2010**, *20*, 10869-10875.
15. Scalise, I.; Durantini, E. N. Photodynamic effect of metallo 5-(4-carboxyphenyl)-10,15,20-tris(4-methylphenyl) porphyrins in biomimetic AOT reverse micelles containing urease, *Journal of Photochemistry and Photobiology A:Chemistry*, **2004**, *162*, 105-113.
16. Johnson-White, B.; Zeinali, M.; Shaffer, K. M.; Patterson Jr. C. H.; Charles, P. T.; Markowitz, M. A. Detection of organics using porphyrin embedded nanoporous organosilicas. *Biosensors and Bioelectronics*, **2007**, *22*, 1154-1162.
17. Cherian, S.; Wamser, C. C. Adsorption and Photoactivity of Tetra(4-carboxyphenyl)porphyrin (TCPP) on Nanoparticulate TiO<sub>2</sub>, *J. Phys. Chem. B*, **2000**,

- 104, 3624-3629.
18. Sobczynski, J.; Toennesen, H. H.; Kristensen, S. Influence of aqueous media properties on aggregation and solubility of four structurally related meso-porphyrin photosensitizers evaluated by spectrophotometric measurements, *Pharmazie*. **2013**, 68, 100-109.
  19. Fayed, T. A.; Extension of fluorescence response to the near -IR region, *Reviews in Fluorescence*, Geddes, C. D.; Lakowicz, J. R.; Springer: New York, **2011**, pp 75-111.
  20. Nolting, D. D.; Gore, J. C.; Pham, W., Near-Infrared Dyes: Probe Development and Applications in Optical Molecular Imaging, *Curr. Org. Synth.* **2011**, 8, 521-534.
  21. Kalita, M.; Basel, M. T.; Janik, K.; Bossmann, S. H. Optical and Electronic Properties of Metals and Semiconductors in Nanoscale Materials in Chemistry, *Nanoscale Materials in Chemistry*, Klabunde, K. J. Wiley & Sons: New York, USA, **2009**; pp 539-578.
  22. Tam, F.; Goodrich, G. P.; Johnson, B. R.; Halas, N. J. Plasmonic Enhancement of Molecular Fluorescence, *Nano Lett.* **2007**, 7, 496-501.
  23. Szarvas, T.; Dorp, F. V.; Ergun, S.; Rubben, H. Matrix metalloproteinases and their clinical relevance in urinary bladder cancer, *Nat. Rev. Urol.* **2011**, 8, 241-254.
  24. Song, E.; Cheng, D.; Song, Y.; Jiang, M.; Yu J.; Wang, Y. A graphene oxide-based FRET sensor for rapid and sensitive detection of matrix metalloproteinase 2 in human serum sample, *Biosens. Bioelectron.* **2013**, 47, 445-450.
  25. Swisher, L. Z.; Syed, L. U.; Prior, A. M.; Madiyar, F. R.; Carlson, K. R.; Nguyen, T. A.; Hua, D. H.; Li, J. Electrochemical Protease Biosensor Based on Enhanced AC Voltammetry Using Carbon Nanofiber Nanoelectrode Arrays, *J. Phys. Chem. C*, **2013**, 117, 4268-4277.
  26. Swedberg, J. E.; Harris, J. M. Natural and Engineered Plasmin Inhibitors: Applications and Design Strategies, *ChemBioChem*. 2012, 13, 336-348.

~~~\*~~~

Green Diesel production from natural fatty acids by decarboxylation; An Overview

Pabasara Gamage

Research Assistant, College of Chemical Sciences, Institute of Chemistry Ceylon, Rajagiriya

Background

Energy is a key factor which contributes to our day to day activities. According to US Energy Information Administration (EIA), industrial sector accounts for the largest share of the world's energy consumption and it continues to be so in 2040 as well.^[1] EIA further states that renewable energy and nuclear power are the world's fastest growing energy sources, increasing by 2.5 per cent every year. The main energy sources utilized currently in the world are liquid fossil fuels, coal, nuclear energy and renewable energy sources.

Fossil fuel

Fossil energy sources mainly include oil, coal and natural gas^[2] and are non renewable forms which were produced when prehistoric plants and animals died and gradually buried by layers of rocks. The type of fossil fuel depends on the combination of organic matter, time it was buried, temperature and pressure conditions. The *International Energy Outlook 2013*

projects that fossil fuels continue to supply almost 80 per cent of world energy usage through 2040.^[1] However, fossil fuel production rate is believed to decline by 10 per cent by 2030.^[3] Fossil fuel further causes many harmful health and environmental effects as well. Therefore, researches are concerned about producing an alternative to fossil fuels.

Nuclear Energy

Energy is produced either by nuclear fission or fusion, which is in turn converted to heat energy that can be used to drive a turbine and generate electricity.^[4] Although there are several advantages of nuclear energy such as no CO₂ emission and efficient power generation, there are distinct disadvantages that have made usage of nuclear energy debatable. The process of nuclear fission generates harmful radioactive materials which may remain in the environment for thousands or even millions of years. Accidents that occur in nuclear power plants are catastrophic. The most deadly accident happened in the

Chernobyl power plant in Ukraine, 1986. The most recent explosion was at Fukushima Daiichi reactors in 2011 which occurred following a major earthquake and tsunami.

Due to the above mentioned drawbacks of several main energy sources, scientists are concerned about creating a renewable fuel which is environmentally and economically friendly. Energy security is one of the main concerns here, with the growing demand and depleting fossil fuel reserves.

Renewable Energy sources

Renewable energy sources are considered as the most popular solution for the energy crisis the world is facing. Solar, wind, bioenergy, geothermal and ocean generation can be included in this category.^[5] Renewable energy sources are non depletable or naturally replenishable. Most of energy sources in this category are more environmentally friendly than fossil fuels or nuclear energy and less hazardous as well. The main concern in this article is about bioenergy or biofuels.

Biofuels

Biofuels can be classified according to arbitrary principles based on multiple aspects.^[6]

- Based on the feedstock

First generation – The sources of the first generation biofuels are edible sources.^[7] Types of the first generation biofuels are bioalcohol, biogas and biodiesel. These have CO₂ benefits and can impact on domestic energy security. However, usage of food crops and the impact on biodiversity are the major drawbacks of the first generation biofuels. Biodiesel can be produced from non edible crops such as Jatropha or Rubber seeds so that it doesn't interfere with food crops. Almost 50 litres of the first generation biofuels are produced annually.^[7]

Second generation – Fuels in this category are largely produced from lignocellulosic biomass, such as grasses, wood^[8] and other non-food materials available in plants. However, it will be a long time before the second generation biofuels can replace the first generation biofuels fully, as there are some technological and economical barriers to overcome.^[9] Once developed, the second generation biofuels can be compared with existing fossil petroleum and diesel fuels, and can be a low carbon fuel with better engine performance.^[10]

Third generation – This is mainly biofuels produced from algae and can be linked to a certain extent to utilization of CO₂ as a feedstock. Requirement of large volumes of water in the production process is one of the main challenges researchers are facing with the third generation biofuels.

- Based on product quality (independent from feedstock)

First generation - These are conventional biofuels with more or less applicational disadvantages.^[7] Bioalcohol and Biodiesel can be included in this category.

Bioalcohol - Bioalcohol can be blended with other fossil fuels to reduce green house gas emission. However, the production process requires high amount of energy and large amount of land to produce biomass. Bioethanol fuel with more than 10 per cent ethanol content is not compatible with existing engine components and may cause engine corrosion.^[11]

Biodiesel - Biodiesel has a kinematic viscosity closer to that of petrodiesel.^[12] It is produced by a process called transesterification, where triglycerides in plant oils are converted to fatty acid methyl esters (Figure 1).^[13] A triglyceride molecule consists of three fatty acids which can be of the same kind or different kinds. Triglycerides are the main component of plant oils.

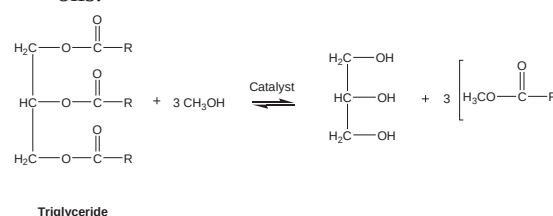


Figure 1. Transesterification process of triglycerides

Biodiesel has a high flash point, hence safe in storage and transportation. It has a low sulphur content and diminishes greenhouse gas emission.^[14] Cetane number is comparable with that of petrodiesel. Distinct disadvantages of Biodiesel production are high cost, slight oxidative properties and mainly cold flow properties.^[15] Due to the oxygen content in fatty acid methyl esters, biodiesel tends to solidify in cold weather leading to the clogging of engine components.

Since the oxygen content in biodiesel is the major drawback, if an oxygen free fuel can be derived from natural fatty sources, it would be greatly

advantageous for the world.

Therefore scientists have come up with a new fuel type, which can overcome many of the drawbacks of conventional fuel as well as newly developed fuels.

Green Diesel

Green diesel is a mixture of hydrocarbons which has carbon chain lengths that are similar to petrodiesel carbon chain lengths. This can be produced either by hydroprocessing and / or decarboxylation/decarbonylation of triglycerides from various agricultural feedstocks.^[16]

The key intention of this article is to discuss the production methods, applications, advantages and disadvantages of Green diesel.

