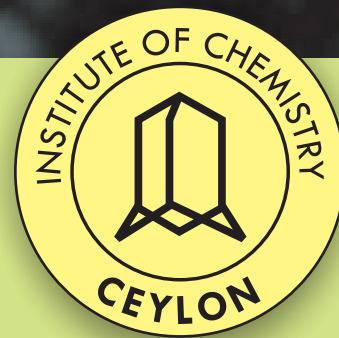
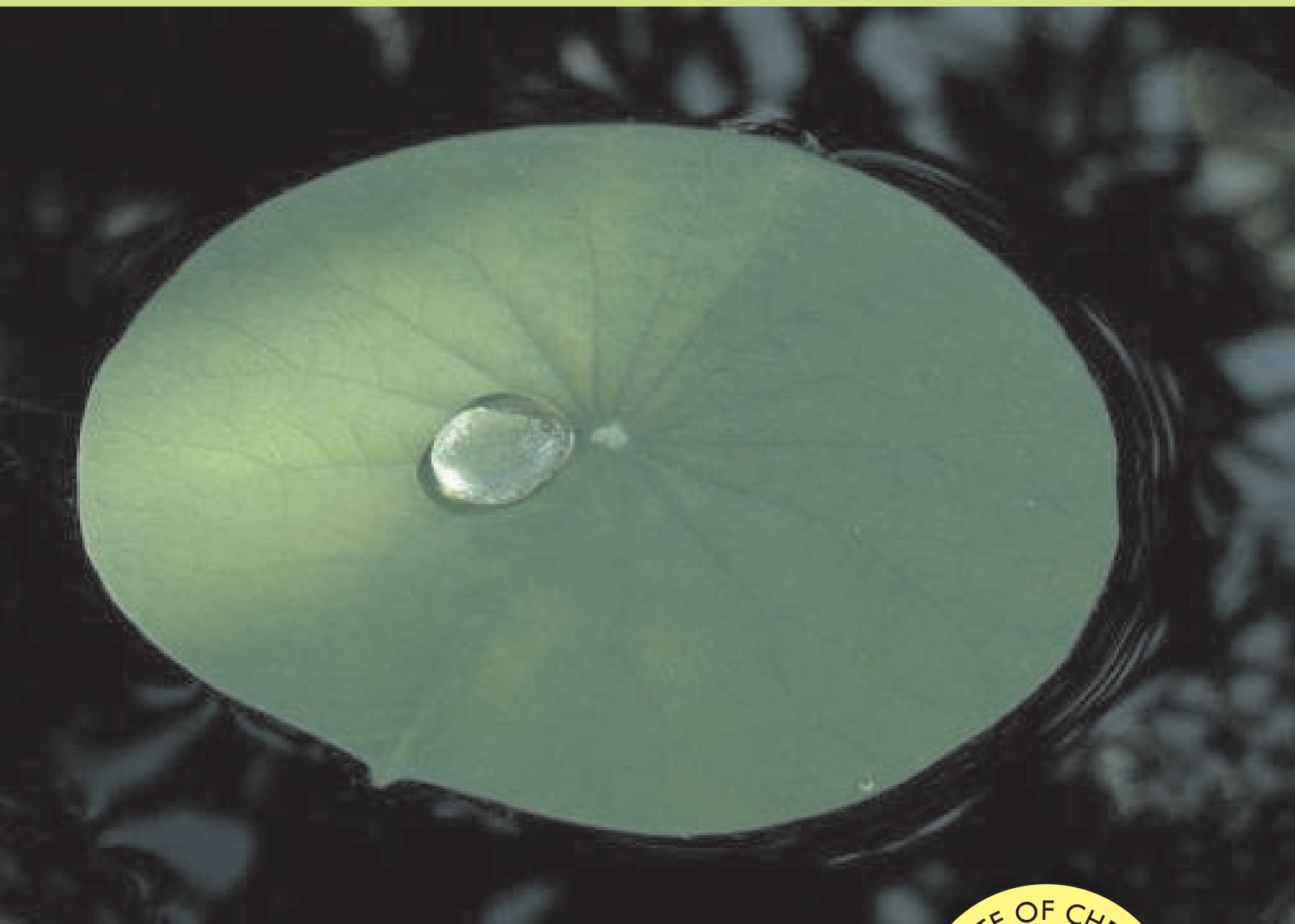


CHEMISTRY

I N S R I L A N K A



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

January 2015 - Volume 32 No. 01

Council of the Institute of Chemistry Ceylon - 2014/2015



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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. 32 No. 1

January 2015

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Theme for the year -

“Chemical Sciences in Food Safety and Security”

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Outline of our Institute

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

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

Corporate Membership

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

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

Revision of Membership Regulation

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

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

Tech.I.Chem.C.

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

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

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

Membership Applications

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

Current Subscription Rates

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

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

Entrance Fee

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

*per application for admission/transfer to any grade

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CHEMISTRY IN SRI LANKA

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

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

Chemistry and Forensic Science

Sakunthala Tennakoon

Government Analyst, Government Analyst's Department, Battaramulla



Forensic science is the application of natural sciences to matters of the law. In practice, forensic science draws upon chemistry, physics, biology, and other scientific principles and methods. The major

responsibilities of a forensic scientist are ; analysing samples such as hair, body fluids, glass, paint and drugs in the laboratory; applying various techniques as appropriate, i.e., DNA profiling, spectrometry, chromatography and the presentation of written and verbal expert evidence in court which may be cross-examined. The scientist will sometimes visit the scene to determine the sequence of events, any indicators as to who the perpetrator might be, and to join in the search for evidence.

There are several sub-disciplines under forensic science namely forensic toxicology, narcotics and psychotropic substances, firearms (forensic ballistics), explosives and fire investigations, forensic serology & DNA, forensic questioned documents & forensic miscellaneous etc. As it is mentioned earlier, forensic scientists require knowledge on different disciplines or probably combination of several disciplines to carry out their duties effectively and efficiently. However, the knowledge on chemistry is far more important in most of the fields.

Forensic Chemists analyse flammable substances and evidence from a scene of a suspected arson. Forensic Drug Chemists analyse suspected drugs of abuse such as heroin, cannabis (marijuana, hashish etc.), cocaine, and amphetamine etc. Forensic Toxicologists analyse specimens from individuals such as stomach contents, liver, kidney, blood and urine for alcohol, drugs, pesticides and other poisons. Forensic biologists or forensic chemists with knowledge on biology analyse blood and other body fluids. Crimes against property includes the analysis of

contact traces, i.e., glass and paint, also fire investigation and serial number restoration. In this respect, Forensic Trace Evidence examiners analyse hairs and fibers, paint, soil, and glass. Other Forensic Scientists specialize in footwear, tool mark, and tire impressions; firearms; explosives and questioned documents analyse and /or examine relevant physical evidence and issue reports on their findings.

In the case of most of the above analysis, the knowledge on chemistry is of paramount importance. Chemistry is used in forensic science to find out information from physical evidence. In criminal cases, chemists analyse substances such as blood, DNA and gunpowder residue in order to determine when and by whom the crime was committed.

Forensic science is fast developing all over the world and very sensitive newer techniques are immersing into the field. Of which sample preparation and analytical techniques play a major role. Introduction of solid phase extraction techniques in place of liquid-liquid extraction created an environmental friendly efficient extraction procedure which requires very low amount of material which is the case may be in most of the forensic cases. Use of mass spectroscopy couple with GC and HPLC (ie. GC-MS/MS, LC MS/MS and also FT IR) especially in the analysis of drugs and poisons, and also explosives etc. made forensic science a more chemistry based discipline. There are large numbers of research opportunities in this field internationally as well.

The Institute of Chemistry Ceylon being one of the institutes producing quality graduates could think of including forensic science at least as one of the optional courses in the degree programme in the future. This will be beneficial to the graduates both locally and internationally. Being the Government Analyst, I am very happy that both graduates and the students following DLTC course at the institute are keen in getting their training at the Government Analyst's Department.

Cover Page

The lotus leaf is able to keep the surface from wetting and exhibits a natural self-cleaning mechanism. This surface chemical phenomenon is used in producing smart textiles which apparently require no washing. For more details on applications of surface science see pages 24-28. Cover page picture copied from <http://ilportocodipinto.it/content/effetto-loto>.

FOOD SAFETY AND FOOD QUALITY—IS THERE SAFE FOOD WITH QUALITY FOR ALL CONSUMERS?

Mr. T Kandasamy

Retired Government Analyst

Food should be available in plenty at reasonable price to all consumers so that they can lead a healthy life. The consumers expect good quality and safe food. Providing Safe and Quality Food has become an important issue for governments of all countries. Providing safe food is achieved by having Food Laws and under the Food Laws having Food Regulations and Food Standards. The establishment of an organization such as Food Control Authority is necessary. Food Control Units/Departments where Food Regulations and Food Standards are made to supervise/monitor the supply or provide food to the consumers with good quality, nutritious and safe food is the responsibility of the government. Framing of Food Laws is important to the consumer for he is provided with safe/quality food but it is also important for the Industry that provides good food and gain the confidence of the consumers and for the country when its manufactured foods and the prepared foods are exported. Most countries have now Food Control Authorities. This paper will discuss the development of the Food Control from the time when the adulteration was at its height in the 19th century to the present day when most countries have Food Control Authorities.

The International Organisations such as Food and Agricultural Organisation (FAO), the World Health Organisation (WHO) and the Codex Alimentarius Commission (CODEX) to mention a few have Annual Meetings of member countries and also assist countries on various aspects of Safety and Security of Food. They have prepared Standards for Food so that member countries have them as guidelines for the preparation of the regulations and standards in their own country.

1. DEFINITIONS OF TERMS –FOOD SAFETY, FOOD SECURITY AND FOOD QUALITY

- (a) FOOD SAFETY is defined as the assurance that the food will not cause harm to the consumer when it is prepared and/or eaten according to the intended use (FAO 1997)

This definition takes into account the handling, preparation and storage of food in a manner that is safe and does not produce health hazards. This definition is repeated in every revised Codex

Hygiene document from 1997.

- (b) FOOD SECURITY- The World Food Summit of 1966 defined food security as existing “when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life”.
- (c) QUALITY is defined by the International Standards Organisation (ISO) in their Glossary of Terms as “Totality of features and characteristics of a product that bear on its ability to safety stated or implied needs”. It has been difficult to get a satisfactory definition for Food Quality. The closed definition that was available was “Food Quality is the quality characteristics of food that is acceptable to consumers”. This includes external factors as appearance (size, shape, colour, gloss and consistency) texture and flavor. Food Quality may include the food conforming to required Regulations and Standards for that food.

2. HISTORY OF FOOD ADULTERATION AND DEVELOPMENT OF QUALITY CONTROL OF FOOD

Historical records indicate that in the early days humans obtained their food by hunting wild animals and gathering food from plants. Then there was a gradual transition. Their life style changed to cultivating crops and rearing of animals for food. The village type of life created no problems. There was sufficient food. However there was no control in the way they cultivated their crops. It is said that the repeated cultivation of food on the same land in ancient Rome depleted the soil of its fertility and the Romans had to obtain their food from other countries. It is recorded that there were incidences of adulteration. There are records of adulteration of wine and bread in the very early days. Around 1200AD the bread was sold by weight. The bakers in order to increase the weight of bread included saw dust or metal amongst other substances in the flour. In 1202AD, King John declared an 'Assize of Bread' to control the bakers making a profit. Bread, wine and beer were the chief articles that were adulterated. Flour was mixed with chalk, alum and bone ash. Another most interesting

document in the Middle Ages (1268AD) in France on food was “*Livre Des Metter*”. This document outlined comparative practices of Trade Guides in Paris. In this work, provisions were for the protection of consumers' health and for ensuring the reputation of the trade. The punishments were severe. Under Louis XI in 1442, the punishments meted out for violations were fines, confiscation, expulsion from Guild and even corporal punishment. One extreme case that was reported was the sale of watered milk. Anyone who sold watered milk shall have a funnel placed in his throat and watered milk was poured down the throat until a doctor or barber declared the man cannot swallow any more without danger.

The conditions in UK in the nineteenth century were highly favourable for malpractices and adulteration. There was the industrial revolution, the growth of urban societies and the trade. There was a growth in population too. The urban population needed food. Many of the Europeans including people from England sailed to Asia and America. During their journeys to these countries they brought back many articles of food. There was trade in tea, coffee and spices. Tea and coffee were expensive to the common man in UK and Europe. Everyone loved to have tea or coffee but because it was expensive it was considered a luxury. Spices were brought from these countries too. Pepper was highly valued and was in great demand as a preservative of meat and other foods. Pepper was therefore mixed with gravel, leaves and twigs. Other spices such as mustard were adulterated with wheat flour. During this period drinking of tea and coffee had become very popular. All could not afford to buy tea and coffee. Spent tea leaves and coffee grounds could be bought from hotels and coffee shops. They were boiled with chemicals or adulterated with other roasted beans. The common adulterant for milk was the addition of water. The only checks on these malpractices were by Guilds. Some of these Professional Guilds were responsible to the government. In London there was Guild of Garblers whose duty was to check on spices particularly pepper and get the trade to clean the product of impurities. The examination was generally physical.

Frederick Accum born in Germany came to London in 1793. For a short period he worked as Laboratory Assistant to Humphry Davy. Later he established himself as a lecturer in chemistry, chemical analyst and consultant. Due to his interest in chemistry he undertook a considerable amount of analytical work looking into the purity of commercial products including food. He found gross adulteration of food. He

published a book on food adulteration “A Treatise on Adulteration of Food, a culinary poison” with a horrifying front page cover. He printed 1000 copies of this book and 1000 copies were sold out in a month. He regarded the adulteration of food a criminal offence.

In 1850, Sir Charles Wood, the Chancellor of the Exchequer told the Parliament that adulteration of coffee with chicory cannot be detected by chemical or any other tests. Dr. Arthur Hill Hassall, a London based Physician set out to show that the statement was not true. He examined some samples of coffee purchased in London and wrote an article in which he stated that with the use of a good microscope it was easy to identify chicory in coffee.

Thomas Wakely, Surgeon and Member of Parliament and the Editor of the Medical Weekly, “The Lancet”, noticed the article of Hassall and other similar articles. He was interested in the problem of adulteration and as he was in charge of the Analytical Sanitary Commission he invited Hassall to be the Chief Analyst which Hassall accepted. Between 1851 and 1854 Hassall analysed 2500 samples of food and published the results in the Lancet as reports of the analytical Sanitary Commission. He commended the genuine traders and gave the names and addresses of the defaulters. The reports of Hassall showed that adulteration was the rule of the day rather than the exception. Besides other methods he used the microscope on many occasions.

The articles of Accum and Hassall created general awareness in the public. Public agitation led to the setting up a Select Committee on Food Adulteration in 1855. The first Adulteration of Food and Drink Act was passed in 1860.

The 1860 Act permitted the appointment of Public Analysts. The appointment was not mandatory. To implement the Act there had to be Public Analysts to examine the food. Knowledge of Food Chemistry and methods of analysis of food were not available. The Act of 1860 was replaced by another in 1875 and this made it necessary for Boroughs to appoint Public Analysts. The reports of the Public Analysts were generally accepted by courts. Public Analysts may have to appear in courts on certain occasions. Therefore it was necessary they should have training and qualification from an organisation to hold the post of Public Analyst.

At the early stages of implementation of the Act there was general dissatisfaction from merchants and traders. They complained that they were unfairly prosecuted. It was no easy matter for the local

authorities to select chemist with the analytical expertise required for the work of Public Analysts. The Act had also mentioned 'medical' knowledge as one of the qualifications and hence the appointments were also given to Medical Officers of Health.

For the implementation of the Act a good laboratory with qualified analytical chemist was very important. Most chemists from the Universities were academics. However there were some private laboratories. It was at this period the Royal Institute of Chemistry became a qualifying and professional body, the aim being to work towards the advancement of chemistry and to ensure that the analytical chemists were properly qualified and trained. This was the need at that period of development of industries and control of the quality and purity of food. The Institute conducted examinations and awarded its own qualifications. Let me not go in detail into the early training and the changes that followed but only to mention that even today if you have to be a Public Analyst for a county you should have obtained the MChemA (Mastership in Chemical Analysis) qualification in the area of food, drugs, water including the use of microscope in the examination conducted by the Royal Society of Chemistry, UK. At the beginning the people who worked in private laboratories and followed classes conducted by the Institute or some colleges sat for Institute Professional examination.

3. DEVELOPMENT OF ANALYSIS OF FOOD

With the Food Act being in force it was the duty of the Local Authorities to implement the Act, The main responsibility was with the Analysts. The Analyst should have a good knowledge of food and many other products and be well trained in the Analytical Chemistry.

Although the Parliament passed the Act the lack of knowledge of food science and shortage of trained analytical chemist created a problem. There were no textbooks, the Public Analysts overcame many of these problems.

It is important that a good knowledge of the composition of food was necessary. A good understanding of analytical chemistry was also necessary. Analytical chemistry as such was there in the early days but applied analytical chemistry was not advanced in the nineteenth century. Knowledge of the composition of basic food was inadequate to determine adulteration or quality. The chemists knew such substances as fat, starches, sugars, proteins, and tannins were present in food but they did not know in what food

they were present and in what proportion. Reliable methods were necessary to identify them and estimate them.

The analytical processes known at that time were precipitation, distillation, filtration, and titration. It is mentioned that platinum was cheap. Dishes and crucibles were made of platinum and used for many analysis such as determination of total solids, ash etc. Today the laboratories cannot think of having Platinum dishes or crucibles. The glassware such as burettes, pipettes and separating funnels were made by the analysts. Some of the physical methods such as refractive index, specific gravity were fairly well established. Microscope was one of the instruments that was used extensively for checking adulteration. It is still one of the most useful instruments in today's food laboratory. Use of the Kjeldahl method for the determination of nitrogen and use of Rose-Gottlieb for determination of milk fat were also known. The alcohol content in beers and wines were made by distilling these and determining the specific gravity using a hydrometer.

With these facilities the Public Analysts did a wonderful job. They analysed several samples of food over a period of one to two years covering all seasons. They collected the data and discussed them in their Association and published them in their journal "Analyst" which was started by the Society of Public Analyst in 1877. The idea was all Public Analysts to have record of the results. These Practicing chemists decided to form an Association known as "Association of Public Analysts". The Society of Public Analysts did not have a journal of their own to publish their results or express their views relating to the 1875 Law. They obtained a column from *Chemical News* to provide the information the members needed. Members were kept informed of their work, the results of their analysis. Then they decided to have a journal of their own. It was the "Analyst" and this was first published in 1877. This journal provided almost all work of the Public Analysts. The *Analyst* had all the analytical data and methods of analysis published in the Analyst. Most of the journals from its first publication were useful as reference books. **IN FACT THE GOVERNMENT ANALYSTS DEPARTMENT, SRI LANKA HAD MOST OF THE JOURNALS, "ANALYST".**

The pioneering work was valuable. As an example they tried to find out whether there was any relationship between different constituents in the sample of food. It would useful to state few examples here. They found that the Ash, Protein, Lactose (A:P:L) ratio was always

2:9:13 for genuine milk. After analysis of liquid milk, milk powder or evaporated (condensed) milk if the A:P:L ratio was 2:9:13 it can be presumed that none of the major components has been added or abstracted. What happens to milk if water has been added. The A:P:L ratio will be the same but other tests will indicate it is not genuine milk. Here the value obtained by determination of freezing point of milk was useful. The freezing point is mentioned in many textbooks and the method is used in many laboratories. Take the case of the Chinese milk which hit headlines in recent times where they tried to increase the nitrogen content, this ratio would have been useful besides other tests. Out of several analysis one more is worth mentioning. This is the estimation of milk fat by the Reichert, Polenske, Kirchner (RPK) values which is obtained by distillation of the fatty acids under very specific conditions. This method is still used by dairy farmers and those manufacturers of butter. There are of course today GLC methods.

In this article I have mentioned in detail about the work of the Public Analysts. The names of many Public Analysts have been omitted. However it should be remembered that they did very valuable service. The Food Act of 1875 provides a Referee Analyst so that the sample can be tested by an independent Analyst. In UK the Referee Analyst was from the Government Chemists Laboratory, London. In the early days there were differences in the reports of the same sample.

What was intended to show was that to control the quality of food, to show it is not substandard, not adulterated there should be a well-equipped laboratory with qualified chemist? The early Public Analysts in this respect have performed very dedicated work.

The article has only been discussing about the adulteration in UK and the development of Food Laws in UK. A brief mention is necessary to show that there were similar problems in other countries and they too had Food Laws.

In the United States of America, Dr. Harvey Washington Wiley, Professor of Chemistry at Purdue University set about testing various products for purity and nutritional quality. He was hired in 1883 by the United States Department of Agriculture (USDA) to head the Bureau of Chemistry. Besides various test methods he employed somewhat a novel method of checking food preservatives for toxicity. In 1902 he formed a "Human Poison Squad" of 12 volunteers from USDA to whom he gave controlled diet containing the chemicals that were generally used as additives such as boric acid, benzoic acid salicylic acid to record their

effects on these humans. Some had diets with no chemicals added. He campaigned so vigorously and as a result of his campaign the Food and Drugs Act 1906 was passed by the congress. There have been several changes in the Act.

Countries like France, Sweden, Germany the problem of adulteration was discussed. The first city in Europe to establish a municipal laboratory to investigate fraud was Brussels in 1856. Then Paris had a laboratory in 1878. These laboratories mainly serviced the trade who were suspicious of the suppliers. The Food Acts in some of the countries, France (1851 and 1905), Britain (1860, 1872 and 1875), Germany (1875), Belgium (1890), Austria (1896), Switzerland (1905) and USA (1906 and 1938). These were the first Acts at the time the countries had problem of food adulteration.

4. DEVELOPMENT OF FOOD ACT IN SRI LANKA

Let us discuss the introduction of Food and Drugs Act in Ceylon. In 1900 tea and milk were the main two food items to be considered. Milk was supplied to all hospitals. The suppliers supplied milk adding water to it. On many occasions the milk supplied had over 50 percent added water. One wondered whether milk was added to water. Ceylon was mentioned at one of the Annual Dairy Federation Conference as achieving the notoriety by taking the first place in the world for milk adulteration. In condensed milk, the milk fat was extracted and replaced by lard. When hospitals were supplied with lactometers to check the quality of liquid milk, the suppliers added water and sugar. This practice went on even between 1950 -1960. Then supplies of milk to hospitals were stopped.

Professor Browning, Professor in Chemistry and Reader in Physics was appointed as a Government Analyst in 1906. The Annual Reports of Government Analysts Department has the number of samples examined and how many were adulterated. In 1912, the Government Analyst was given the US Food and Drugs Act 1906 by the American Consul. In the same year the Colonial Secretary had given the Government Analyst the UK Food and Drugs Act 1875. A committee consisting of the Attorney General as the Chairman, the Government Analyst, Medical Officer of Health and Manager, Cargills Limited were appointed by the Colonial Secretary to study the UK 1875 Act and bring out an Act to suit Ceylon. For various reasons such as finance, suitable building for the Government Analyst and the wars there was no Food Act until 1949. The

Draft was prepared by the committee immediately after the committee was constituted. The committee felt that to properly implement the Act, Food Standards and Food Regulations were necessary. They recommended a Board with Principal Collector of Customs as Chairman, Government Analyst, Medical Officer of Health, two members nominated by the Chamber of Commerce and other members appointed by the Governor. Unfortunately the Draft was set aside. Finally Ceylon had its first Food and Drugs Act in 1949. The Act was not satisfactory. The Local bodies had to Gazette the implementation of the Act in their areas and also had to identify an analyst to work for them. In effect the Act was operative only in a few areas in Ceylon and not the whole of Ceylon. There were 34 Food Standards. Since Ceylon was importing most of the imported foods were examined. Customs would take samples of the imported food and send them to the Government Analysts to check whether the imported foods conformed to the Food Standards. However checks for locally produced or food offered for sale was poor. On the recommendation of Dr. Piyaseeli, Assistant Director in charge of food at the Department of Health a Interdepartmental Committee was appointed in 1969 to look into Food and Drugs Act 1949 and to bring in necessary amendments. This committee decided to recommend new Acts. They spent a lot of time, had several meetings and decided to recommend two Acts, the Food Act and the Cosmetics, Devices and Drugs Act. Sri Lanka was the first country to split the Food and Drugs Act into separate Acts. But it took the Government a couple of years to Gazette the two Acts. It was done in 1980. The Acts are known as the Food Act 1980 and the Cosmetics, Devices and Drugs Act 1980.

In the meantime between the years 1970 to 1979 Sri Lanka had witnessed the worst type of adulteration of food. The Government in order to encourage local industries to be set up, restricted or stopped imports of food items except for a very few essential items under permit granted to the importer.

A few examples of the types of adulteration are worth recording. Most of the spices and condiments were either adulterated or substandard. Turmeric powder sold in the market was very heavily adulterated with wheat starch. Some samples had about 90 percent wheat flour. At that period wheat flour was sold at Rs. 2 a kilo and turmeric was sold at Rs. 22 a kilo. The consumers were deceived by the colour of turmeric sold in the market because the trade had added a yellow colour, metanil yellow. Even tubers had wheat starch on them. Adding starch to tubers is a laborious process but

the tubers had 25 percent wheat flour. A merchant in Singapore wanted turmeric rhizomes from Sri Lanka. A merchant in Sri Lanka accepted to ship the turmeric to Singapore. He collected the amount required from the local open market. When the consignment was ready, the customs took a sample for examination and sent the sample to the Government Analyst and the Government reported that it was adulterated. The merchant's consignment was ceased and he was also fined. Poor merchant he was unaware of the malpractice. Chille powder had starch but coloured with a red dye.

Besides adulteration there was shortage of essential food items in the country. In fact according to the definition in this article there was no Food Safety, Food Quality or Food Security.

The new Food Act was Gazetted in 1980 and import restriction were removed. There were a number of imports of food items. Since there were no imports for a long period and the trade was apparently unaware of the Food Act. In order to make the trade know that they have to import food items conforming to standards and avoid import of sub quality food the Food Advisory Committee in 1980 decided to check all food imports. The Government Analyst with the collaboration of the customs checked 1100 imported samples in 6 months. During the course of this checking that the authorities found canned fish imported had only 30-35 percent fish. Immediate regulations were brought in that the fish content should be 70 percent. New Food Regulations and Food Standards had to be brought in under the new Act.

5. PRESENT POSITION OF FOOD CONTROL ACTIVITIES IN SRI LANKA

The Sri Lanka's Draft Food Act was ready for presentation to Parliament in 1969. There was a change of Government in 1970 and the Assistant Director Dr. Piyaseeli who was in-charge of Food Control activities and under whose guidance the Interdepartmental Committee prepared the Draft left the department in 1970. The officers who succeeded him did not consider Food Control needed priority treatment. This was the 1970 -1977 period. Not only was the Draft ready, even Food Regulations and Food Standards in Draft Form were ready. The Regional WHO office in Delhi sent the retired Government Analyst, Mr. Janathanan Iyer from Kerala (India) as a WHO consultant to help the Government of Sri Lanka to prepare the Food Act and hold a few training classes for the implementing staff, the Food Inspectors and Public Health Inspectors. Mr.

Iyer met the Additional Government Analyst who was a member of the Interdepartmental committee for the arrangement of his programme. He was surprised to see the Draft Food Act and Draft Food Regulations were already there. He did not have to spend his time on drafting a new Act but to go through the draft that was already there. He had now sufficient time to train the Inspectors and take them to a few Manufacturing centres. The Consultant Mr. Iyer's visit was in 1976 for 4 months and later again in 1977 for 3 months.

The new Food act was Gazetted in 1980 as the Food Act 26 1980. Implementation of the Food Act is with the Ministry of Health. In 1980 there were regular meetings at the Health Department where the Director General of Health Services as the Chief Food Authority presided in order to approve the Food regulations and Food Standards. After a couple of meeting it was decided to appoint a sub-committee to go through these documents and submit it to main committee with their observations. At that stage the Food Unit had the Director, Environmental & Occupational Health to supervise the work of the unit. There was also a Deputy Director and a senior Food and Drugs Inspector. As this is set there was a delay in getting the Regulations approved. The Regulations have to be approved, translated into Sinhalese and Tamil and send to the Legal Draughtsman.