Green diesel production methods

- Hydroprocessing/Hydrodeoxygenation

In this process, triglycerides and free fatty acids present in plant oils, react with hydrogen to eliminate oxygen and produce n-paraffins and water (Figure 2). For this process moderate temperature between 300-600 °C and high hydrogen pressures are required in the presence of a heterogeneous catalyst to eliminate the oxygen heteroatom.^[16] This can be called as hydrodeoxygenation as elimination of oxygen atoms occurs here.

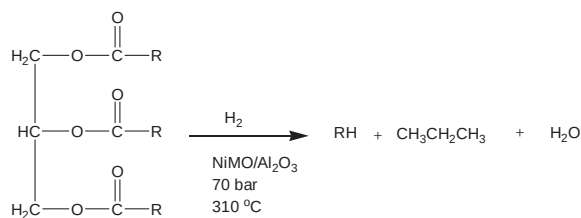


Figure 2.Hydroprocessing reaction^[16]

The requirement of a high hydrogen pressure is one of the economical disadvantages as providing this would be very much costly. Due to these high pressures, catalyst deactivation can occur preventing the recovery of the catalyst which adds to the commercial disadvantages of hydroprocessing.

As a solution to overcome these drawbacks, decarboxylation/decarbonylation can be implemented as a commercially viable green diesel production method.

Decarboxylation/ Decarbonylation

First it is essential to understand decarboxylation and decarbonylation reactions and the difference between the two.

In the decarboxylation reaction –COO group is eliminated as CO₂(Figure 3).

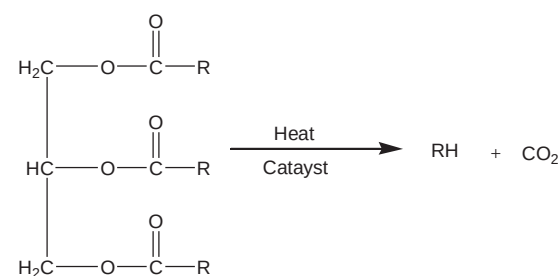


Figure 3. Decarboxylation reaction

Decarbonylation is the reaction where –C=O group is split off as a carbon monoxide molecule (Figure 4).

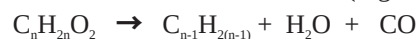


Figure 4. Decarbonylation reaction

However, the dominance of each reaction type depends on the hydrogen partial pressure available. Although high hydrogen pressures are not required as in hydrodeoxygenation, a constant hydrogen flow should be maintained through out the process to convert saturate fatty acids to unsaturated fatty acids, to activate the metal component in the heterogeneous catalysts and help organic species to desorb from metal surface.^[17] This is usually carried out by sending a hydrogen flow along with a noble gas such as He or Ar as the carrier gas. If the partial pressure of hydrogen increases, decarbonylation reaction becomes dominant and vice versa.

However, decarboxylation/decarbonylation cannot be carried out under normal laboratory conditions. There are several kinds of reactors that facilitate the processes.

They are slurry or batch reactor, tricle bed or fixed bed reactor and monolithic reactor.^[16] Monolithic reactor reduces production cost and enables catalyst recovery and is the preffered choice in the process. Catalytic recovery is somewhat tedious in slurry and fixed bed reactors. However, the initial purchasing cost of monolithic reactor is somewhat higher.

Decarboxylation heavily depends on the performance of the catalyst. Pd/C^[17] and Pt/C^[18] catalysts can be used for this purpose.

Conclusion

Green diesel is an upcoming approach to overcome many of the disadvantages related to application and production of existing biofuels. As the produced hydrocarbons are in the range of that of fossil hydrocarbons, green diesel is compatible with

existing engines and refineries, hence no modifications are required. Since there is no oxygen present, green diesel would not solidify in cold climates clogging the engines and pipelines. Green diesel has high cetane number which is a desired feature in an ideal fuel.

Green diesel can be produced by either hydroprocessing and/or decarboxylation/decarbonylation. Decarboxylation/decarbonylation is preferred as hydroprocessing requires high hydrogen pressure leading to a higher cost.

Decarboxylation/decarbonylation employs the function of a catalyst. Opportunities are open for interested researches to optimize conditions such as pressure and temperature for this process, in the presence of a suitable catalyst. Various feedstocks can be utilized as well.

References

1. *International Energy Outlook 2013*; www.iea.gov/ieo (last accessed 20 August 2014).
2. <http://energy.gov/science-innovation/energy-sources/fossil>(last accessed 20 August 2014).
3. *Forbes magazine*, July 2009; <http://www.forbes.com/2009/07/24/peak-oil-production-business-energy-nelder.html>(last accessed 20 August 2014).
4. *Genesis Energy 2010*; www.electrocity.co.nz (last accessed 20 August 2014).
5. <http://www.iea.org/publications/freepublications/publication/Cities2009.pdf>(last accessed 21 August 2014).
6. Hancsok, J.; Eller, Z.; Polczmann, G.; Varga, Z. Sustainable production of bioparaffins, *ChemEng.Transactions*, **2013**, 35, 1027-1032. DOI:10.3303/CET1335171
7. Naik, S. K.; Goud, V. V.; Rout, P.; Dalai, A. K. Production of first and second generation biofuels: A comprehensive review. *renew.sust.energ.rev*. Vol 14. **2010**, 578-597
8. Green energy perspectives. Updated June 2010. www.greenenergy.com (last accessed on 21 August 2014).
9. Second generation biofuels; A review from a Market barrier perspective by IEA Bioenergy. <http://task39.org/files/2013/05/Second-generation-biofuels-A-review-from-a-market-barrier-perspective.pdf> (last accessed on 22 August 2014)
10. Mabey, W. E.; Gregg, D. J.; Saddler, J. N. Assessing the emerging biorefinery sector in Canada. *Appl.Biochem.Biotechnol.* **2005**, 121-124, 765-78.
11. Lee, A. R. ;Lavoie, J. M. *Animal Frontiers*.**2013**. vol. 3 no. 2, 6-11 DOI: 10.2527/af.2013-0010
12. Knothe, G.; Gerpen, J. V.; Krah, J. *The Biodiesel Handbook*; AOCS Press, **2005**.
14. Ma, F.;Hanna, M. A. Biodiesel production; a review. *Bioresour. Technol.***1999**,70, 1-15
15. <http://www.biotecharticles.com/Environmental-Biotechnology-Article/Advantages-and-Disadvantages-of-Biofuels-163.html> (last accessed on 22 August 2013)
16. Sari, E.; DiMaggio, C.; Kim, M.O.; Salley, S.; Ng, K. Y. S. Production of Green Diesel From Brown Grease Via Decarboxylation. Presented at AIChE annual meeting 2011. Originally presented on 20th October 2011.
17. Immer, J. G.; Kelly, J.; Lamb, H. Catalytic reaction pathways in liquid-phase deoxygenation of C18 free fatty acids. *Appl.Catal. A-Gen.* **2010**, 375, 134-139
18. Fu, J; Lu, X; Savage, P E. Hydrothermal decarboxylation and hydrogenation of fatty acids over Pt/C. *Chem. Sus. Chem.* 2011. Vol 4, 481-486

~

Molecular Docking

Amali G. Guruge

Research Assistant, College of Chemical Sciences, Institute of Chemistry Ceylon, Rajagiriya.

Background

Computational applications and molecular modelling are broadly applied in medicinal chemistry and in chemistry today. These methods help to discover and understand phenomena in chemistry. Computational tools are used to predict,

1. Energies of molecular structures

2. Vibrational frequencies of molecular systems
3. Chemical reactions under various conditions
4. Stable structures and short-lived transition state structures, and many more.

Gaussian, HyperChem, Spartan, WinMopac,

and ChemBio3D Ultra are some of the popular computational tools used today. These tools have the ability to carry out molecular structure calculations using both, molecular mechanics and quantum mechanics methods. There are many tools available for the same purpose. Researchers should always select the best tool available to achieve the targeted results.

Computer based models play an important role in medicinal chemistry, and in the process of drug discovery. Drug designing is an expensive, time consuming and challenging process. Normally it takes nearly ten or more years for a new drug to reach the market. Several computational tools are available to accelerate this process, and these methods save both money and time in the drug discovery process. One of the approaches in drug discovery is to find a novel inhibitor which alters the function of a harmful protein. This inhibitory action is generated by binding of a small molecule known as a 'ligand' to the target protein known as 'receptor'. There are several theoretical methods and computational techniques available to categorize these ligands as possible drug candidates. These techniques are commonly known as 'virtual screening'.^[1] The most practically applied screening method is Docking-Based Virtual Screening (DBVS).

Molecular Docking

In molecular docking, the computer program attempts to insert a ligand in to the binding pocket of the targeted protein. In other words, the docking program searches for different docked conformations, and finally it selects the most favourable conformation as the docked receptor-ligand complex.^[2]

Docking technique is used for three purposes in the drug discovery process, namely,

1. to identify new ligands that bind with the target protein
2. to predict the preferred binding mode of receptor-ligand complexes
3. to calculate binding affinities of analogue compounds derived from active ligands

Many computational tools are available for docking process. AutoDock^[3], DOCK^[4], FlexX^[5] and GOLD^[6] are some flexible docking tools that are used very often. These tools have the ability to produce receptor-ligand complexes with reasonable accuracy and speed. Since docking process requires the atomic

coordinates of macromolecules, the use of these methods is enhanced by rapidly increase in number of three dimensional macromolecule structures in the Protein Data Bank. In addition to that, several ligand data bases such as ZINC, PubChem, ChemDB, and DrugBank are available for screening.