In February 1981, the Additional Government Analyst, a member of the Food Advisory Committee had to go to the FAO office in Rome on a programme where he was going to visit laboratories in India. He met Dr. Rajkumar Mallik, Head of the Food Nutrition and Food Regulations and Food Standards unit. The Codex holds once in two years a Coordinating Committee meeting for each region. The Coordinating Committee for Asia meeting was to be held in India. India could not hold it. Dr. Malik asked whether Sri Lanka could host this meeting. The Coordinating Committee meeting was held in Sri Lanka in February 1982 and Sri Lanka had a group of 22 delegates led by the Additional Government Analyst, a member of the Food Advisory Committee. It was a very successful meeting from the point of the FAO, Rome.

Dr. Malik after reviewing Food Control activities suggested that Sri Lanka to write out a proposal for strengthening of the National Food Control Infrastructure and that FAO will try to get the fund for the project. It was the UNDP/FAO/SRL/84 "Strengthening of the National Food Control Infrastructure". This project commenced in 1986. The plan was to have two new Food Laboratories, Food

Control Administrative Unit (FCAU) with full complete compliment of staff like scientific officers etc and a full time Director to be in charge of the unit and training of field staff. Unfortunately only one Food Laboratory at Kalutara was set up in this project for lack of funds. No attempt was to set up the Food Control Unit as suggested in the document, as the Deputy Director of Public Health Services had stated that he will be able to manage Food control activities. The project was from 1984 to 1988.

The Review team that came to review the success of the project noted that the money was well utilized although it was possible to have only one new laboratory. They were disappointed that FCAU was not there. However they recommended that funds be made available to continue the project.

The Part II of the project SRL/92/006 commenced in 1996. Fortunately there were 4 Sri Lankan UN National consultants, thereby saving a lot of money for other activities. The Kalutara Food laboratory was further strengthened. A new well equipped Food Laboratory was set up at Anuradhapura. The Director, Environmental and Occupational Health was asked to be also the Director of Food Control unit. He was given one Assistant director and a few Food and Drugs Inspectors.

Under the Food Act there is the Food Control Administration Unit (FCAU). FCAU manages all food control activities. Under the FCAU there is a Food Advisory Committee (FAC). There are about 25 members. The members are from departments that are connected with food, members from Chamber of Commerce, member from food industry, food scientists. They meet once a month normally but there may be a meeting in between if some important issue is to be discussed. The Chairman of FAC is the Director of Health Services. He is also Chief Food Authority. FAC appoints sub committees. There is one Standing Subcommittee that meets regularly every month. This committee looks into matters that were discussed at the monthly FAC meeting.

There is sufficient staff at periphery or the District/local level. There are Medical Officers of Health, the Food Inspectors and Public Health Inspectors to implement the Food Act.

The staff at FCAU consists of the Director, two Assistant Directors and a few Food Inspectors. The Food Inspectors at the central unit also attend to food imports at the Customs. It is difficult to fill all the vacancies of Food Inspectors at the Central unit as most of them prefer to work at the District level.

Let us look at the staffing in the Central Unit. The Director is a Medical Officer. Since the Food Act came into operation from 1949 and it was with the Health Department, the Director has been a Medical Officer. The Directors do not remain long. So some of them do not show that amount of interest and to most of them Food control is new. They depend a lot on the members of FAC. If the Food Control to be implemented in a satisfactory manner the Director should acquire knowledge in Food Science and be in the unit for a number of years. As it is, the Directors are there for a few years and they wait for their promotions and move into other sections of the department or retire. In order to retain the services of the Director for a longer period, this section should be considered a special unit of the Health Department and the post be up graded to the level of Deputy Director General of Health Services.

There should be two Deputy Directors who also have been given training in Food Science and Food Control Activities. They will help the Director in the Unit and other sections in the unit which I will refer to later.

The unit should be expanded to have a number of scientific officers. These officers should be in various scientific disciplines like Food scientists, Food Technologists, Biochemists, Nutritionists, Microbiologists etc. The need for this unit is so very important that the authorities have so far not taken the trouble to make the recommendation to the authorities. There are so much of activities in the area of food technology and food production. They should be able to collect all literature in the area of Food science. They should know the Food Laws of other countries. There are a lot of materials put out by FAO, WHO, CODEX etc on food and allied areas. Information related to management of Food safety, Food quality, food Security should be available to the authorities.

It was noticed while writing this paper that there was the "The Fisheries and Aquatic Resources Act 1996. FAC has been preparing Standards for fish and dried fish products. Did the members of the FAC know about the above Act and clauses in it? One of the sections in the Act is worth reproducing here" Part x of the Fisheries and Aquatic Act (1996) grants the Minister general powers to make regulations with regard to the handling and distribution of fish, fish products and other aquatic resources as well as licensing of the establishment for the processing of fish and other aquatic resources and the conditions attached to such licenses."

I have quoted the above to show that there was such

an Act. How many of FAC members know of this Act and if a direction was given to license and register a canned fish factory they may have done it without the knowledge of the Fisheries Act? How many Acts are there? A well-established central unit would have collected and catalogued all these materials.

Another example that needs to be mentioned here is a paper by Environmental Foundation, a non-profit public interest environmental organization in Sri Lanka. The paper is titled "EFL Position on Genetically Modified Food Ban in Sri Lanka –August 2001". This was the time when FAC was trying to bring in Regulation on GM.

The Regulations are at resent prepared by members of the FAC who have their own work in their Institution. So preparation takes time. If the unit is well staffed they could be given the task to prepare the regulations.

The next drawback in the Food Control is that there are two or more institutions involved in Food Control activities. This creates problems. A case in point is the compulsory testing of imported foods by two organisations. When SLSI brought in the compulsory testing of 19 food products it was pointed out that this duty came under the Food Act and there were Food Inspectors at the Customs. The UNDP consultants who were in Sri Lanka in connection with a project were surprised with this situation where the importer has to go through two organisations before his product was released. Even after this was pointed out the SLSI has brought in many more food items under compulsory inspections.

Consumer Affairs Authority (CAA) at one stage wanted to go into the work carried out by the Food Authority without working along with the Food Authority leading to a bit of confusion.

A report entitled "Food Control Management In Sri Lanka" by Bhagya Madusanka mentions about multiple organisations in the food control system. Some of the statements in his are reproduced here.

"In study of prevalent national food control frame work of Sri Lanka, the central food control administration does not seem to cover the whole spectrum of farm to table continuum of the food chain."

"The fragmented mandate of food controlling is a major concern in local food controlling system."

"To cut short, at the moment the local food control mechanism does not have a farm to table approach and it is following a Multiple Agency System in organizational structure of national food controlling. It has resulted following drawbacks

- *Lack of overall coordination in national level*
- *Duplication of regulatory activities; duplication of Import inspection by FCAU and SLSI*
- *Conflicts between public health objectives and facilitation of trade and industry development*

I have quoted a few paragraphs from the report but it is worthwhile having a look at the report as a whole and read his suggestions and recommendations.

The restructuring Food Controlling activities have to be considered seriously. A broad based committee should be appointed to study in detail. For the present the suggestion of expanding FCAU with better and more qualified staff and regular interdepartmental discussions will help.

There is another factor of importance. There is no recent data on composition of the indigenous food crops over a year covering all seasons. There may have some work in this area in the past. This data is very important particularly in determining the quality of a product in the market. There are number of Universities offering Food Science courses. They can obtain grants from some agency and get students to carry out analysis of food and collect the data. There exists a problem of determining of the fruit content in jams and cordials. The Public Analysts in UK had analyzed the fruits for potassium, phosphorus and had maximum, minimum and average values. These values used to determine the fruit content, in addition to other analytical figures for that product.

The use of pesticides in our crops could result in having pesticide residues in fruits, vegetables and other crops. Are there any data of residue levels and are they used in the recommended manner? Is there any control on the quality of fertilizers used? Is there any connection between the use of these chemical and the kidney disease? Has there been proper investigation carried out?

There is so much movement of food within the country and between countries it is very important to have a check on the quality and safety of food available to the consumers. Contamination could occur at any stage during these movements. There are new types of food. With the knowledge in Food microbiology, food chemistry and food technology new food products with better nutrition or better keeping qualities are produced. In the years to come Nano technology is likely to bring in new products. One involved in the field of food safety programme should keep in touch with all the developments.

It is also important to be vigilant with trade

producing poor quality product or trying to market fraudulent products like the baby milk food from China. It is necessary to have knowledge of what is happening in the world. In the EU sector there are number of food recalls.

There are safeguards and control in many countries but all of them not to the maximum level expected. Some have very strict vigilant level and better control and some it is low, due to what reason. It is the duty of all governments to provide safe and quality food, They should examine whether the food control system is working satisfactorily.

It is necessary to review our Food Control System. As stated above there are a number of deficiencies.

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Common Naturally Radioactive Foods

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Technically, all foods are slightly radioactive. This is because all foods and other organic molecules contain carbon, which naturally exists as a mixture of isotopes, including radioactive carbon-14. That's the basis for carbon dating, used to identify the age of fossils. However, some foods emit much more radiation than others. Here's a look at some naturally radioactive **foods consumed in Sri Lanka** and how much radiation you get from them.

1. Bananas

Bananas are sufficiently radioactive that they can set off radiation alarms at ports and airports. They offer 1 pCi/kg (pico-Curie per kilogram) from radon-226 and 3,520 pCi/kg from potassium-40. The high potassium content is part of why bananas are so nutritious. You do absorb the radiation, but it's not harmful.

2. Carrots

Carrots give you a pico-Curie or two of radiation per kilogram from radon-226 and about 3,400 pCi/kg from potassium-40. The root vegetables are also high in protective antioxidants.

3. Potatoes

As with carrots, white potatoes offer between 1 and 2.5 pCi/kg of radon-226 and 3,400 pCi/kg of potassium-40. Foods made from potatoes, such as chips and french fries, are similarly slightly radioactive.

4. Low Sodium Salt

Low sodium salt contains potassium chloride, KCl. You'll get around 3,000 pCi/kg. No-sodium salt contains more potassium chloride than low-sodium salt and thus is more radioactive.

5. Red Meat

Red meat contains appreciable amounts of potassium, and thus potassium-40. Your steak or burger glows to the tune of about 3,000 pCi/kg. Meat is also high in protein and iron. The high amount of saturated fat in red meat presents more of a health risk than the radiation.

6. Beer

Beer gets its radioactivity from potassium-40. Expect to get about 390 pCi/kg. That's only about a tenth of the radiation you'd get from the same amount of

carrot juice, so from a radiation standpoint, which would you say is healthier?

7. Drinking Water

Drinking water isn't pure H₂O. Your radiation dose varies according to the water source. On average, expect to pick up about 0.17 pCi/g from radium-226.

8. Peanut Butter

Peanut butter releases 0.12 pCi/g of radiation from radioactive potassium-40, radium-226, and radium-228. It's also high in protein and is a good source of healthy monounsaturated fats, so don't let the slight rad count scare you off.

Radioactive Iodine-131 in foods

Iodine is one of the 64 elements that make up 0.4 percent of the earth's mass and occurs in an abundance of 0.3 ppm. Although there are iodine-deficient areas in the world, traces of this element can be found in practically all plant and animal life. The significance of iodine in the metabolism of animals and man has been well established. The traditional sources of iodine in the diet are primarily the marine fishes and certain vegetables and fruits, including asparagus, cabbage, green beans, potatoes, lettuce, grapes, pears, and pineapple. On the other hand, foods derived from terrestrial animal sources, such as milk, eggs, and meat, are relatively low in iodine.

On 27 March 2011, the Massachusetts Department of Public Health reported that ¹³¹I was detected in very low concentrations in rainwater from samples collected in Massachusetts, USA, and that this probably originated from the Japanese Fukushima power plant. Farmers near the plant dumped raw milk, while testing in the United States found 0.8 pico-Curies per liter of iodine-131 in a milk sample, but the radiation levels were 5,000 times lower than the FDA's "defined intervention level."

Fortunately, we, in Sri Lanka, are not too close to places where there are huge nuclear power plants, which may cause damage to the foods we consume. But we should be careful with imported foods coming to the country from places where there have been nuclear accidents.

The Next Global Pandemic

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The tsunami that killed 140,000 people across southern Asia in December 2004 ranks as one of the most devastating disasters in recent decades. But the next global catastrophe could be much worse. It is likely to kill many millions of people, can sicken a quarter of the world's population and send the global economy into a tailspin. *Influenza* is a highly contagious respiratory virus that poses a serious threat to public health. On average, seasonal influenza epidemics cause 36,000 deaths and over 200,000 hospitalizations annually in the US.¹ In addition, emergence of novel *Influenza* strains could lead to pandemics resulting in millions of hospitalizations and deaths worldwide. Though vaccines are available for seasonal influenza, generation of vaccines for a pandemic strain can only occur after the emergence of a pandemic and may require up to 6 months.² Hence, anti-influenza drugs represent not only a prophylactic approach, but also an important early control measure of disease. Currently, the leading drugs available to treat influenza infections are the neuraminidase inhibitors Relenza® (zanamivir) and Tamiflu® ((-)-oseltamivir phosphate).³ However, development of influenza strains with significant resistance against tamiflu and other antivirals due to constant evolutionary pressure demand the development of new antiviral drugs for the treatment of influenza.

Influenza viruses are classified as members of the *Orthomyxoviridae* family. Members of this family have a genome composed of negative-sense, segmented, single stranded, ribonucleic acids (RNAs). The family of *Orthomyxoviridae* contains five different genera: the influenza A, B and C viruses, Thogotovirus and Isovirus. Influenza viruses type A, B and C are distinguished according to antigenic differences between their internal nucleocapsid (NP) and matrix (M) proteins.⁴ Further, all influenza A viruses are classified into subtypes based on the antigenic characteristics of their surface glycoproteins; hemagglutinin (HA) and neuraminidase (NA). 16 Different HA (1-16) subtypes and 9 different NA (1-9) subtypes of influenza A viruses have been identified thus far.⁵

Influenza virus nomenclature for different influenza virus strains includes their genus, the species

from which the virus was isolated (except for humans), location of isolate, the number of the isolate, the year of isolation, and the HA and NA subtypes. For example, the nomenclature: A/California/7/2009 (H1N1) represents a type A influenza virus, isolated in California as a virus strain 7, isolated in 2009, and according to the HA and NA characteristics, this virus is assigned as subtype H1N1.⁴

Influenza A, B and C viruses are also distinguished according to the species they infect and the number of RNA segments in their genome (Table 1.1). Influenza B viruses infect only humans while influenza C viruses have been isolated mainly from humans and in some cases in swine. Thus, Influenza B and C usually do not cause severe disease and are responsible for seasonal epidemics, but not pandemic flu. In contrast, Influenza A viruses naturally infect a variety of avian species, humans, swine, horses and rarely some other mammalian species. Wild waterfowl act as natural asymptomatic carriers of influenza A viruses. Occasionally, viruses are transmitted from these birds to other species which may result in devastating outbreaks in domestic poultry or give rise to human influenza pandemics.⁴ Hence, the focus will be on Influenza A in the following sections.