To identify the cavity or binding pocket of the target, computational tools use several algorithms and they can vary from one another. Incremental Construction (IC), Fast Shape Matching (SM), Simulated Annealing (SA), Distance Geometry (DG), Evolutionary Programming (EP), Genetic Algorithm (GA), Tabu Search (TS) and Monte Carlo (MC) are some algorithms used in docking tools.^[7] Current literature available on molecular docking shows some interesting computational studies carried out recently.^[8-14]

Initially both target macromolecule and ligand molecules should be prepared following default procedures given in the computational tool. This step contains removal of already bound ligands in the targeted protein, optimization processes, assigning proper charges etc. Thereafter each ligand is virtually docked with the target using a docking program which searches for a stable receptor-ligand complex. Recent computational tools perform two types of docking known as rigid docking and flexible docking. In rigid docking, both receptor and ligand structures are considered as rigid. In flexible docking, receptor is considered as rigid while ligand is considered as flexible. Due to time consuming calculations and due to lack of computational power, receptor flexibility remains as a key challenge in docking programs.^[15] The effect of ligand and protein flexibility in molecular docking has been investigated by Erickson et al. in 2004.^[16] They used four docking programs as DOCK, FlexX, GOLD and CDOCKER with 41 ligand-protein complexes. Finally they concluded CDOCKER program is performing accurate results compared to other three when ligand structure contains eight or more rotatable bonds. For visualization and analysis of docked complex, visualization software like Chimera^[17] or Pymol^[18] is needed.

A mathematical method, named as 'scoring function' is used to evaluate the fitness between the ligand and the receptor. This function is a significant component since its accuracy depends on the final result of the docking program. Accuracy of different scoring methods has been studied by Wang et al. in 2003.^[19]

There are three types of scoring functions, namely

1. Force field-based scoring functions
2. Empirical scoring functions
3. Knowledge based scoring functions

Force field scoring functions compute non-covalent interactions like van der Waals and electrostatic energies. Additionally, bond stretching, bond bending and bond torsion forces are also used. Empirical scoring functions compute overall binding free energy using hydrogen bond interactions and hydrophobic interactions. The third type, knowledge-based scoring functions use energy potentials which are derived from the experimentally determined atomic structures.^[20] Depending on score values some ligand molecules can be neglected without doing further experiments and high ranked ligand molecules may be selected for further investigations. Additional investigations like molecular dynamics simulations should be carried out for the selected ligands. Evidence of success stories in virtual screening are available.^[21] One story is about the Epidermal Growth Factor Receptor (EGFR). It is evident that inhibition of EGFR leads to the treatment of cancer. A virtual screening has been carried out for 1246 molecules by Cavasotto et al. in 2007.^[22] As the next step of this study, 50 best-scoring molecules were selected and these molecules were used to check EGFR tyrosine kinase activity and anti-proliferative activity in cancer cells. As a result, seven molecules were identified as inhibitors of EGFR tyrosine kinase activity. Another story is about low molecular weight protein tyrosine phosphatase (LmWPTP). It is known that LmWPTP inhibition is important for the treatment of cancer and diabetes. Virtual screening techniques have been carried out for 875,866 molecules initially by Vidal et al.^[23] Based on scoring values, 1289 molecules were selected for further experiment. Finally the researchers discovered five compounds which have the inhibition constant values in the range of 10-900 μ M. Availability of such success stories implies the importance of virtual screening in drug discovery.

Conclusions

Virtual screening is currently applicable in many areas of chemistry as well as pharmacology. Docking-based virtual screening plays a major role in the drug discovery process. Since drug discovery is time consuming and expensive, docking techniques are used to accelerate this process saving both money and time. Receptor flexibility still remains a challenge for docking tools. However available tools produce results

with reasonable accuracy. There is no doubt that molecular docking will be one of the most powerful techniques in the next decade especially in pharmacology.

References

1. Cheng, T.; Li, Q.; Zhou, Z.; Wang, Y.; Bryant, S. H. *AAPS J.* **2012**, *14*, 133-141.
2. Kuntz, I. R.; Meng, E. C.; Shoichet, B. K. *Acc. Chem. Res.* **1994**, *27*, 117-123.
3. Morris, G. M.; Goodshell, D. S.; Halliday, R. S.; Huey, R.; Hart, W. E.; Belew, R. K.; Olson, A. J. *J. Comput. Chem.* **1998**, *19*, 1639-1662.
4. Ewing, T. J. A.; Makini, S.; Skillman, A. G.; Kuntz, I. D. *J. Comput. - Aided Mol. Des.* **2001**, *15*, 411-428.
5. Rarey, M.; Kramer, B.; Lengauer, T.; Klebe, G. *J. Mol. Biol.* **1996**, *261*, 470-489.
6. Jones, G.; Willette, P.; Glen, R. C.; Leach, A. R.; Taylor, R. *J. Mol. Biol.* **1997**, *267*, 727-748.
7. Dias, R.; De Azevedo, W. F. Jr. *Curr. Drug Targets*, **2008**, *9*, 1040-1047.
8. Ismail, M. M. F.; Rateb, H. S.; Hussein, M. M. M. *Eur. J. Med. Chem.* **2010**, *45*, 3950-3959.
9. Sandhya, B.; Giles, D.; Mathew, V.; Basavarajaswamy, G.; Abraham, R. *Eur. J. Med. Chem.* **2011**, *46*, 4696-4701.
10. Huang, X. Y.; Shan, Z. J.; Zhai, H. L.; Su, L.; Zhang, X. Y. *Chem. Biol. Drug Des.* **2011**, *78*, 651-658.
11. Froufe, H. J. C.; Abreu, R. M. V.; Ferreira, I. C. F. R. *SAR QSAR Environ. Res.* **2011**, *22*, 315-328.
12. Mokale, S. N.; Lokwani, D. K.; Shinde, D. B. *Med. Chem. Res.* **2014**, *23*, 3752-3764.
13. Girija, C. R.; Karunakar, P.; Poojari, C. S.; Begum, N. S.; Syed, A. A. *J. Proteomics Bioinform.* **2010**, *3*, 200-203.
14. Suvannang, N.; Nantasenamat, C.; Isarankura-Na-Ayudhya, C.; Prachayasittikul, V. *Molecules*, **2011**, *16*, 3597-3617.
15. Leach, A. R.; Shoichet, B. K.; Peishoff, C. E. *J. Med. Chem.* **2006**, *49*, 5851-5855.
16. Erickson, J. A.; Jalaie, M.; Robertson, D. H.; Lewis, R. A.; Vieth, M. *J. Med. Chem.* **2004**, *47*, 45-55.
17. Pettersen, E. F.; Goddard, T. D.; Huang, C. C.; Couch, G. S.; Greenblatt, D. M.; Meng, E. C.; Ferrin, T. E. *J. Comput. Chem.* **2004**, *25*, 1605-1612.
18. DeLano, W. L.; The PyMOL Molecular Graphics System, DeLano Scientific LLC, San Carlos, CA,

- USA.
19. Wang, R.; Lu, Y.; Wang, S. *J. Med. Chem.* **2003**, 46, 2287-2303.
 20. Huang, S.; Grinter, S. Z.; Zou, X. *Phys. Chem. Chem. Phys.* **2010**, 12, 12899-12908.
 21. Villoutreix, B. O.; Eudes, R.; Miteva, M. A. *Comb. Chem. High Throughput Screen*, **2009**, 12, 1000-1016.
 22. Cavasotto, C. N.; Orry, A. J. *Curr.Top. Med. Chem.* **2007**, 7, 1006-1014.
 23. Vidal, D.; Blobel, J.; Perez, Y.; Thormann, M.; Pons, M. *Eur. J. Med. Chem.* **2007**, 42, 1102-1108.

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

Technical Sessions : A - 04

A comparative study on mercury, arsenic and cadmium in herbal fairness cream products in local market

A.A.A.C. Upeksha , N. Kottegoda and B. Asiri Perera *

Department of Chemistry, University of Sri Jayewardenepura, Sri Lanka

*E-mail: basirip@yahoo.com

Herbal cosmetics are highly practiced in beauty culture field and Ayurveda treatments. But there can be impurities present in cosmetics like heavy metals which are toxic to health. Most widely contaminated heavy metal is mercury. Mercury is considered as a melanotoxin and fairness cream containing mercury is being widely manufactured.

The aim of the present study is to evaluate the level of heavy metal contamination in herbal fairness cream. Contamination level of mercury, arsenic and cadmium in five brands of herbal fairness cream were analyzed. Six batches from each brand with different manufacturing dates were taken for the study. The levels of heavy metals were analyzed by graphite furnace atomic absorption spectrometry for Cd and Hg and hydride generation for As, prior to microwave digestion.