Table 1.1 Factors that distinguish the three different influenza virus genera.

Influenza A	Influenza B	Influenza C
8 RNA Segments	8 RNA Segments	7 RNA Segments
3 key membrane proteins HA, NA, M2	3 key membrane proteins HA, NA, M2	1 key membrane protein HEF
Infects Humans, other mammals and birds	Infects Humans	Infects Humans
Causes epidemics and Pandemic influenza	Causes seasonal epidemics	Only minor disease

The influenza A viruses exhibits pleomorphism and can be visualized as either spherical or filamentous particles. The spherical virus particles are characteristic for egg or tissue culture grown viruses (diameter of 80-120 nm) while filamentous particles are mainly characteristic for fresh clinical isolates (diameter ~300nm).^{4,6} The virions of the influenza A viruses possess a complex structure and have a lipid envelope derived from the plasma membrane of the host cell in which the virus infects. HA, NA and matrix

2 (M2) proteins are embedded in the viral envelope and project from the influenza A virus surface (Figure 1).⁴ Morphologically, influenza A virus particles are characterized by the presence of distinctive rod-shaped spikes of HA and mushroom-shaped spikes of NA when observed with an electron microscope. These spikes are usually 10-14 nm long and the estimated ratio of HA to NA is 4:1.^{4,6}

Within the lipid envelope, the virion is lined by the M1 protein, which forms the viral capsid. Encapsulated within the lipid envelope and protein capsid, Influenza A viruses contain eight distinct single stranded RNA (ssRNA) segments. These eight viral RNA segments of influenza A viruses encode 11 recognized gene products. These are PB1, PB1-F2, PB2 and PA, HA, NP, NA, M1 and M2, NS1 and NEP/NS2 proteins.⁴

PB1, PB1-F2, PB2 and PA play important roles in influenza virus replication. The M1 protein forms the viral capsid whereas NP help package the viral genome.

Hemagglutinin: HA is an integral membrane glycoprotein found on the surface of Influenza viruses. HA binds to sialic acid receptors on the cell surface allowing the attachment of a virus particle to a cell. HA of viruses that replicate in different species have affinity for sialic acids with different linkages. Human viruses preferentially bind to N-acetylneuraminic acid attached to the galactose sugar by an $\alpha 2,6$ linkage (SA $\alpha 2,6$ Gal) while avian viruses mostly bind to sialic acid with an $\alpha 2,3$ linkage (SA $\alpha 2,3$ Gal). However, this influenza A virus specificity is not absolute and it is reported that both avian and human cells can contain both neuraminic acid linkages. In addition, swine influenza viruses can recognize both SA $\alpha 2,6$ Gal and SA $\alpha 2,3$ Gal types of sialic acid receptors. Thus HA determines the species specificity of a given influenza virus. HA mediates the fusion of the viral envelope and the endosomal membrane, which results in the release of the viral genome into the cytoplasm. In addition, HA is the major surface antigen against which the host immune system generates neutralization antibodies.

Neuraminidase: NA is the second major integral membrane glycoprotein of the influenza virion. Also known as sialidase, NA is a glycoside hydrolase enzyme, which catalyzes the hydrolysis of terminal sialic acid residues. Due to this enzymatic activity, NA plays an important role in the release of new viruses from infected cells as it disintegrates bonds formed between HA molecules on new virus particles and the sialic acid residues on the infected cell surface. In addition, influenza A NA has also been shown to play a

role in early stages of infection, possibly by facilitating virus entry into the cell and NA has also been shown to assist the motility of the virus particles in the respiratory tract.

Like HA, NA contains highly variable regions considered to be antigenic sites and is the second major target of the host immune system. Since viral neuraminidases are distinct from human sialidases, Influenza NA has also been the target of several anti-influenza drugs.

M2 protein: M2 acts as ion channel, which permits the influx of protons from acidified endosomes into the interior of the virus. This allows the dissociation of the viral genome from the rest of the viral components, thus completing the uncoating process. Due to this essential function in the influenza lifecycle, the M2 protein is highly conserved among influenza strains, making it a prime anti-viral drug candidate. Several commercially available anti-flu drugs target the M2 protein. In addition, the external portion of M2 has also been used as a target to develop a universal influenza vaccine development.

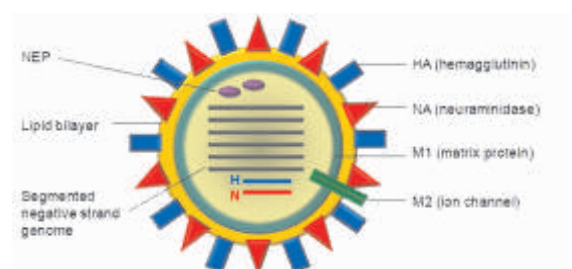


Figure 1.1 Schematic of influenza A virion structure. The virus is composed of 8 RNA segments contained within a protein capsid. The viral polymerases and other proteins required for viral replication are also packaged into the virion. The virus is enveloped by a lipid bilayer and the integral membrane glycoprotein HA, NA and M2 are embedded in the viral envelope.

Influenza A virus replication begins with attachment of HA to sialic acids on the cellular surface. Following attachment, influenza A virus enters the cell by receptor-mediated endocytosis (Figure 1.3). Successful uncoating of the virus depends on the presence of the M2 ion channel, which permits the influx of protons from the endosome into the virion. This proton influx results in the dissociation of the viral genome from the M1 protein.⁴ The HA mediated fusion of the viral envelope with the endosomal membrane and the M2-mediated release of the viral genome from the viral capsid completes the uncoating process and results in the release of free

viral RNPs to the cytoplasm of the host cell. The released RNA-protein complexes migrate into the host cell nucleus where influenza virus transcription and replication occurs. Once in the nucleus, the viral RNA (vRNA) is transcribed into messenger RNA (mRNA). Replication occurs via a two-step process. First a full-length complementary RNA (cRNA) is made and this in turn is used as a template for the synthesis of new vRNA. Newly synthesized vRNAs are encapsulated in NP and serve as templates for secondary transcription of viral mRNAs and synthesis of the remaining proteins. Towards the end of the virus life cycle, newly synthesized vRNAs associated with the NP and polymerase complex proteins are exported from the nucleus.⁵ Newly synthesized HA and NA proteins are transported to the cell surface where they integrate into the host cell membrane (Figure 1.3). Interactions between M1 coupled with RNPs HA, NA and M2 activate the signals for budding which is the last stage in influenza A virus replication. Progeny viruses bud from the host cell, enveloped in the host cell's membrane. Virus exit from the cell is facilitated by NA, which cleaves bonds between HA and sialic acid, thus releasing newly formed viruses from the cell.

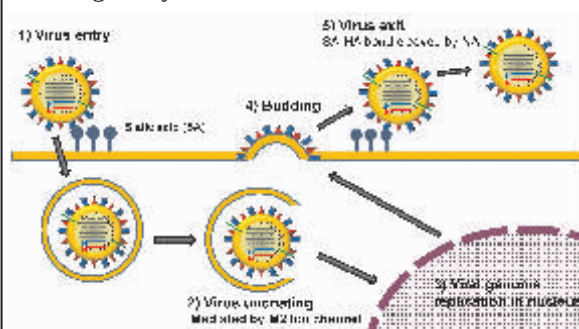


Figure 1.2 Influenza A virus life cycle. 1) The virus enters the cell via interactions between hemagglutinin (HA) on the virus surface and sialic acid (SA) residues on the cell surface. The virus enters the cell via receptor mediated endocytosis. 2) Virus uncoating is achieved utilizing the M2 ion channel. 3) Following viral genome replication in the host nucleus the genome is encapsulated in Influenza structural proteins and the host lipid membrane. 5) Virus exit is facilitated by Neuraminidase which cleaves bonds between HA and SA.

Selective pressure imposed by the host immune response results in the constant evolution of Influenza viruses. Despite their small genome size, influenza virus populations display immense diversity, which allows them to evolve continuously. Influenza virus diversity occurs by two main mechanisms: 1) point

mutations or “antigenic drift” and 2) reassortment or “antigenic shift.” Each of these mechanisms represents a powerful tool in evolution of influenza viruses and plays a key role in the generation of pandemic flu strains.

1) Antigenic shift: Mutations arising in vRNAs due to substitution, insertion and deletion of nucleotides during viral replication play a key role in generation new influenza strains. Such errors in replication are largely due to the lack of proofreading ability among RNA polymerases. As such, each round of influenza virus replication generates a mixed population of viruses with many variants. Most new viruses are not viable, but some might have potentially advantageous mutations that can become dominant under the appropriate selective pressure.⁶ Accumulation of a series of such advantageous point mutations results in a drift in antigenicity. These mutations lead to amino acid substitutions and minor, gradual, antigenic changes in the influenza HA and NA proteins. These changes in HA and NA prevent virus neutralization by antibodies induced during previous infections or vaccination. Thus, positive selection by neutralizing antibodies generated by the host immune system leads to the rise of virus drift variants. Mutations within the amino acid sequence of HA and NA in human influenza viruses occurs at a frequency of less than 1% per year. Antigenic drift variants cause epidemics and normally exist for 2 to 5 years before being replaced by a different variant.

2) Antigenic shift: Reassortment or antigenic shift occurs when a cell is concurrently infected with two or more different influenza virus strains (Figure 1.3B). The segmented genome of influenza facilitates the generation of new virus strains that contains a mixture of RNA segments from the original viruses (Figure 1.3B). Unlike strains generated by point mutations, viruses generated by antigenic drift contain a new HA or NA subtypes which make them immunologically distinct from previously circulating strains. Thus, antigenic shift causes high infection rates in the immunologically naïve population resulting in a pandemic.⁷ In addition this process may also generate highly virulent strains.

Unlike antigenic drift, which occurs in all types of influenza, antigenic shift occurs only in influenza A viruses. This is due to the ability of these viruses to infect multiple species.⁷ Antigenic shift provides

influenza A viruses the opportunity for major reorganization of surface antigens thereby drastically changing its phenotype. In contrast Influenza B and C infect only humans, thereby minimizing the possibility of reassortment. Reassortment usually occurs in pigs as these animals can be infected with both human and avian influenza viruses in addition to swine influenza viruses. For example, concurrent infection of a pig with a human and an avian may result in the emergence of a new virus that has most of the genes from the human virus, but avian HA or NA. The resulting new virus could potentially infect humans and spread from person to person (Figure 1.4).

The importance of reassortment is highlighted by past and current influenza pandemics. The 2009 H1N1 “quadruple” reassortant viruses emerged from the reassortment of the North American swine viruses H3N2 and H1N2 with Eurasian avian-like swine influenza viruses. These viruses possess PB2 and PA genes of North American avian virus origin, a PB1 gene of human H3N2 virus origin, HA (H1), NP, and NS genes of classical swine virus origin, and NA (N1) and M genes of Eurasian avian-like swine virus origin. In addition, pandemics of 1957 and 1968 were also caused by reassortant viruses.⁴

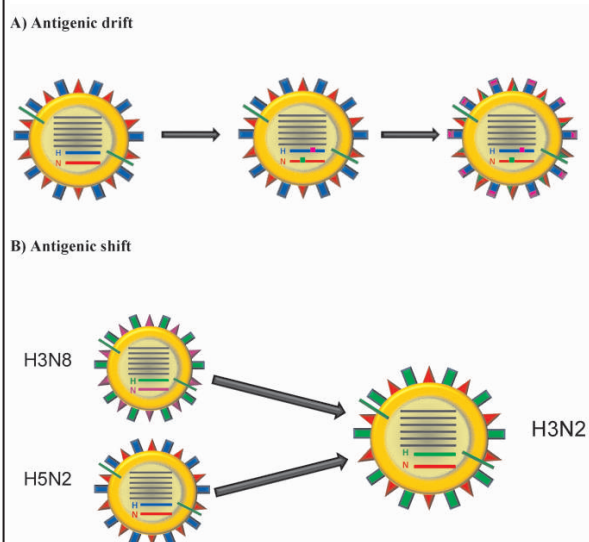


Figure 1.3 Evolution of influenza A viruses. A) Antigenic shift - Point mutations of single nucleotides cause Minor changes in the antigenic character and accounts for seasonal variation in influenza viruses. B) Genetic reassortment between circulating human and animal strains is responsible for shifts in antigenicity. Antigenic shift is facilitated by the segmented genome of influenza viruses and accounts for emergence of novel pandemic strains of virus.

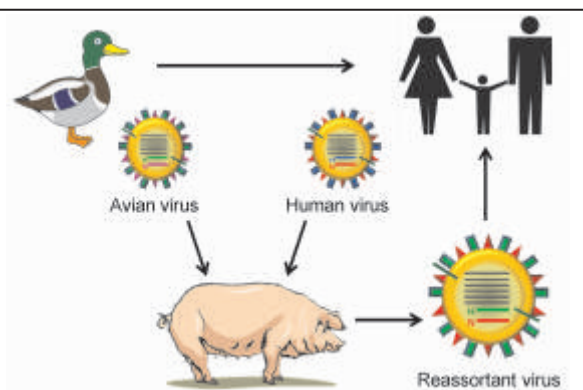


Figure 1.4 Generation of pandemic influenza strains. Influenza A viruses infects specific host species. However, pigs are susceptible to avian, human and swine viruses. Concurrent infection of a pig with multiple viruses results in the generation of a reassortant virus that contains a mixture of viral segments from the original viruses. This new virus may cause severe pandemic influenza in humans. In addition, certain mutations in avian viruses may also render it possible for these viruses to directly infect humans, which could also result in pandemic flu.

Since vaccines would not be available for the first 3-6 months of a pandemic, anti-viral drugs are likely to be the only major medical countermeasure available early during a pandemic. Anti-influenza drugs could act as a 'first-line-of-defense' against the spread of influenza infection and buy time for necessary vaccine development. Hence, targeted use of stockpiled antivirals is a key component of any *pandemic influenza* containment plan. The U.S. goal is to stockpile enough antiviral drugs to treat 25% of the U.S. Population.