The mean mercury values (in $\mu\text{g g}^{-1}$ wet weight) for three herbal fairness cream brands were found exceeding the United State Food and Drug Administration permissible limit ($1\mu\text{g g}^{-1}$). Highest mercury value (29813 ± 1169) for brand C, second highest for brand B (6130 ± 1013) and followed by brand A ($38.1616.41$). Mean mercury value for brand D (0.0837 ± 0.063220) and brand E (0.1492 ± 0.03782) were found below the permissible limit. Mean arsenic

levels (in $\mu\text{g g}^{-1}$ wet weight) for brand A (0.07686 ± 0.03933), brand B (0.8719 ± 0.4761) and brand D (0.1233 ± 0.04616) were found far below the highest permissible limit for Canada ($3\mu\text{g g}^{-1}$) and for brand C and E arsenic was not detected. Mean cadmium values for brand B (0.05864 ± 0.04058), brand C (1.571 ± 1.383) and brand D (0.05999 ± 0.02967) obtained were lower than the Health Canada highest permissible limit ($3\mu\text{g g}^{-1}$). Brand A (3.954 ± 0.7807) exceeded the permissible value and for brand E arsenic was not detected. There were statistically significant differences between heavy metals levels and date of manufacturing (Tukey's test $p < 0.05$).

Finally results of the study depict the inconsistency of heavy metals levels within brands and between the brands. Toxic amount of mercury found for three brands and this emphasize the importance of mandatory testing programs to analyze heavy metal levels in herbal fairness cream product and there should be regulatory guidelines for promotion of Good analytical practice and good manufacturing practices.

Acknowledgement

Authors wish to thank Sri Lanka Institute of Nano Technology for their technical support.

Comparative Toxicochemical Analysis of Heavy Metals (As, Cd, Zn, Cu) in Fruits

N. P. Madavi and B. Asiri Perera *

Department of Chemistry, University of Sri Jayewardenepura, Sri Lanka

*E-mail: basirip@yahoo.com

Sri Lanka been a 3rd world country rely heavily on fruit consumption as a cost effective measure to alleviate micronutrient deficiencies. Increased demand for fruits have lead to intensive fruit production in Sri Lanka over last few years which is characterized by extensive usage of agro chemicals. So contamination of heavy metals is to be expected which may cause detrimental effects on human health. Fruits are natural staple food for humans and ingestion is one of the major routes for entry of heavy metals in to the human body. But studies relating to this area are very rare or non-existent.

In this study heavy metals As, Cd, Zn, Cu were assessed in three types of fruits namely Banana (*Musa hybrids*), Papaya (*Carica papaya*) and Pineapple (*Ananas comosus*). Fruits were purchased from a super market and a home garden. Cadmium (Cd) was analyzed with Graphite Furnace Atomic Absorption Spectrometer, Arsenic (As) with Hydride Generation Assembly and Zinc (Zn), Copper (Cu) with Flame Atomic Absorption Spectrometer subsequent to dry ash preparation procedure in the presence of Mg (NO₃)₂ as the ashing aid.

Mean heavy metal concentrations of all the fruits in both sampling sites were below the permissible limits given by WHO/FAO in dry basis (0.1 mg/kg, 0.2 mg/kg, 100 mg/kg, 40 mg/kg) for As, Cd, Zn and Cu respectively. According to our results order of the abundance of mean heavy metal concentration for Banana from super market is Cu (36.13 mg/kg) > Zn (26.07 mg/kg) > As (0.0559 mg/kg) > Cd (0.02319 mg/kg) where as for other fruit types in same sampling sites as follows, Zn > Cu > As > Cd. Arsenic (As) was not detected in home grown fruits and the order of abundance of other metals is Zn > Cu > Cd.

Statistical significance was calculated for differences between metal concentrations and sampling sites and also between metal concentrations and fruit type.

Even though heavy metal levels do not exceed the permissible levels, high concentrations of some heavy metals in fruits from the super market provide initial evidence of heavy metal contamination emphasizing the importance of further investigations

Call for Nominations for Institute of Chemistry Gold Medal 2015 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 Subramaniam** 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 2015 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 2015
- 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 44th Annual Sessions. **Nominations should be forwarded to reach the Hony. Secretary, IChemC not later than 31st March 2015.**

44th Annual Sessions of the Institute of Chemistry Ceylon 2015

Theme:

Chemical Sciences in Food Safety and Security

Date: June, 2015

CALL FOR ABSTRACTS AND EXTENDED ABSTRACTS

Last Date for receiving abstracts and extended abstracts is 31st January 2015

AWARDS 2015

The following awards will be presented at the Annual Sessions 2015 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.
- **INSTITUTE OF CHEMISTRY SILVER MEDALS**
 - Devanathan Memorial Award**
Awarded for an exceptional research contribution of an original nature in the field of Physical Chemistry and or related areas, such as Physical-Inorganic, Physical-Organic and Biophysical chemistry.
 - Chandrasena Memorial Award**
Awarded for an exceptional research contribution of an original nature in the field of Organic Chemistry and/ or related areas such as Biochemistry, Pharmacognosy, Molecular Biology and Bioactivity studies.
 - Ramakrishna Memorial Award**
Awarded for an exceptional research contribution of an original nature in the field of Inorganic and/ or Analytical Chemistry and/ or related areas such as Bio-inorganic Chemistry or Bio- analytical Chemistry.
- **INSTITUTE OF CHEMISTRY BRONZE MEDALS**
 - Kandiah Memorial Awards**
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 the content.
 - 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.

Closing date for receiving applications / nominations for the above awards: 28th February 2015

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

Introduction and History of Chromatography

Dr. Udaya K. Jayasundara

Senior Lecturer, College of Chemical Sciences, Institute of Chemistry Ceylon, Rajagiriya

This is the introductory article written for the **student corner** under the title of *Chromatography Techniques in Chemistry*. In this article, primary attention was focused to *Introduction and History of Chromatography*. Each different type of chromatographic technique will be discussed in future publications in the order they are introduced here.

1. What is Chromatography?

Chromatography may have several definitions depends on the field you are interested. However, all these definitions can be summarized as “the science which studies the separation of molecules based on differences in their structure and/or composition”. The IUPAC definition¹ is

“Chromatography is a physical method of separation in which the components to be separated are distributed between two phases, one of which is stationary while the other moves in a definite direction”.

According to this definition, almost all chromatography techniques involve moving a test sample of the materials dissolved in a Mobile Phase to be separated on a stationary support (Stationary Phase). The molecules in the test sample may have different interactions with the stationary phase leading to separation of similar molecules. Test molecules which have stronger interactions with the stationary phase will tend to move slowly than those molecules with weaker interactions. In this way, different types of molecules can be separated from each other as they move over the stationary phase.

2. History of Chromatography²

The history of chromatography spans from the mid-18th century to the 21st century. Some of the main contributions to the development of chromatography are listed below.

- I. Friedlieb Runge (1794 -1867)- Used unglazed paper and pieces of cloths for spot testing dye mixtures and plant extracts.
- II. Friedrich Goppelsröder (1837-1919) - Introduced paper strip analysis of dyes, milk,

beer, colloids, plant, and animal.

- III. Mikhail Tsvett (1872-1919) - Used to separate plant pigments such as chlorophyll (which is green) and carotenoids (which are orange and yellow).

The meaning of the word chromatography is to write with colors or color to write and the word was coined by Mikhail Tswett. This is literally translated from its Greek roots *chroma* and *graphein*. Even though there were early developments, chromatography was first developed by the Russian botanist Mikhail Tswett in 1903 as he produced a colorful separation of plant pigments through a column of calcium carbonate.

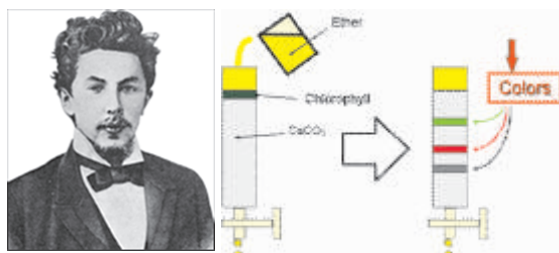


Figure 1: (a) Mikhail Tswett (1872-1919) a Russian botanist. (b) Mikhail Tswett's first chromatographic experiment to separate color pigments.

Chromatography has since developed into an invaluable laboratory tool for the separation and identification of compounds. The importance of chromatography can be understood by its applications in every branch of the physical and biological sciences and awarding 12 Nobel prizes between 1937 and 1972 alone for work in which chromatography.

3. Theory of Chromatography

As mentioned in Section 1, chromatography is a physical method of separation in which the components to be separated are distributed between two phases. The chromatographic process occurs due to differences in the distribution constant which is an equilibrium constant of the individual sample components. The distribution constant is sometimes referred as distribution coefficient or partition coefficient and denoted as either K_D or D . Therefore,

the reader should understand that these terms may be used interchangeably. This quantity is defined as follows;

$$K_D(D) = \frac{\text{Concentration of the sample in organic phase } (C_{org})}{\text{Concentration of the sample in aqueous phase } (C_{aq})}$$

Even though, this is defined as explained, the significance of the term comes with the value of K_D . If $K_D > 1$ then the sample dissolve or prefer the organic phase than the aqueous phase and vice versa. There are other mathematical expressions available depend on the type of chromatography and will be introduced and discussed later.