Currently 4 drugs have been approved by the FDA for the treatment of uncomplicated influenza infections. These are classified into two categories based on their mechanism of action. The first drugs to be approved were the M2 inhibitors Amantadine and Rimantadine. Subsequently the Neuraminidase inhibitors Relenza, and Tamiflu were approved.³

Table 1.3 FDA approved drugs for influenza.

Drug class	Effective against	Drug name	Brand name	Year Approved	Manufacturer
M2 Inhibitors	Influenza A	Amantadine	Symmetrel	1976	Endo Pharmaceuticals
		Rimantadine	Flumadine	1994	Forest Laboratories
Neuraminidase inhibitors	Influenza A and B	Zanamivir	Relenza	1999	Glaxo Smithkline
		Oseltamivir phosphate	Tamiflu	1999	Hoffman-La Roche

M2 inhibitors: M2 inhibitors act by blocking the influx of hydrogen ions through the M2-proton

channel of influenza A, thereby inhibiting the uncoating and release of free viral RNPs into the cell cytoplasm.³ However, there are 2 main concerns about the use of this older class of drugs; 1) side effects, 2) Antiviral drug resistance. The use of M2 inhibitors has been associated with negative effects on the central nervous system (dizziness, nervousness, and insomnia) and gastrointestinal toxicities.³ Antiviral drug resistance is a major concern with the adamantanes. A single amino acid substitution in the transmembrane portion of the M2 ion channel protein causes amantadine resistance. Amantadine resistance has been found in human and avian H5N1 strains in China, Thailand, Vietnam and Cambodia, although other variants found in Indonesia, China, Mongolia, Russia and Turkey remain sensitive. Worldwide seasonal A/H3N2 and A/H1N1 strains are becoming increasingly resistant to the adamantanes.³

Neuraminidase inhibitors: Neuraminidase inhibitors prevent the release of newly formed influenza virions from an infected cell by disrupting the function of the viral neuraminidase. As a result, Neuraminidase inhibitors prevent the spread of infection in the respiratory tract.³

Zanamivir is delivered by inhalation or, rarely, intravenous infusion. When administered through a diskhaler, zanamivir is effective within 10 seconds.³ Oseltamivir commercially known as Tamiflu is an oral preparation (either a capsule or liquid suspension) and after absorption is widely distributed throughout the body. Compared to the older adamantanes, both of these drugs have fewer side effects, making them safer for older and younger individuals. Between Zanamivir and Oseltamivir, the latter has become the preferred drug due to its oral bioavailability.³ Worldwide cost-benefit analyses have concluded that use of Tamiflu as a post-exposure prophylaxis (within 48 hours of exposure) is strongly indicated, especially in the high-risk populations of children and the elderly.³

However, the development of Tamiflu resistant influenza strains is inevitable due to constant evolutionary pressure. For example, concerns have been raised recently due to the rise of pandemic 2009 A(H1N1) virus strains with Tamiflu resistance.⁷ The prevalence of such Tamiflu-resistant strains had risen to 12% in the 2007 to 2008 influenza season and had reached 99% in the 2008 to 2009 season. This increase was not linked to prior exposure to Tamiflu. The loss of oseltamivir from the clinical arsenal would leave

physicians and patients with only one effective antiviral drug, zanamivir, to treat severe influenza as more than 99% of the strains of this virus are "inherently resistant" to the adamantane family of antivirals. Thus the development of novel antivirals to combat severe influenza infections is vital. In addition, accounts of human deaths caused by Tamiflu resistant variants of the avian H5N1 strain, including a probable person-to-person transmission underscores the critical necessity for the development of new antiviral drugs for the treatment of seasonal and pandemic influenza.

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The Story of Sweeteners

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Sweetness, one of the five taste modalities identified in humans, is a pleasurable experience preferred by people of all ages throughout the world. More importantly, sweetness has played a key role in the evolution of mankind as it provides a means of identifying the energy-rich nutrients such as carbohydrates that are vital for survival.¹ Due to these reasons, sweet compounds have become an important component of our diet since ancient times.

Sweet Compounds

A vast range of compounds, including sugars, sugar alcohols, amino acids, peptides and proteins elicit sweet taste. Sweeteners can be broadly classified in to two groups, bulk sweeteners and high-intensity sweeteners. Bulk sweeteners such as simple sugars add calories and bulk to the foods and have a sweet intensity comparable to that of table sugar. High-intensity sweeteners, on the other hand, are non-caloric sweeteners with a higher sweet intensity compared to sugars.²

Sugars and Sugar Alcohols

Sugars are the most abundant form of sweeteners in nature. Glucose, which is found in fruit juice and honey, can be produced industrially by enzymatic hydrolysis of starch. Fructose, the sweetest of all sugars, is abundantly found in fruit juices, must, and honey. Galactose, mannose, and sorbose are some other important monosaccharides found in food products. Chemical structures of these hexose sugars are given in Figure 1. Sucrose, commonly known as table sugar, is a disaccharide made of glucose and fructose. Lactose or the milk sugar is another disaccharide that is composed of glucose and galactose. Maltose, which is made of two subunits of glucose, is the major end product of enzymatic hydrolysis of starch.³

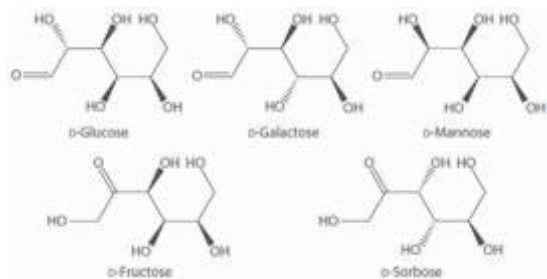


Figure 1. Chemical structures of some hexoses important in food applications.³

Sugar alcohols are produced by reduction of carbonyl groups of sugars. Sorbitol, mannitol, and xylitol are derivatives of monosaccharides whereas maltitol and lactitol are derived from disaccharides. Structures of some selected sugar alcohols are shown in Figure 2. Sugar alcohols are used as sugar alternative in reduced-calorie products and foods intended for diabetics because of their lower energy values. Additionally, sorbitol is used to retain freshness of confectionary products because of its hygroscopic properties.^{3,4} Table 1 compares the sweetness of different sugars and sugar alcohols.

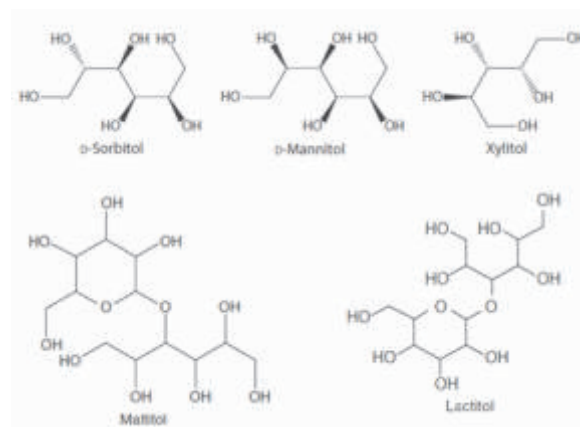


Figure 2. Chemical structures of sugar alcohols important in food applications.^{3,4}

Table 1. Sweetness characteristics of some selected sugars and sugar alcohols.³

Sweetener	Relative Sweetness (Sucrose = 1)
Fructose	170
Xylitol	85–120
Sucrose	100
Glucose	75
Maltitol	50–90
Sorbitol	50
Mannitol	40
Lactitol	30–40
Maltose	30
Galactose	30
Lactose	15

High-intensity Sweeteners

Consuming excess amounts of sugars can result in several health problems including over-weight, obesity, and related chronic diseases. Artificial sweeteners were introduced to the market with the intention of controlling the ever-increasing obesity epidemic. High-intensity sweeteners can be classified into three groups: synthetic artificial, semi-synthetic, and natural sweeteners.⁵

Saccharin, acesulfame-K, aspartame, neotame, alitame, cyclamate, and sucralose fall into the group of synthetic artificial sweeteners. Chemical structures of some commonly used synthetic high-intensity sweeteners are shown in Figure 3. Saccharin, the first high-intensity sweetener to enter the market, was discovered accidentally in 1879 by a graduate student at Johns Hopkins University while working on the synthesis of toluene derivatives. Today, saccharin is used in a wide range of low-calorie and sugar-free food products. Acesulfame-K, which was also discovered accidentally, has excellent stability (against high temperatures and low pH) and solubility properties.^{5,6}

Aspartame is a nutritive sweetener which is metabolized to methanol and amino acids aspartic acid and phenylalanine. Neotame is also metabolized to produce aspartic acid and phenylalanine. Both aspartame and Neotame have unique flavor enhancement properties. Alitame is another amino acid-based sweetener formed from L-aspartic acid, D-alanine, and another amine (2,2,4,4-tetraethylthioethanyl amine). Like many other artificial sweeteners, alitame is stable at higher temperatures and a wide range of pH. However, prolonged storage under acidic conditions at higher temperatures can result in off flavors. Furthermore, alitame can undergo Maillard reaction in the presence of high levels of reducing sugars.^{5,6}

Sucralose is a chlorinated derivative of sucrose which offers a wide pH, thermal processing, and shelf stability. However, under extreme pH and temperatures, it can undergo hydrolysis or degradation. Cyclamate, which has the least intensity of all artificial sweeteners, is widely used in carbonated beverages since it is stable over a wide range of temperatures and pH.^{5,6}

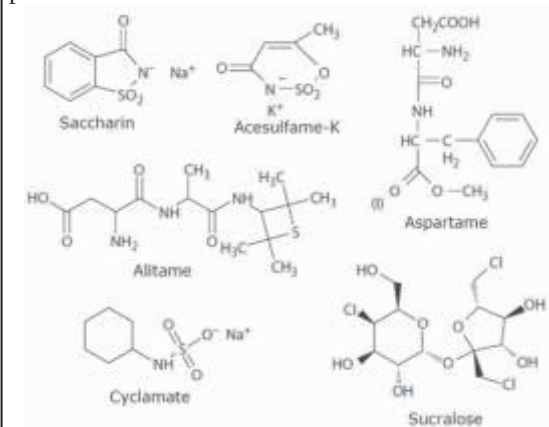


Figure 3. Chemical structures of some synthetic high-intensity sweeteners.⁵

Dihydrochalcones are obtained by catalytic hydrogenation of a group of bitter flavonones in citrus fruits and hence, considered as semi-synthetic sweeteners. They are capable of decreasing the perception of bitterness, saltiness, and spicy attributes. Dihydrochalcones are used in toothpaste, mouthwash, and some pharmaceuticals because of their lingering menthol or licorice-like aftertaste and cooling sensation.^{5,6}

Steviol glycosides, Glycyrrhizin, and Thaumatin are examples for natural sweeteners. Steviol glycosides are a group of sweet diterpenes extracted from the leaves of *Stevia rebaudiana* plant which is native to South America. The structure of stevioside, a predominant glycoside in *Stevia* extracts, is shown in Figure 4(a). Steviosides are highly soluble in water, and are stable in acidic conditions. Nevertheless, the bitter aftertaste associated with *Stevia* extracts restricts their use in processed foods. Glycyrrhizin (Figure 4(b)) is extracted from licorice root and its use in food products is limited due to its sweet woody flavor. Thaumatin is a mixture of intensely sweet basic proteins extracted from the fruit of *Thaumatococcus danielli*. It can be used as a sweetener or a flavor enhancer.^{5,6}

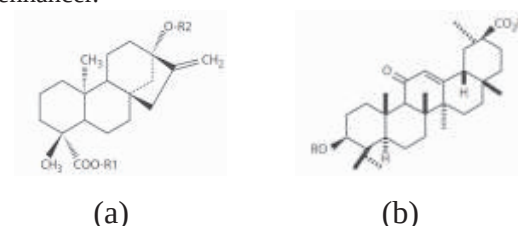


Figure 4. Chemical structures of (a) Stevioside ($R_1 = \beta\text{-D-Glucose}$, $R_2 = \beta\text{-D-Glucose-}\beta\text{-D-Glucose}$ (21)) and (b) Glycyrrhizin ($R = \beta\text{-D-Glucouronic acid}$).⁵

High-intensity sweeteners can be used in a variety of food products including soft drinks, baked goods, chewing gum, canned fruit, desserts, candies, and salad dressings. Since most of them have synergistic effects, food manufacturers use several sweeteners in combination to produce the sweet taste that matches their product requirements.⁶ Table 2 lists sweetness characteristics of some commonly used artificial sweeteners compared to sucrose.

How do we perceive sweetness?

Sweet receptors present in taste buds distributed across papillae of the tongue and palate epithelium are the major organs responsible for sweetness perception. Sweeteners, dissolved in saliva, will activate the sweet

receptor by interacting with it. The receptor, thus activated, will initiate the signal transduction pathway for sweet sensation via coupled G proteins.¹

Several theories have been developed to identify the common structural features of sweeteners and to explain the mechanisms by which the sweeteners interact with the sweet receptor. The AH-B theory proposed by Shallenberger and Acree (1967) suggests that a sweet-tasting compound must contain a hydrogen bond donor (AH) and a hydrogen bond acceptor (B), separated by a distance of 2.5 to 4.0 Å. This AH-B unit (glycophore) on the sweet molecule will react with a complementary AH-B pair on the receptor via two hydrogen bonds (Figure 5(a)). Likely AH/B sites of some well-known sweeteners are shown in Figure 5(b).^{1,7,8}

Table 2. Sweetness characteristics of commonly used artificial sweeteners.⁵

Sweetener	Relative Sweetness (Sucrose = 1)
Neotame	7000–13000
Thaumatococin	2000
Sucralose	400–800
Saccharin	300–600
Stevioside	250–300
Aspartame	160–220
Acesulfame-K	150–200
Glycyrrhizin	50–100
Cyclamate	30–40

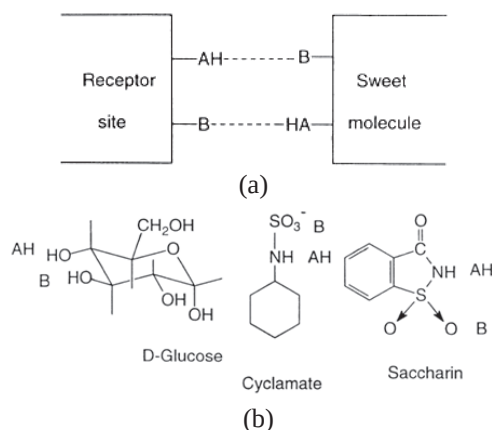


Figure 5. (a) AH-B Theory. (b) AH/B sites in well-known sweeteners.⁷

Although AH-B theory reveals the ligand binding chemistry behind sweet taste response, it does not explain the variation in potency among different sweeteners. Kier (1972) proposed an extension to AH-B theory by introducing a third binding site “X” or “Y”, which modulates the sweet potency by forming hydrophobic interactions. Figure 6(a) shows how D-leucine (a sweet amino acid) may interact with the sweet receptor according to this three-point attachment

theory. Likely AH/B/X sites of Acesulfame-K are illustrated in Figure 6(b). However, later it was discovered that the hydrophobic interaction between Y units is not essential to trigger the sweet taste signaling pathway.^{1,7-9}

Nofre and Tinti (1996) proposed a more complex model consisting of eight recognition sites (B, AH, XH, G1, G2, G3, G4, and D) which interact with eight sites in the sweetener (Figure 7(a)). Some of these sites are high-affinity sites while others are secondary sites. According to this theory, the receptor is present in its contracted form at resting state due to hydrogen bonds and ionic interactions between some recognition sites (Figure 7(b)). When a sweetener interacts with the receptor, some bonds will be broken causing conformational changes in the receptor that will trigger the signaling pathway. This theory further suggests that the potency of a sweetener is governed by the number of additional sites involved in interactions.^{1,8,9}

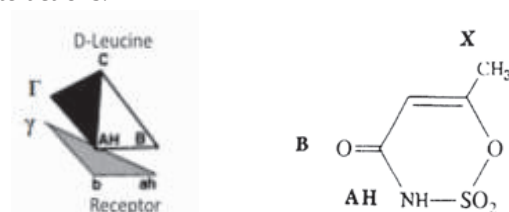


Figure 6. (a) Interaction of D-leucine with the sweetness receptor.⁸ (b) AH/B/X sites in Acesulfame-K.⁷

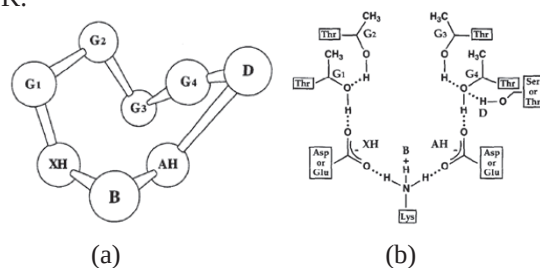


Figure 7. (a) Spatial arrangement of the eight interaction sites. (b) Schematic representation of the sweetness receptor in its resting state.⁹

However, all these theories were based solely on the structure of the sweeteners because sweet taste receptors were not characterized at that time. The discovery of the T1R class receptors marks a milestone in the developments associated with the sweet taste perception.

Characterization of Sweet Taste Receptor

Intense research carried out by several research groups using cell-based assays, naturally occurring sweet receptor mutants, and genetically modified

mouse lines paved way to the discovery of the sweet receptor T1R, which belongs to the family of G protein-coupled receptors. The sweet receptor occurs as a heterodimer of T1R2 and T1R3 subunits, and both subunits are required to recognize the diverse array of sweeteners. Each subunit consists of three domains: a large extracellular N terminal domain (NTD), a cysteine-rich domain (CRD), and a seven helices transmembrane domain (7TMD) (Figure 8).^{1,10-13}

Scientific evidence suggests that there are multiple ligand binding sites on both T1R2 and T1R3 subunits. Some sweeteners show a higher affinity toward respective binding sites. Table 3 lists the binding sites for some commonly used sweeteners. Structure–function relationships for T1R2 and T1R3 receptors are illustrated in Figure 8.

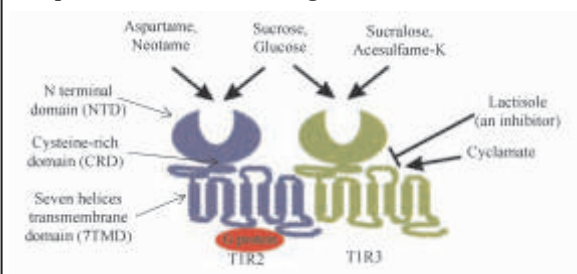


Figure 8. A working model for sweet taste receptor structure–function relationships. (Adopted from Xu *et al.*, 2004)

Table 3. Binding sites of commonly used sweeteners.¹

Sweetener	Binding site(s)
Sucrose	T1R2 NTD, T1R3 NTD
Glucose	T1R2 NTD, T1R3 NTD
Sucralose	T1R2 NTD, T1R3 NTD
Acesulfame-K	T1R2 NTD, T1R3 NTD
Cyclamate	T1R3 7TMD
Aspartame	T1R2 NTD
Neotame	T1R2 NTD
Brazzein	T1R3 CRD

Preferential binding sites are marked in bold.

What lies ahead? – The Future of Sweeteners

The understanding of the molecular structure and function of the sweet receptor has allowed scientists to design and develop several non-caloric sweeteners through intense research. In future, food scientists will come up with novel sweeteners that will allow consumers to enjoy the pleasure of sweet taste while maintaining a healthy body weight. These sweeteners

will play a significant role in creating a healthier and happier population in the years to come.

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Search for Bioactive Compounds from Mango

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Background

Diet rich with fruits and vegetables provides health benefits such as remedies for certain type of cancers, cardiovascular diseases and other chronic diseases. These health beneficial effects are mainly due to the presence of different bioactive compounds in them. Phenolic compounds and carotenoids are some of the important compounds present in fruits and vegetables. These compounds exhibit health benefits such as antioxidant, antimicrobial, anti-inflammatory and anti-arthrogenic effect. Byproducts of most of the fruits and vegetables from food processing industries are traditionally considered as environmental pollutants. However recent studies indicate that, they can be recognized as important and potential sources of bioactive compounds and mango is one of them.

Mango Fruits in Sri Lanka

Mango is known as the king of fruits, belongs to the family Anacardiaceae. Mango fruits are believed to be a native of Indo-burma region. Mango is one of the most cultivated fruit in Sri Lanka and a considerable amount of foreign exchange is earned by exporting raw and processed mango products. Presently there are wide ranges of mango cultivation in Sri Lanka. Fruits of different varieties have their own characteristic flavor and taste.

According to the data available in the Department of Agriculture, 10 types of mango varieties are commonly available in Sri Lanka. They are Karuthakolomban, Willard, Vellaicolomban, Ambalavi, Chembatan, Malwana, Bettiamba, Gir-amba, Peterpras and Dampara. Among those varieties, Karuthakolumban, Willard, Vellaicolomban, Ambalavi and Malwana mangoes are native to Sri Lanka.

Mango is a seasonal fruit and they are commonly available during the period from December to January and May to June in Sri Lanka. The physical and chemical properties of these mangoes can vary due to different agro climate regions and the age of mango trees. As mentioned in Table 1 below, dry zone mangoes have distinct properties such as unique colour, taste, flavor and aroma properties. Presently in Sri Lanka, mangoes have been cultivated in about 27,500 Ac of the whole land area. Total mango production in Sri Lanka is around 80,000 metric tons per annum.

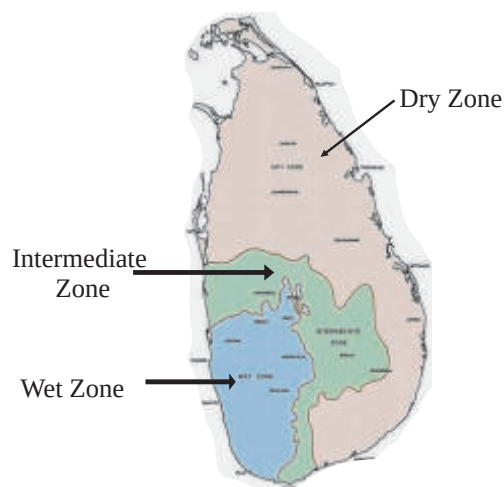


Figure 1: The different Agro-climate region of Sri Lanka

Table 1: Type of mangoes available in different climate regions in Sri Lanka.

Wet Zone	1.Vellaicolomban 2. Gira amba 3.Peterprasand 4.Dampara
Intermediate Zone	1.Karuthakolomban 2.Vellaicolomban 3.Willard 4.Bettiamba 5.Malwana
Dry Zone	1.Karuthakolomban 2.Willard 3.Vellaicolomban 4.Ambalavi 5.Chembatan 6.Malwana

Bioactive compounds in mango fruits

Apart from being important as a food, all parts of the mango fruit including peel, seed and flesh are sources of bioactive compounds with potential health promoting activities. It has been reported that mango fruit contains bioactive compounds such as ascorbic, dehydroascobic acid, phenolic compounds, carotenoids, terpenoids, fibres and antioxidant minerals. Phytochemicals such as phenolics, carotenoids and dietary fibers are gaining increased attention because of their antioxidant, anticancer, antimutagenic and other health promoting properties.

Phenolic Compounds

Mango fruit is considered as a rich source of

antioxidants, since it contains phenolic compounds in considerable quantity. Total phenolic content of mango can be identified using HPLC method or Folin–Ciocalteu method. Mangiferin and Quercetin 3-O galactoside are the main phenolic compounds present in mango. These phenolic compounds have the ability to scavenge free radicals by reducing threats for non-communicable diseases and exhibits anti-carcinogenic, anti-glycemic, anti-cholesterol, anti-inflammatory and anti-microbial activities.

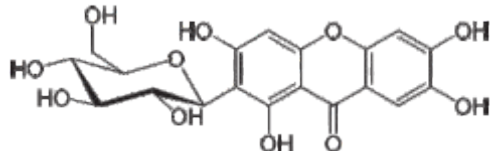


Figure 2: Mangiferin

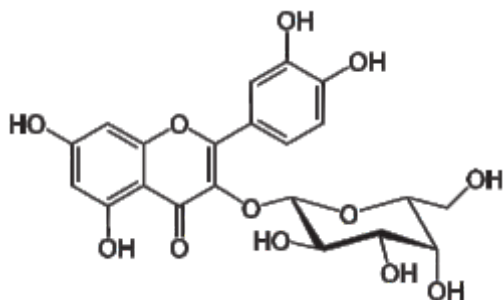


Figure 3: Quercetin 3-O galactoside

Carotenoids

Another class of antioxidant compounds is the carotenoids. These are the compounds responsible for the yellow, orange, red or green colour of mango fruits. Carotenoids are important not only because of vitamin A activity but also it has ability to work as pharmaceutical supplements, protect against degenerative diseases like cancer, cardiovascular diseases.

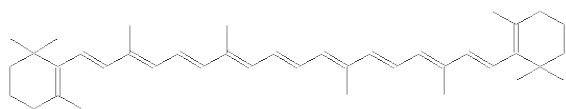


Figure 4: Beta carotene-It has Vitamin A activity

Fibers

Mangoes are good sources of dietary fibers. These dietary fibres do not constitute a defined chemical group, but are combination of chemically heterogeneous substances. Dietary fibres can be classified into insoluble and soluble dietary fibers depending on their solubility in water. These fibres help to reduce blood cholesterol level and decrease of glucose absorption.

Conclusion

Mango peel and seed are the major by-products

obtained during the processing of mango products. The main bioactive compounds in mango fruits are phenolic compounds, carotenoids and fibres. These bioactive compounds offer health benefits including protection against cancer, cardiovascular diseases and other degenerative diseases. Percentage of bioactive compounds can differ according to the type of mango, different agro-climatic regions and type of extraction process. Advanced research work is being carried out in relation to the literature mentioned above for Sri Lankan mango Varieties.

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Applications of 'Un'popular Surface Science

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Surface science has long been known and it may be the most interdisciplinary branch of science out of all; but unfortunately, it has been always 'labelled' as a very specific field of study. As a consequence of this, surface science is often neglected by researchers and research funding agencies simply because they do not identify the 'bright' side of this field which is actually applied almost everywhere.

This brings us to the most fundamental question: "What is a surface"? Yes, what exactly is a surface and why exactly we, as scientists need to bother about a surface? We encounter many surfaces on a daily basis which are involved in all of our day-to-day activities – be it a surface science research project or a simple activity as going to the supermarket. A surface can simply be defined as the portion of any object which is exposed to the external environment. Best example is your skin. Why do you have to take a shower in the evening when you return home from work or school? The answer to this question includes the very basic property of a surface. Your skin is a surface and the dirt particles 'love' to cling onto it. Any surface would prefer to take on any molecules, particles etc. so that it satisfies the 'unbalanced valence' of a surface. Figure 1 depicts the forces that act around a surface molecule and a molecule in the bulk. Take a glass of water for example. As we know, and as shown in Figure 1, the surface molecules have unbalanced forces simply because they are lying on the surface of the water. To complete the 'unsatisfied valence' these molecules will attract the incoming molecules. This is exactly how our skin gets dirty at the end of the day. Same applies for any other surface like the surface of your car which needs occasional cleaning.

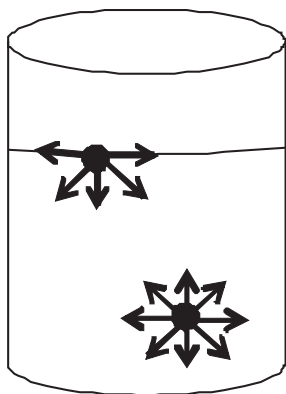


Figure 1 : Forces acting on a molecule on the surface in comparison to those on a bulk molecule.

Surface science is the study of the surface phenomena using surface analytical techniques. Although this is the standard definition and sounds like a specific topic which is confined to only a separate group of people, it actually is applied in a variety of situations. Surface science has never been very popular among scientists because of the unawareness of its applicability in various disciplines. In this article, my main intention is to point out a few interesting applications of surface science so that the reader will get a glance of its wide applicability. It is also intended to get the reader more attracted towards surface science research. In order to achieve this, the standard textbook definitions, details and calculations involved in surface science have been omitted. The interested reader is advised to refer to a standard textbook in surface science for these details.

Learn from the Lotus leaf

Nature would be a good point to start our discussion with. Let us focus our attention to the beautiful Lotus leaf (Figure 2). You might think that it is a typing error when I say that Lotus leaf is beautiful. Shouldn't it be the Lotus flower? Whereas the flower is pretty to the eyes of a typical person, the leaf is even more beautiful when you look at it in a surface science point of view. We have never observed a lotus leaf getting wet in the rain. If we pour some water onto the Lotus leaf and shake it off, it comes out perfectly dry.