4. General Terminology

When a new subject is learned, there are many new terms that come across. In order to get the better understanding of the subject matter, it is a good practice to learn them before. Therefore, this section introduces some of the terms used in chromatography.

i. Chromatography

Chromatography is a physical method of separation in which the components to be separated are distributed between two phases, one of which is stationary (*stationary phase*) while the other (*mobile phase*) moves in a definite direction.

ii. Chromatogram

A graphical or other presentation of detector response, concentration of analyte in the effluent or other quantity used as a measure of effluent concentration versus effluent volume or time.

iii. Chromatograph (verb)

To separate by chromatography

iv. Chromatograph (noun)

The assembly of apparatus (instrumentation) for carrying out chromatographic separations

v. Stationary Phase

The stationary phase is one of the two phases forming a chromatographic system. The stationary phase may be a solid, a gel or a liquid. If a liquid functions as a stationary phase, usually it is distributed on a solid by a physical method called physisorption. The underlying solid may or may not contribute to the separation process. If the liquid is chemically bonded (chemisorption) to the solid (*Bonded Phase*) or immobilized onto it (*Immobilized Phase*).

vi. Bonded Phase

A stationary phase which is covalently bonded to the support particles or to the inside wall of the column tubing.

vii. Immobilized Phase

A stationary phase which is immobilized on the

support particles, or on the inner wall of the column tubing, e.g., by *in situ* polymerization (cross-linking) after coating.

viii. Mobile Phase

A fluid which percolates through or along the stationary bed, in a definite direction. It may be a liquid (*Liquid Chromatography*) or a gas (*Gas Chromatography*) or a supercritical fluid (*Supercritical-Fluid Chromatography*).

ix. Carrier Gas

In gas chromatography the expression *Carrier Gas* may be used for the mobile phase.

x. Eluent

In elution chromatography the expression *Eluent* is also used for the mobile phase.

xi. Elute (verb)

To chromatograph by elution chromatography. The process of elution may be stopped while all the sample components are still on the chromatographic bed or continued until the components have left the chromatographic bed.

xii. Effluent

The mobile phase leaving the column.

xiii. Sample (test sample)

The mixture consisting of a number of components the separation of which is attempted on the chromatographic bed as they are carried or eluted by the mobile phase.

xiv. Sample Components

The chemically pure constituents of the sample. They may be unretained (*i.e.*, not delayed) by the stationary phase, partially retained (*i.e.*, eluted at different times) or retained permanently.

xv. Solute

This refers to the sample components in partition chromatography.

xvi. Solvent

This refers to the liquid stationary phase in partition chromatography. *Note:* In liquid chromatography the term "solvent" has been often used for the mobile phase. This usage is not recommended.

xvii. Zone

A region in the chromatogram where one or more components of the sample are located. The term *Band* may also be used for it.

5. What really happens?

If we can relate this chromatographic process to a known example, then it would be much easier to understand. In fact, this process can be related to a river as shown in Figure 2.

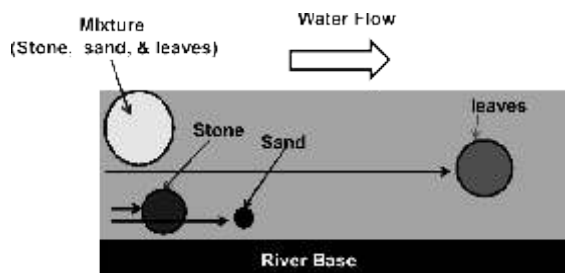


Figure 2: The chromatographic process is similar to a river

According to the Figure 2, the water flow will act as the mobile phase whereas the base of the river will be the stationary phase. Assume you have thrown a pile of stones and leaves into the flowing river. From your general knowledge you know that the stones will directly go to the bottom whereas the leaves may start to flow. Further, if you have sands in your mixture they may move certain distance with the flow and rest there. In other words, your original mixture will no longer exist as a mixture but as components due to the flow of water in the river.

As we are aware now, the chromatographic separation involves mobile phase and the stationary phase. The process taking place in the instrument can be shown as in Figure 3.

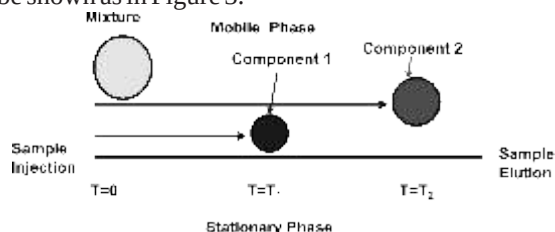


Figure 3: The process taking place inside the chromatograph.

Once a mixture is injected to the chromatograph it starts to bind to the stationary phase depends upon the strength of interaction. Components with strong interactions will stay for a long period of time in the instrument whereas components with weak interactions will stay for a short period of time in the instrument. Therefore, components with strong interactions will have a higher elution (retention) times whereas the components with weak interactions will have a shorter elution (retention) times.

6. Classification of Chromatography³

There are several ways of classifying chromatographic techniques. One way of doing so is according to the experimental setup.

6.1. Planer chromatography

In this method solid phase is placed in an open planer surface such as a sheet, paper or a glass. The mobile phase is always a liquid. These are further classified according to the type of stationary phase.

6.1.1. Paper Chromatography

6.1.2. Thin Layer Chromatography

6.2. Column chromatography

In this method the stationary phase is in a closed column. Unlike in planer chromatography, the mobile phase should not be a liquid. According to the mobile phase, the chromatography can be classified as follows.

6.2.1. Gas mobile phase - Gas Chromatography

6.2.2. The Gas Chromatography can be further classified according to the stationary phase.

6.2.1.1. Liquid stationary phase - Gas Liquid Chromatography

6.2.1.2. Solid stationary phase - Gas Solid Chromatography

6.2.3. Liquid mobile phase - Liquid Chromatography

The Liquid Chromatography can also be classified according to the stationary phase.

6.2.2.1. Adsorption Chromatography

6.2.2.2. Partition Chromatography

6.2.2.3. Ion Exchange Chromatography

6.2.2.4. Gel Permeation Chromatography

6.2.2.5. Affinity Chromatography

6.2.3. Super critical fluid mobile phase - Supercritical Fluid Chromatography

Each of these chromatographic techniques will be discussed in detail in future publications.

References:

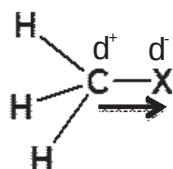
1. <http://www.etymonline.com> Accessed Sep 8, 2014.
2. Touchstone, J. C. *J. Liq. Chrom.*, **1993**, 16 (8), 1647-1665.
3. Skoog, D.A.; Holler, F.J.; Crouch, S.R. *Principles of Instrumental Analysis* 8th ed.; Cengage Learning India Private Limited, India, 2010 pp 836-837.

Nucleophilic Substitution Reactions of Alkyl Halides

Dr. Ireshika De Silva

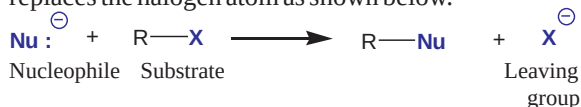
Senior Lecturer, College of Chemical Sciences, Institute of Chemistry Ceylon, Rajagiriya

In alkyl halides the halogen atom is attached to an sp^3 -hybridized carbon. Since the halogen (X) atom is more electronegative than the carbon atom, the C-X bond is polarized as indicated below.



Nucleophile (Nu:) is defined as a reagent that seeks a positive center. Negatively charged species, such as hydroxide (OH^-) and methoxide (OMe^-) ions or uncharged species with an unshared electron pair such as water and methanol are considered as nucleophiles.

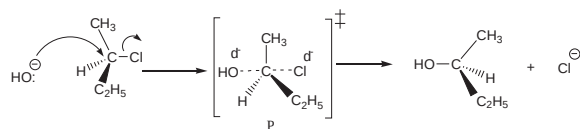
In nucleophilic substitution reactions, a nucleophile (Nu:) replaces the leaving group in the substrate. Due to the polarizability of the C-X bond, the carbon atom attached to the halogen (X) is electrophilic. Therefore Nu: can attack that carbon and replaces the halogen atom as shown below.



The nucleophilic substitution reactions of alkyl halides can occur via two mechanisms, S_N2 and S_N1 .

a) S_N2 ; Substitution, Nucleophilic, Bimolecular

According to this mechanism, the nucleophile attacks the carbon atom bearing the halogen from the direct opposite side of the halogen, which is the leaving group. Attack of the nucleophile and the departure of the leaving group occur simultaneously. This is depicted in the example in Scheme 1.



Scheme 1. S_N2 reaction mechanism

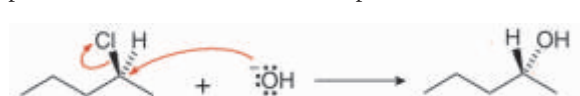
S_N2 reaction is a single step reaction. It has one transition state (**P** in scheme 1) and there are no intermediates. The rate of the reaction depends on the concentrations of both alkyl halide (substrate) and the nucleophile.

$$\text{Rate} = k[\text{R-X}][\text{Nu:}]$$

S_N2 reactions occur with inversion of configurations. Consider the stereochemistry of the

substrate (alkyl halide) and the product in Scheme 1. The configuration of the chiral carbon of the alkyl halide is (*R*) and that of the product is (*S*). This means that there is an inversion of configuration.

Another example is given below. Since the leaving group (Cl^-) is above the plane, the nucleophile (OH^-) should attack from below the plane, which is the opposite side of the leaving group. Therefore, in the product $-\text{OH}$ has to be below the plane.



There are several factors that affect the relative rate of a S_N2 reaction.

i) Structure of the substrate

As mentioned above in S_N2 reactions (Scheme 1), the nucleophile approaches the carbon bearing the halogen from the back side. Therefore, steric hindrance near that carbon has to be minimal for nucleophile to approach it. Methyl halides, which are the least hindered alkyl halides, react rapidly in S_N2 reactions whereas tertiary alkyl halides, which are the most hindered, are unreactive. Though neopentyl halides (Figure 1) are primary alkyl halides, they also very less reactive due to the presence of the bulky $-\text{C}(\text{CH}_3)_3$ group.

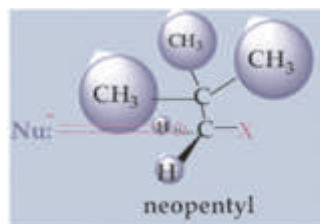


Figure 1. Neopentyl halide

S_N2 reactivity of simple alkyl halides is as methyl > primary > secondary >> neopentyl >>> tertiary (unreactive).

ii) Strength and the concentration of the nucleophile

The strength of the nucleophile is also important in S_N2 reactions since it involves in the rate-determination. Examples of good nucleophiles are given below.

CN^- , HS^- , RS^- , $(\text{CH}_3)_3\text{P}$, $(\text{CH}_3)_3\text{N}$, NH_2^- , I^- , HO^- , RO^-

You can consider the following factors to identify strong nucleophiles.

- Negatively charged nucleophiles are more reactive than the corresponding neutral ones
 $\text{HO}^- > \text{H}_2\text{O}$ $\text{RO}^- > \text{ROH}$ $\text{SH}^- > \text{SH}$ $\text{NH}_2^- > \text{NH}_3$
- More electronegative elements tend to "hold" their electrons more tightly. Therefore nucleophilicity decreases going from left to right in the periodic table.
 $\text{OH}^- > \text{F}^-$ $\text{NH}_3 > \text{H}_2\text{O}$ $\text{R}_3\text{P} > \text{R}_3\text{S}$
- Nucleophilicity increases going down the periodic table as the size and the polarizability increase
 $\text{I}^- > \text{Br}^- > \text{Cl}^- > \text{F}^-$ $\text{R}_3\text{P} > \text{R}_3\text{N}$ $\text{SeH}^- > \text{SH}^- > \text{OH}^-$
- When the nucleophilic atom is the same, nucleophilic order is the same as basicity order
 $\text{RO}^- > \text{HO}^- \gg \text{RCO}_2^- > \text{ROH} > \text{H}_2\text{O}$

The concentration of the nucleophile also affects the rate of the reaction. According to the rate equation, $\text{Rate} = k[\text{R-X}][\text{Nu}^-]$, when the concentration of the nucleophile is doubled the rate of the reaction also doubles.

iii) Solvent

Polar protic solvents (H_2O and alcohols, acetic acid) are not suitable for $\text{S}_\text{N}2$ reactions, because they slow down the reaction. Polar protic solvents have a hydrogen atom attached to a strongly electronegative element. They can cluster around the nucleophile (solvate it) via H-bonding, lower its energy (stabilize it) and reduce the reactivity of the nucleophile. Polar aprotic solvents (Figure 2) are more suitable for $\text{S}_\text{N}2$ reactions. They do not have hydrogen atom that is attached to an electronegative atom. Therefore polar aprotic solvents do not hinder the nucleophile through H-bonding.

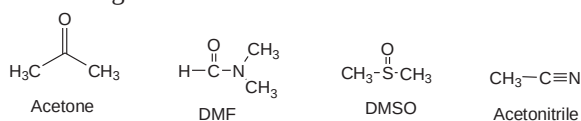


Figure 2. Examples of polar aprotic solvents

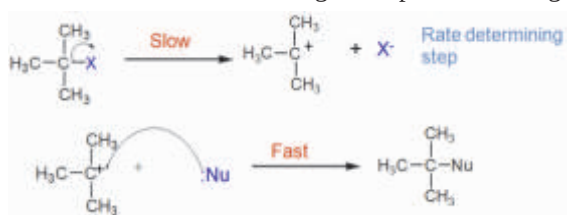
iv) The ability of the leaving group to leave

The leaving group (halogen) usually leaves as an anion. The best leaving groups are those that best stabilize the negative charge. Weak bases are stable as anions and are good leaving groups. The leaving group order of halogen is as $\text{I}^- > \text{Br}^- > \text{Cl}^- > \text{F}^-$.

b) $\text{S}_\text{N}1$; Substitution, Nucleophilic, Unimolecular

As mentioned above tertiary alkyl halides do not react by $\text{S}_\text{N}2$ mechanism due to the steric effects. However tertiary alkyl halides undergo substitution

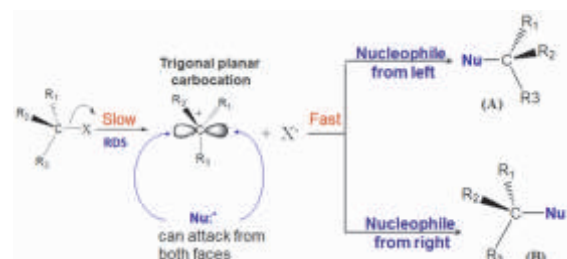
reactions by $\text{S}_\text{N}1$ mechanism. According to this mechanism, the leaving group (halogen) first leaves from the substrate (alkyl halide) forming a carbocation intermediate. Then the nucleophile attacks the carbon bearing the positive charge



Scheme 2. $\text{S}_\text{N}1$ reaction mechanism

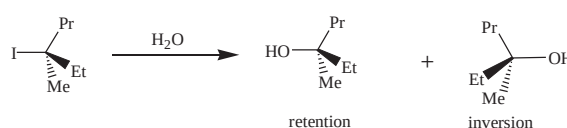
The first step in this reaction mechanism is the rate determining step. Therefore $\text{Rate} = k[\text{R-X}]$.

Now let us consider the stereochemistry of the $\text{S}_\text{N}1$ reaction. The carbocation intermediate which forms in the first step is trigonal planar. The nucleophile can attack the central carbon from either side as shown in Scheme 3. This results in the formation of two products, one with inversion of the configuration (A) and other one with the retention of configuration (B). The product mixture is a racemic mixture.



Scheme 3. Stereochemistry of $\text{S}_\text{N}1$ reaction

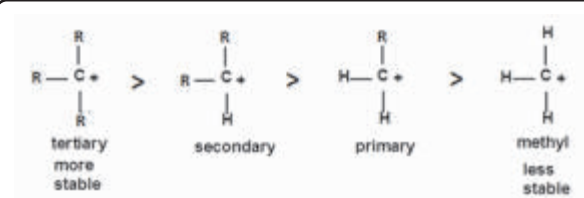
An example is depicted below.



Now let us consider the factors that affect the relative rate of a $\text{S}_\text{N}1$ reaction.

I) Structure of the substrate

The reactivity order of simple alkyl halides in $\text{S}_\text{N}1$ reactions is opposite of that of $\text{S}_\text{N}2$ reactions. That is tertiary > secondary >>> primary and methyl (unreactive). This order is the same as carbocation stability order (Scheme 4). Now you should understand why tertiary alkyl halides undergo substitution by $\text{S}_\text{N}1$ mechanism.



Scheme 4. Carbocation stability order

Note that vinyl halides ($\text{CH}_2=\text{CHX}$) or aryl halides (ArX) do not undergo substitution by either $\text{S}_{\text{N}}2$ or $\text{S}_{\text{N}}1$ reaction mechanisms.

ii) Strength and the concentration of the nucleophile

Strength and the concentration of the nucleophile do not affect the rate of the $\text{S}_{\text{N}}1$ reaction, because it does not involve in the rate-determination step. Therefore, even with weak nucleophiles (H_2O , MeOH , EtOH) tertiary alkyl halides undergo substitution by $\text{S}_{\text{N}}1$ mechanism.

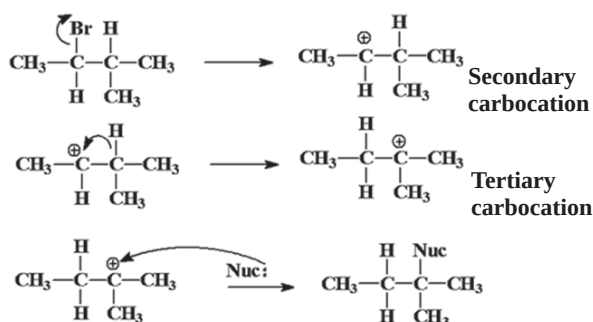
iii) Solvent

Polar protic solvents like H_2O and ROH favor $\text{S}_{\text{N}}1$ reactions because the carbocation intermediate can be stabilized by solvation.