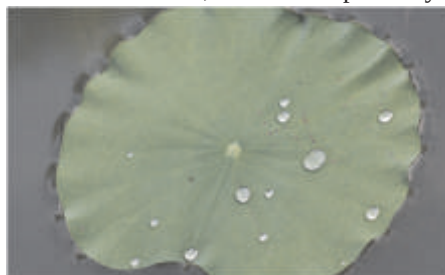


Figure 2 : Water droplets sitting on the surface of lotus leaves

It took a while for the scientists to discover this as a surface phenomenon. It is the micro- and nano-scale hairy structures present on the surface of the Lotus leaf that renders this non-wetting property, or better known as 'superhydrophobicity' to the Lotus leaf (Figure 3)¹. If there is any possibility of making the surface of any object looks just the same way as the surface of the

Lotus leaf, that surface can be made superhydrophobic. There are two approaches to this. One is to make the surface very rough by having micro- and nano-scale structures on the surface. The second way is to decrease the surface energy. There comes the surface chemistry; what we need to do is to chemically modify the surface of the object or the material of interest so as to introduce micro- and nanoscale roughness and also to decrease surface energy. This is now explored mainly in the textile industry for producing the so-called 'smart' textiles which apparently requires no washing. The technology comes from the famous and well-known lotus effect. Lotus effect is not only the ability to keep the surface from wetting (being superhydrophobic), but it is also the ability to exhibit a self-cleaning mechanism (Figure 4).² Self-cleaning is again facilitated by the micro- and nano-scale surface structures which ensure the efficient removal of dirt particles that come in contact with the surface. This is achieved by the rolling of dirt particles along with the water droplets which roll over the surface, in contrast to the sliding movement of an unmodified surface. Beauty of the nature has played a major role and it indeed is a surface chemical phenomenon.

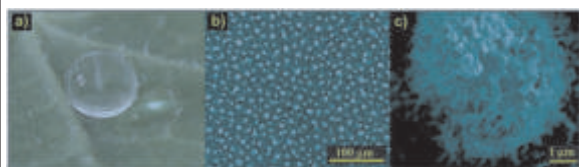


Figure 3 : (a) An almost ballshaped water droplet on a non-wettable plant leaf. (b) Low- and (c) high-magnification scanning electron microscope images of the surface structures on the lotus leaf.¹

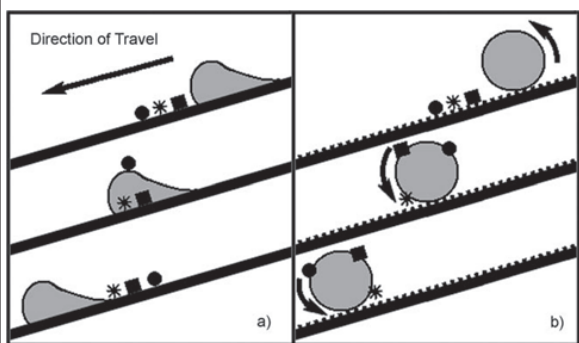


Figure 4: Self-cleaning mechanism of a superhydrophobic surface²

Superimposable or non-superimposable?

Many objects in nature are incongruent with their mirror image and they are referred to enantiomorphs. This phenomenon, known as chirality, is another very important aspect of applied surface chemistry which is

ubiquitous in the medicinal industry. The best known example for the role and the importance of chirality is the famous thalidomide case. Left-handed S-Thalidomide (Figure 5) is a powerful sedative, and therefore in 1950s a racemic mixture of thalidomide was prescribed for pregnant women to combat morning sickness, not knowing at that time, that the right-handed R-Thalidomide disrupts fetal development (Figure 5).

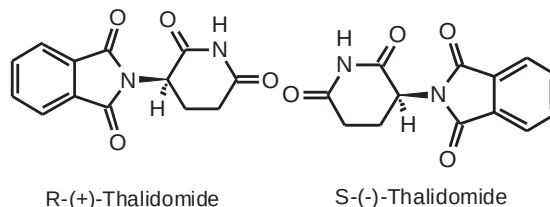


Figure 5: Chemical structures of R- and S-Thalidomide

Although the thalidomide was immediately withdrawn from the market in 1960, by that time, many children had already been born with severe birth defects in their limbs. This opened up the discussion and research about synthesizing enantiomerically pure isomers of certain drugs which at the moment is mostly done using homogeneous catalytic systems or enzymes. About 50% of the new drugs in development require chiral chemistry. Moreover, production of agrochemicals, fragrances and flavours also require active compounds which are enantiomerically pure. When large scale production is required, it is quite costly to carry out homogeneous catalytic pathways for enantioselective synthesis of a particular isomer. At the same time, separation and isolation of the pure compound would be much difficult in such a case. Enzymatic catalysis has the same disadvantages. Therefore, the ideal pathway for these syntheses would be to use heterogeneous catalysis, where the reactants and the catalyst exist in two different phases, making the separation of the products cleaner and easier. However, this approach is still in its infancy and needs a lot of improvement especially in terms of getting a yield of almost 100%. Chiral catalysis at solid surfaces has attracted the attention of many researchers involved in surface science and this can be achieved in many different ways.³ Four such approaches are; (1) use of heterogenized chiral transition metal complexes, (2) use of chirally modified solid surfaces, (3) attaching of chiral auxiliaries to the reactants and (4) use of intrinsically chiral solids or surfaces. The mostly studied is the second category, the use of chirally modified metals to impose asymmetry on a non-chiral substrate. The surface science studies on the action of the modifiers, R,R-tartaric acid and S-alanine (Figure

6) have received the most attention in literature. These molecules are known as 'chiral modifiers'. The most interesting fact is that the enantioselectivity is achieved only if the achiral metal surface is first modified by adsorbing the chiral organic modifiers.

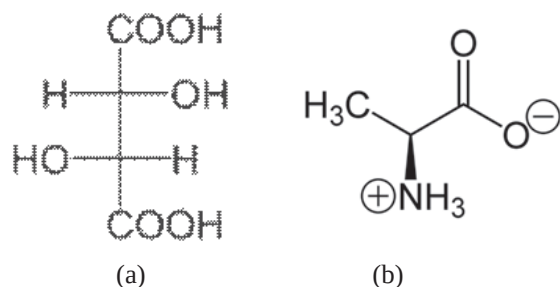


Figure 6 : Chemical structures of (a) R,R-tartaric acid and (b) S-alanine.

Asymmetric hydrogenation of β -ketoesters and diketones such as methylacetoacetate (MAA) and acetylacetone over R,R-tartaric acid modified Ni surfaces is known to reach enantioselective excess of more than 90% for the R-product (Figure 7).³ It seems that the modifier adopts different orientations upon adsorption onto the catalyst surface, favouring the production of only one of the two possible enantiomers of the product. If developed further, this may be the way out to synthesize enantiomerically pure drugs at low cost.

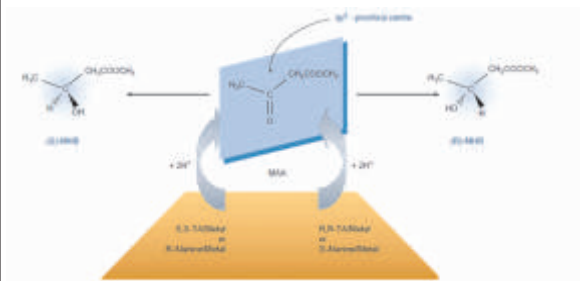


Figure 7: For Ni pre-modified with R,R-tartaric acid or S-alanine, reaction is stereodirected to give the R-product.³

Can you 'see' the atoms?

Above are only two applications which are understood even by the general public. But there are many more interesting applications and advantages of surface science in the field of chemistry itself. Just think for a moment and recall how you learned a reaction mechanism. Let us take a simple reaction such as hydrogenation of ethylene to produce ethane. The best tool your teacher had in hand was most probably a blackboard or a white board, when explaining the mechanism of this reaction. Even if we get to do the

reaction in a laboratory, we do not get to 'see' the mechanism. In surface chemistry research focused on catalysis, it is imperative to know which bonds are broken, which intermediates are formed, and which bonds are formed, during the course of the reaction. The times have changed and now we can actually see the molecules – reactants and products - with the chemical bonds between atoms. Using the language spoken by a typical high school student, I would say "this is cool". The chemists and physicists at the University of California, Berkeley have been able to make a dream come true, by capturing a snapshot of a chemical in the atomic scale, before and after the reaction.⁴ This is picture-perfect because they could see not only the atomic structure, but also the bonds between the atoms which connect them together (Figure 8). This was possible thanks to the very important surface analytical tool called the Atomic Force Microscope (AFM). This has been in use for quite some time for the purpose of imaging heterogeneous catalytic surfaces but this is the first time someone was able to use it to get atomic scale images of a reaction.

Moving molecules around

Scanning tunneling microscopy (STM) is yet another technique similar to AFM. This technique has also been in use for a long time for imaging purposes of conductive surfaces, which employs the theoretical concept of quantum mechanical tunneling. Quantum mechanical tunneling is the tunneling of electrons through a barrier, in contrast to their movement over the barrier. This can be achieved only if the vacuum gap between the two solid surfaces involved is extremely small, such as in the case of an STM experiment, in which the STM tip (a metallic tip) is kept very close to the surface of the metal catalyst on which the reaction or adsorption event is taking place. What is more interesting is that as you decrease this surface-tip distance, the interaction of the molecules at the very end of the tip and those on the surface which are directly below the tip gets higher and higher, resulting in displacement of the surface molecules. This has been put to good use to create surface patterns like the famous "Molecular man," built from 28 CO molecules, measuring 45 Å from head to foot.⁵ The CO molecules were slid on a Pt metal surface by lowering the tip of a scanning tunneling microscope, thereby increasing the interaction strength between the tip and the adsorbed molecules (Figure 9).

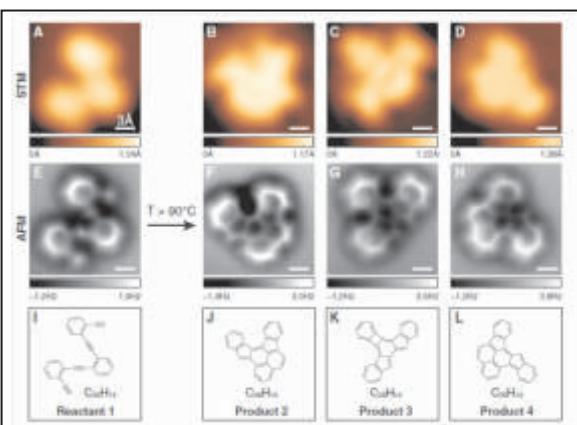


Figure 8 : Images of a molecule before and after a reaction; top – STM images; middle – AFM images; bottom – molecular structure⁴

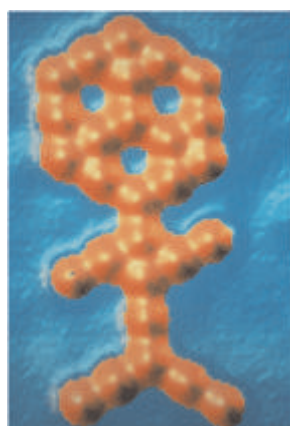


Figure 9: “Molecular Man”⁵

A very attractive production of IBM using STM is the “World's smallest movie” named as “A boy and his atom” which was announced in 2012 (Figure 10). As implied by the name it is a very simple movie where a boy plays with an atom. This has been achieved by moving only 12 atoms to produce different frames of the movie and later on combined together. This looks interesting and seemingly striking but the uses of this is far beyond making movies. It was the world's smallest magnetic memory bit. Typically, to store a bit of data it takes approximately a million of atoms. This will probably change in the future with this invention of IBM. This IBM movie has been verified by the Guinness World Records as the smallest stop-motion film.

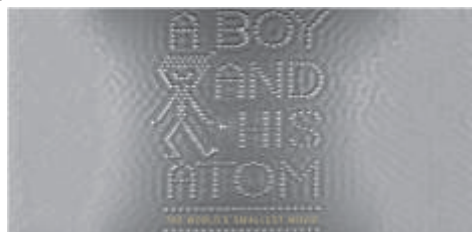


Figure 10: A snapshot of the world's smallest movie, “A boy and his atom”.

Simplicity of a sophisticated field of science

One reason for classifying surface science as a very specific field in science is because of the requirement of specialty analytical instruments such as those used in STM, AFM, LEED (Low-energy-electron spectroscopy), XPS (X-ray photoelectron spectroscopy) and other kinds of surface spectroscopic techniques. Another reason is the necessity of an ultra-high vacuum (UHV) in order for most of the surface analytical spectroscopies to function. Indeed it is a specific field where only a few scientists have the expertise to operate and maintain these expensive instruments to get valuable results from surface science experiments. For those of us who have done basic research in surface science know how critical it is to maintain a good UHV in order to get a good piece of data and how difficult it is to maintain the UHV equipment. However, as I have mentioned in the first few paragraphs of this article, none of these special instruments are required for most of the applied surface science work. Nanocatalysts have opened up a new door to reach the applied surface science. Surface modifications of a lot of materials are now achieved using nanoparticles which introduce a new property to the surface or enhance an existing property of the surface. Modifications of surfaces have become easier than ever. It is true that you still need a scientific basis to prove what you have done, for example by taking a scanning electron microscope (SEM) image of the surface, but a lot of preliminary work can be done without the need for sophisticated analytical equipment.

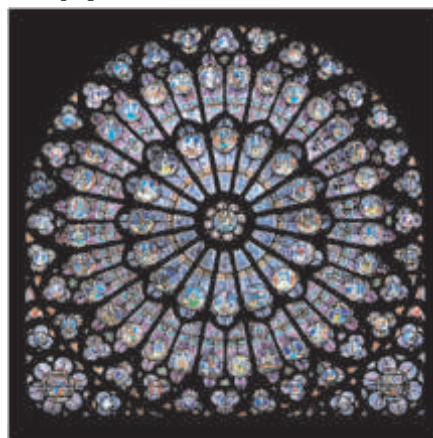


Figure 11 : Gothic stained glass rose window of Notre-Dame de Paris

I would like to end this discussion with another pretty picture. Figure 11 is a picture of Gothic stained glass rose window of Notre-Dame de Paris. The beautiful colours are obtained by having colloids of gold nanoparticles. Brilliant colours of noble metal

nanoparticles are due to a surface phenomenon called surface plasmon resonance (SPR) and this is exactly why the colour of nanoparticles of silver is different from that of gold and this colour is highly dependent on the shape and size of the nanoparticle. The curiosity is left open for the reader to explore more on the SPR phenomenon and its applications.