iv) The ability of the leaving group to leave

This factor is also important in $\text{S}_{\text{N}}1$ reactions. As stated above under $\text{S}_{\text{N}}2$ reactions, weak bases are stable as anions and are good leaving groups. The leaving group order of halogen is $\text{I}^- > \text{Br}^- > \text{Cl}^- > \text{F}^-$.

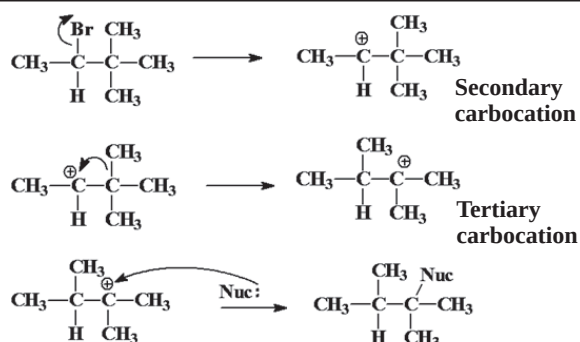
The other feature of $\text{S}_{\text{N}}1$ reactions is the rearrangement of the initially formed carbocation to more stable carbocation. Consider the following examples in Schemes 5 and 6.



Scheme 5. Hydride shift to form more stable tertiary carbocation

The initially formed secondary carbocation rearranges to the more stable tertiary carbocation which is then attacked by the nucleophile (Scheme 5).

If no hydrogens are available, an alkyl group (eg. CH_3) moves from adjacent carbon to form the more stable carbocation (Scheme 6).



Scheme 6. Methyl shift to form more stable tertiary carbocation

Now you should be able to identify whether a given substitution reaction takes place by $\text{S}_{\text{N}}2$ or $\text{S}_{\text{N}}1$ mechanism considering the above factors. To identify the correct substitution mechanism you should consider the strength of the nucleophile and the substrate (whether it is methyl, primary, secondary or tertiary).

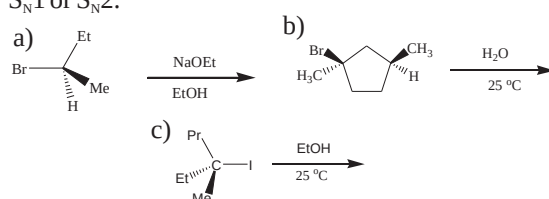
In summary $\text{S}_{\text{N}}2$ and $\text{S}_{\text{N}}1$ reaction mechanisms are compared in Table 1.

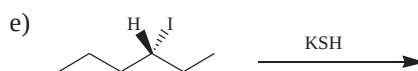
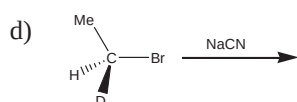
Table 1. $\text{S}_{\text{N}}2$ vs $\text{S}_{\text{N}}1$

| $\text{S}_{\text{N}}2$ | $\text{S}_{\text{N}}1$ |
|---|--|
| Attack by the nucleophile and the leaving group departure occurs simultaneously | Two steps: leaving group departure and nucleophile attack |
| One step, concerted mechanism | Two steps, stepwise mechanism |
| Rate $\propto [\text{R-X}][\text{Nu}]$ | Rate $\propto [\text{R-X}]$ |
| Rate $\propto$ primary > secondary | Rate $\propto$ tertiary > secondary |
| Strong nucleophile (e.g. hydroxide, alkoxide, amine, cyanide) | Weak nucleophile (e.g. water, alcohols, ethers) |
| Aprotic solvents are suitable | Polar protic solvents are suitable |
| One product, product configuration inverted | Two products with both inverted and retained configurations (racemization) |

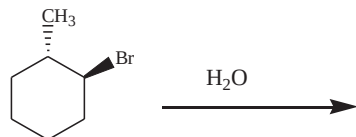
Activities

- Rank the following compounds in the order of increasing reactivity in the $\text{S}_{\text{N}}2$ reaction.
 $\text{CH}_3\text{CH}_2\text{Br}$, $\text{CH}_2=\text{CHBr}$, $\text{CH}_3\text{CH}_2\text{Cl}$, $\text{CH}_3\text{CH}(\text{Br})(\text{CH}_3)$
- Rank the following compounds in the order of increasing reactivity in the $\text{S}_{\text{N}}1$ reaction.
 $\text{CH}_3\text{CH}(\text{Br})(\text{CH}_3)$, $\text{CH}_3\text{CH}_2\text{Br}$, $\text{CH}_3\text{C}(\text{CH}_3)(\text{Br})(\text{CH}_3)$, $\text{CH}_2=\text{CHBr}$
- Predict the products of the following reactions. Indicate the stereochemistry of the each product where necessary. State whether the mechanism is $\text{S}_{\text{N}}1$ or $\text{S}_{\text{N}}2$.





4. What would be the product/s of the following reaction? Write a suitable mechanism.

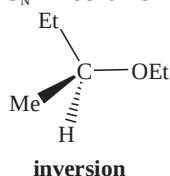


Answers

1. $\text{CH}_2=\text{CHBr}$ (unreactive) < $\text{CH}_3\text{CH}(\text{Br})(\text{CH}_3)$ < $\text{CH}_3\text{CH}_2\text{Cl}$ < $\text{CH}_3\text{CH}_2\text{Br}$ (Br^- is a better leaving group than Cl^-)

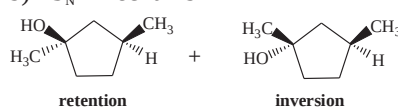
2. $\text{CH}_2=\text{CHBr}$, $\text{CH}_3\text{CH}_2\text{Br}$ (unreactive) < $\text{CH}_3\text{CH}(\text{Br})(\text{CH}_3)$, < $\text{CH}_3\text{C}(\text{CH}_3)(\text{Br})(\text{CH}_3)$

3. a) $\text{S}_{\text{N}}2$ mechanism



inversion

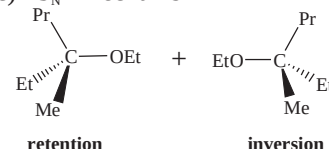
b) $\text{S}_{\text{N}}1$ mechanism



retention

inversion

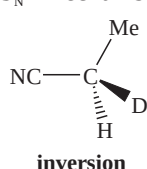
c) $\text{S}_{\text{N}}1$ mechanism



retention

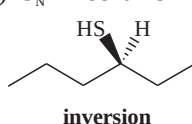
inversion

d) $\text{S}_{\text{N}}2$ mechanism



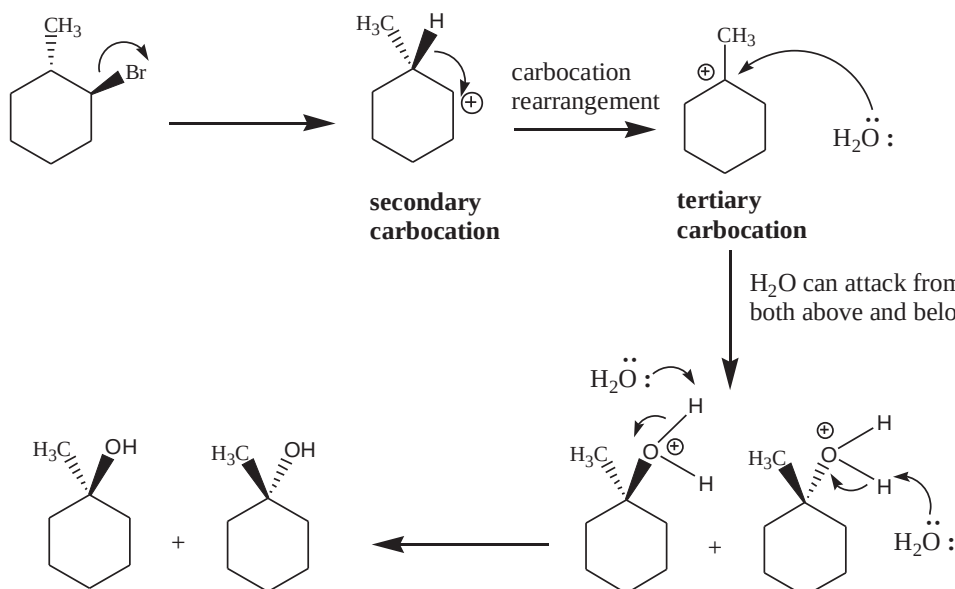
inversion

e) $\text{S}_{\text{N}}2$ mechanism



inversion

4. Substrate is a secondary alkyl halide and the nucleophile is a weak nucleophile. Therefore mechanism of this reaction has to be $\text{S}_{\text{N}}1$.



References

1. Wade, Jr., L. G.; Singh, M. S. Organic Chemistry, Sixth edition, 407-446.
2. Solomons, T. W. G.; Fryhle, C. B. Organic Chemistry, Tenth edition, 230-265.
3. McMurry, J. Organic Chemistry, Third edition, 359-386.

- 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).

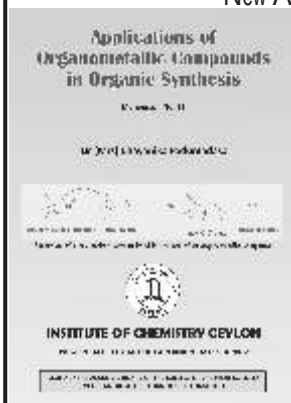
Any member who has paid membership fees for life (after 3years of such payment) is entitled for these benefits.
All members are advised to pay the membership fee for life and become beneficiaries.

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

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

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

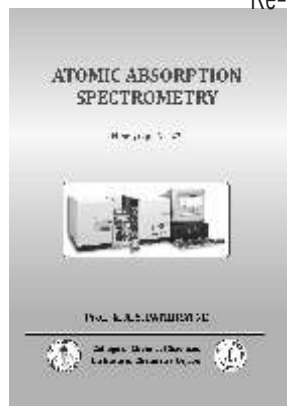
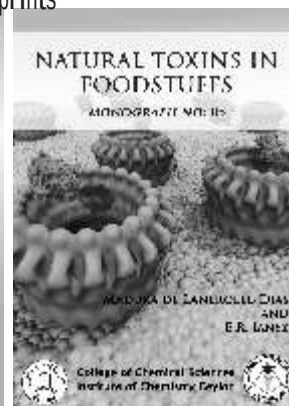
New Arrivals



Rs. 60/-



Rs. 200/-

**Rs. 100/-**

Rs. 50/-

Re-prints

| | | | | | |
|------------------------|-----|----------------------|-----|----------------------|---------|
| Deputy Registrar | 200 | Security | 214 | Dr. R Kandiah | 224 |
| Addl. Deputy Registrar | 200 | Office | 215 | Dr. H I C de Silva | 225 |
| Registrar | 201 | New Laboratory | 216 | Dr. T Gobika | 226 |
| Assistant Registrar | 202 | Fax | 217 | Dr. U K Jayasundara | 227 |
| Library | 203 | Pantry | 218 | Dr. R Parthipan | 229 |
| Account Division | 204 | Prof. M D P de Costa | 219 | IT Room | 230 |
| Old Laboratories | 206 | Institute Officials | 220 | | |
| Prof. JNO Fernando | 208 | New Board Room | 221 | Supplementary Campus | 2053148 |
| Dr. M Infas | 212 | Confidential Room | 222 | Dr. U S K Weliwegama | 203 |
| Auditorium | 213 | Prof. S Sotheeswaran | 223 | Dr. C Udawatte | 204 |



RSC NEWS

THE ROYAL SOCIETY OF CHEMISTRY SRI LANKA SECTION

1. Membership

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

Category

Number

| | |
|----------------------------|----|
| CChem, FRSC | 11 |
| FRSC | 05 |
| CChem, MRSC | 10 |
| MRSC | 20 |
| AMRSC | 08 |
| Affiliate /Under Graduate. | 06 |

Total Membership as at July 2014 **60**

2. Committee of Management

The following were elected to the Committee at the 53rd Annual General Meeting held in July 2014.

| | |
|-----------------|---------------------------|
| Chairman | - Mr. R M G B Rajanayake |
| Vice Chairman | - Prof. Sudantha Liyanage |
| Chairman Elect | - Mr. I M S Herath |
| Hony. Secretary | - Mr. Sulith Liyanage |
| Hony. Treasurer | - Mr. I M S Herath |

Committee Members -

Prof. W S Fernando
Dr. M P Deeyamulla
Mr. T M Kumar
Mr. W K Samarakoon
Mr. S Perasiriyan
Mr. W J P D Jayalath

3. Activities

3.1 Contributions to Activities of the Institute of Chemistry Ceylon

- (a) Full page advertisement of "Chemistry in Sri Lanka".
- (b) Contribution for the Interschool Chemistry Quiz
- (c) Award for the Best Performance at the Graduate ship Examination in Chemistry Part II Theory Examination

3.2 All - Island Inter School Chemistry Essay Competition.

3.3 Inter - University Chemistry Competition.

3.4 A/L teacher workshops.

3.5 Advanced Level chemistry seminar.

3.6 Book donation programmes

3.7 Industrial Visit.

3.8 Collaborations with SLAAS -E2 Work Shop and Seminars

3.9 Supporting Chemical Societies of Universities of Sri Lanka

4. Web Site

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

Mr. Sulith Liyanage
Hony Secretary

PUBLICATIONS OF THE INSTITUTE OF CHEMISTRY CEYLON

| Monograph | Title | Author | Price |
|-----------|---|---|-------------------|
| 01 | Textile Fibers | Mr T Rajasekeram | Rs.50/- |
| 02 | Principles of Food Preservation | Prof U Samarajeewa | Rs.75/- |
| 03 | Biotechnology | Prof C P D W Mathew | Rs.75/- |
| 04 | Recombinant DNA Technology | Prof J Welihinda | Rs.75/- |
| 05 | *Natural Toxins in Foodstuffs | Prof E R Jansz & Ms A S Perera | Rs.50/- |
| 06 | Fat Soluble Vitamins | Prof E R Jansz & Ms S Malavidana | Rs.50/- |
| 07 | Nucleic Acid and Protein Synthesis | Prof J Welihinda | Rs.75/- |
| 08 | Extraction of Energy from Food | Prof J Welihinda | Rs.50/- |
| 09 | Corrosion of Materials | Dr A M M Amirudeen | Rs.75/- |
| 10 | Vitamin C-Have all its mysteries been Unravalled ? | Prof E R Jansz & Ms S T C Mahavithanage | Rs.75/- |
| 11 | *Environmental Organic Chemistry (second edition) | Prof S Sotheeswaran | Rs.150/- (US \$3) |
| 12 | Enzyme Kinetics and Catalysis | Prof (Mrs) S A Deraniyagala | Rs.100/- |
| 13 | Insecticides | Prof (Mrs) Sukumal Wimalasena | Rs.95/- |
| 14 | Organotransition Metal Catalysts | Prof S P Deraniyagala & Prof M D P De Costa | Rs.75/- |
| 15 | Some Important Aspects of Polymer Characterization | Prof L Karunanayake | Rs.75/- |
| 16 | Hard & Soft Acids & Bases | Prof (Mrs) Janitha A Liyanage | Rs.65/- |
| 17 | Chemistry of Metallocenes | Prof Sarath D Perera | Rs.65/- |
| 18 | Lasers | Prof P P M Jayaweera | Rs.65/- |
| 19 | *Life and Metals | Prof (Mrs) Janitha A Liyanage | Rs.75/- |
| 21 | *Silicones | Prof Sudantha Liyanage | Rs.65/- |
| 22 | Pericyclic Reactions: Theory and Applications | Dr M D P De Costa | Rs.65/- |
| 23 | Inorganic NMR Spectroscopy | Prof K S D Perera | Rs.65/- |
| 24 | Industrial Polymers | Prof L Karunanayake | Rs.75/- |
| 25 | *NMR Spectroscopy | Dr (Mrs) D T U Abeytunga | Rs.65/- |
| 26 | Mosquito Coils and Consumer | Ms D K Galpoththage | Rs.100/- |
| 27 | *Atomic Absorption Spectrometry | Prof K A S Pathiratne | Rs.100/- |
| 28 | Iron Management on Biological Systems | Prof (Ms) R D Wijesekera | Rs.100/- |
| 29 | Nutritional Antioxidants | Prof. (Mrs) Sukumal Wimalasena | Rs.100/- |
| 30 | *f-Block Elements | Prof Sudantha Liyanage | Rs.65/- |
| 31 | Scientific Measurements and Calculations | Prof (Mrs) S A Deraniyagala | Rs. 80/- |
| 32 | Applications of Organometallic compounds in Organic Chemistry | Dr. Chayanika Padumasena | Rs. 60/- |
| 32 | Organosulfur Compounds in Nature | Prof. S Sotheeswaran | Rs. 200/- |

* - Second Edition /new print published on popular demand

CCS Publications

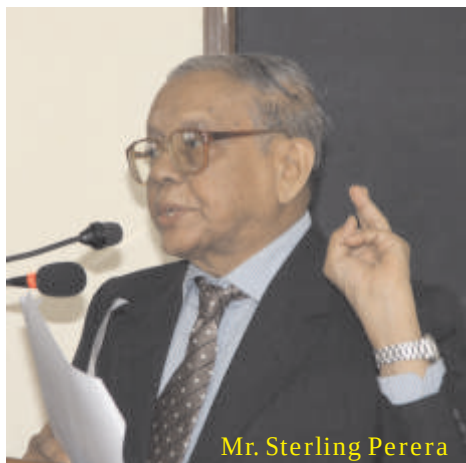
| | | | |
|----|--|---|-----------|
| 01 | Functional Group Analysis in Organic Chemistry | Prof A A L Gunatilake | Rs. 175/- |
| 02 | Zinc Metalloproteins | Prof S Sotheeswaran
Prof (Ms) R D Wijesekera | Rs. 175/- |

General Publications

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



Theme Seminar on
“Curricula and Evaluation in Chemistry for a Sustainable Economy”



Mr. Sterling Perera



Prof. Manjula Vithanapathirana



Dr. P A N Punyasiri



Ms. Sangheetha Srisikandarajah



Dr. Jayantha Gunatilleke



Professor H D Gunawardhana



Professor K R R Mahanama



Mr. L P R J Wijesinghe



Mr R P Samarakkody



section of participants



section of participants