Surface science has now spread its wings to all branches of science. The future of surface science seems to be promising with a lot of potential applications and interesting breakthroughs in the world of scientific research.

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Metal Organic Frameworks

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Introduction

Metal Organic Frameworks (MOFs) are a class of crystalline materials that are currently attracting a tremendous amount of interest due to their fascinating properties. The backbone of the compound is constructed from metal ions which act as connectors and organic bridging ligands as linkers. The formation of the desired architectural, chemical, and physical properties of MOFs depends on the chemical structure of the ligand and the properties of the connecting metals.¹ A huge range of network topologies are designed by aggregating molecular building blocks to achieve a specific structure and objective. Record-high surface areas, high porosity, structural regularity and "fine-tunability" are among the well-known features of the MOFs.²⁻⁴

Network Geometry

Metal coordination and the properties of the organic ligand play a vital role in predicting the network geometry. Specifically, by changing the bridge or its functionalization, new MOFs can be designed without changing the underlying topology.⁵ Transition metal ions provide coordination sites for the organic ligands. The oxidation state and coordination numbers of the metal ion play a significant role in giving rise to various geometries, which can be linear, T- or Y-shaped, tetrahedral, square-planar, square-pyramidal,

trigonal-bipyramidal, octahedral, trigonal-prismatic, pentagonal-bipyramidal, and the corresponding distorted forms.⁶

Linkers are normally multidentate bridging ligands. These contain a wide variety of linking sites or donor atoms, with binding strength and directionality of the ligand unique to its structure.¹ For example, rigid ligands will be in control of the structural topologies during the synthesis process.⁷ The physical properties of the MOFs are highly dependent on the organic ligand, so it is worthwhile studying them carefully. The length of the ligand, its flexibility and number of binding sites are considered important when selecting a ligand for the synthesis of a certain network.⁷ The most frequently reported problem with the bridging ligand is its flexibility. When a ligand has several probable conformations this could lead to unexpected and unpredictable structures. In order to overcome this problem rigid ligands have been introduced. Rigid backbones such as in 4,4'-bipyridine can be used to restrict the free rotation of the ligand lone pairs.¹ Rigid ligands are mostly used in the assembly of MOFs to avoid complications in the expected product. Multidentate ligands containing N and O donors are widely used in constructing these structures.⁸ Some common examples of N-donor and O-donor ligands are given in Figure 1.

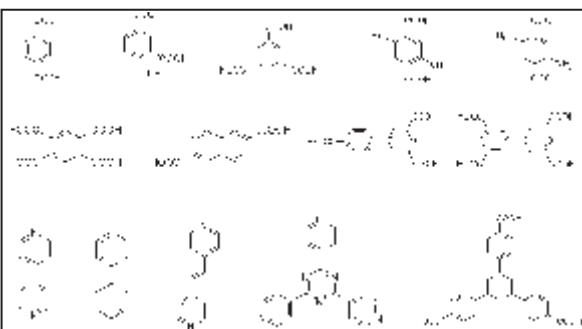


Figure 1. Some of the common ligands used in the synthesis of MOFs⁸

Secondary building units

The intense interest in this field can be attributed to the potential use of designed materials in a wide variety of technologically important applications. Therefore the synthesis of MOFs should not just be the selection of some raw materials and their synthesis but should have some foresight as how the final solid is formed by the assembling of the raw materials. An emerging approach in the rational assembly of networks is through the use of secondary building units (SBUs). The concept of "Secondary Building Units" as structural entities of MOFs was adopted from zeolite structure analysis. These are molecular complexes and cluster entities that are linked together by the organic linkers to form extended porous networks. This approach has allowed the synthesis and use of a large number of inorganic and organic SBUs with varying geometries (Figure 2).⁹

The use of SBUs is attractive in part because of their steric requirements and rigidity, which dramatically reduce the number of possible network topologies arising for a given node/linker combination.¹⁰ This is analogous to aluminosilicate zeolite chemistry, where nine SBUs based on tetrahedral AlO_4 and SiO_4 primary building units have been classified.¹⁰ Although many of the SBUs can be observed in molecular form, they are not generally introduced directly but these specific SBUs can be generated *in situ* under the correct chemical conditions. As the metal ions are locked into their positions by carboxylate groups (Figure 3), the SBUs are sufficiently rigid to produce extended frameworks of high structural stability. In clusters with terminal ligands, the reactivity of the metal site can be studied through the removal of these ligands, which frees a coordination site.¹⁰

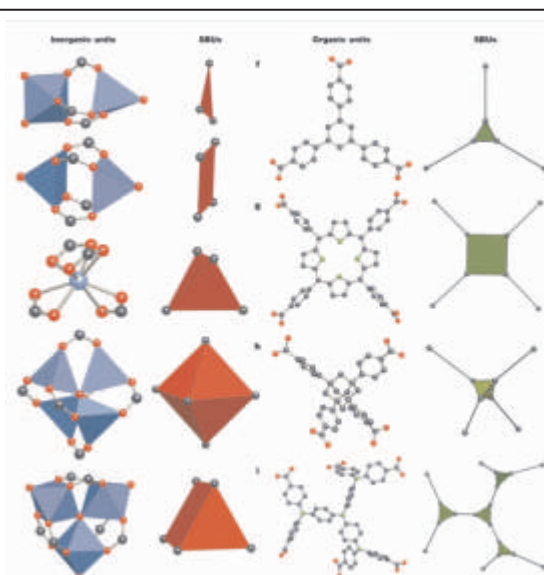


Figure 2. Examples of SBUs from carboxylate MOFs.⁹

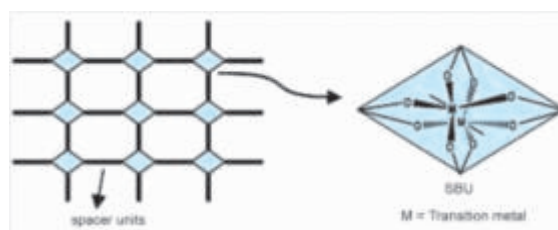


Figure 3. Part of the two-dimensional coordination polymer built with 1,4-benzene dicarboxylate spacer and the SBU (paddlewheel cluster)¹⁰

Reticular synthesis

Once identified the SBUs, the next step is to try to arrange them to generate a desired structure. A better understanding of the mechanistic stability of the framework is needed to design a MOF. The challenge of synthesizing these materials is to change the chemical composition, functionality and molecular dimensions without changing the underlying topology. Thus on designing a target structure the following factors should be considered.⁴

1. Whether the starting material exhibits the relevant features which are expected to be in the product.
2. Appropriate techniques should be used to obtain different functionalities and dimensions by having the same skeleton.
3. The product should be highly crystalline in nature.

Reticular synthesis is designing experiments to produce materials of predetermined ordered structures.⁹ This technique was developed as a way of identifying the principles governing the way target

frameworks assemble, and these principles are then used to develop new frameworks with similar topologies, but varying functional groups and properties.¹¹ This is different from retrosynthesis of organic compounds because the structural integrity and rigidity of the building blocks in reticular synthesis remain unaltered.⁶ Yaghi *et al* has produced a series of 16 isorecticular metal–organic frameworks (IRMOFs) in crystalline form, differing in the polarity, reactivity, and bulk of the pendant groups on the aromatic link (Figure 4).⁶ These IRMOFs demonstrates the design of the porous structures in which pore size and functionality varied systematically.

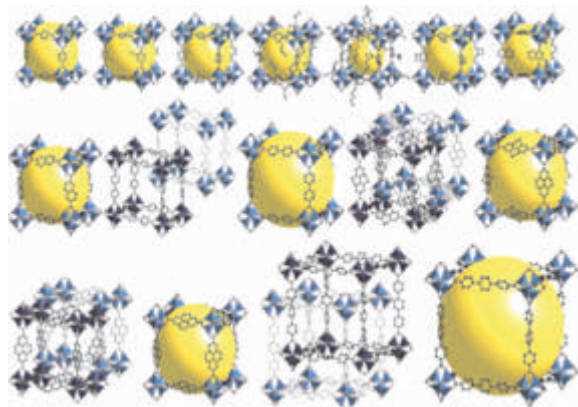


Figure 4. A large series of isorecticular metal–organic frameworks (IRMOFs) has been produced in which each member shares the same cubic topology⁶

MOFs for Gas Separation

Separation is a process that divides a mixture into its components. This can be achieved by selective adsorption since it is based on different affinities at the given condition. Different techniques are used for gas separation which includes cryogenic distillation, pressure or thermal swing adsorption and membrane based separations.¹² Notable examples are nitrogen-oxygen (air), H₂ and CH₄ purification, CO₂ capture and noble gas (Kr-Xe) separations.¹³ Development of adsorption based separations have become a key in the gas separation industry some of which use zeolitic adsorbents.¹³ This has induced the research on new porous materials to overcome the demand for the adsorptive separation. Adsorptive separation is meant to be two types: bulk separation and purification.

Gas adsorptive separation depends on the following mechanisms;

- Molecular sieving effect
- Thermodynamic equilibrium effect
- Kinetic effect
- Quantum sieving effect

Molecular sieving effect happens according to size and shape exclusion. Some of the components in the gas mixture cannot enter the material due to the size and shape of the pore structure of the material. This depends on the size of the pore and the kinetic diameter of the molecule. Separation of normal paraffin from isoparaffin using zeolite 5A is one of the most common examples for molecular sieving effect.¹³ Once a gas stream entered the channel system the interactions between the adsorbate and adsorbent is crucial in determining the separation efficiency. This phenomenon is known as thermodynamic equilibrium effect.

The kinetic separation is known as "partial molecular sieving effect".¹⁴ Because of the different diffusing rates, certain components adsorb faster than the others which leads to the separation. Quantum sieve effect also allows separation based on difference in the diffusion speeds, but it is discussed mainly for the light molecules such as H₂, D₂ penetration,¹⁴ where pore sizes become comparable with the *de Broglie* wave length of these molecules at low temperature.

Metal Organic Frameworks are ideal candidates for gas separation due to higher surface area, adjustable pore sizes and controllable surface properties. The tunability of MOFs makes it unique because in zeolites pores are difficult to alter due to its rigid tetrahedral oxide skeletons. Currently, investigation of MOFs for gas separation is in its early stage.

The adsorptive gas separation or purification can be done by passing streams of gas mixture through a column packed with adsorbents followed by a strong desorption. This will lead a product rich with weakly adsorbed component. MOFs can be used as the adsorbents in this context and possibly used to remove ppm-traces of components from various gases.¹⁵ For example, removal of tetrahydrothiophene (THT) from natural gas has been studied at room temperature.¹⁶ Electrochemically prepared fixed bed reactor has been used for this purpose which is filled with Cu-EMOF. About 10-15 ppm traces of sulphur was able to capture down to less than 1ppm from this process.¹⁶ MOFs with accessible open metal sites are well suited for the separation process.⁵

Adsorptive selectivity of rigid MOFs (Figure 5) is different than flexible MOFs (Figure 6). In rigid MOFs, guest inclusion has a limitation with the kinetic size of the guest molecule and the diameter of the pore window of the MOF. Therefore similar to zeolites, the separation occurs due to the molecular sieving effect

and/or different strengths of the interactions between adsorbent-adsorbate as well as adsorbate-adsorbate.¹⁷ In flexible MOFs guest molecules act as external stimuli on the structural transformation process.¹⁸ Therefore certain guests are preferentially recognized than the others. "Gate effect" occurs when the structural transformation happened during the adsorption from a closed structure to an open structure.¹⁸ In the closed state the pores are usually not available for guest molecules but it expands and become available when certain type of guest molecules is introduced. This process is known as "gate opening process" and the pressure at that point is called "gate opening pressure" which generates a sigmoidal adsorption profile.¹⁸ Therefore in flexible MOFs, same factors govern the separation efficiency but unlike rigid MOFs these factors are combined with the structural rearrangement effect.

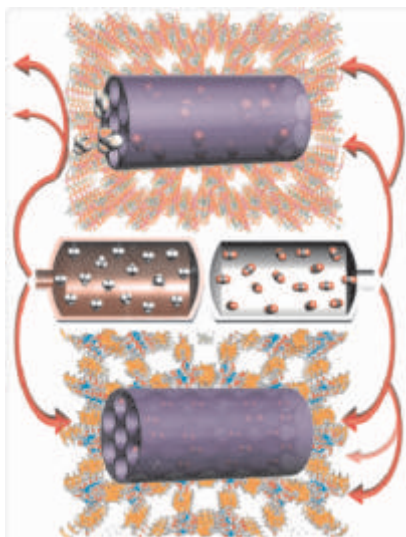


Figure 5. Schematic illustration of selective gas adsorption in rigid MOFs (top: the molecular sieving effect, bottom: preferential adsorption).

The separation of carbon dioxide from methane is important in natural gas upgrading since CO₂ reduces the energy content in natural gas and induces pipeline corrosion. Separation of CO₂/CH₄ mixtures have been studied by Snurr *et al* using a carborane based MOF with and without coordinatively unsaturated open metal sites.¹⁷ The study has confirmed the selective adsorption of CO₂ over CH₄ with a selectivity factor of ~ 17.¹⁷ The separation occurred according to adsorbate-surface interactions and shows that the open metal sites have an influence in separation of quadrupolar and non-polar gas pairs.¹⁷

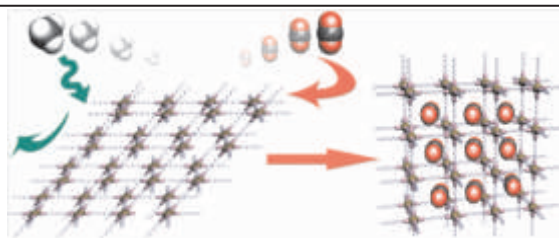


Figure 6. Schematic illustration of selective gas adsorption in a flexible MOF.

A 3D MOF based on manganese and formate, which has 1D channel, has been studied for gas separation.¹⁹ The structure contains larger cages connected by small windows. Experiments show that, at 78 K the material selectively adsorbs H₂ over N₂ and at 195 K it has selectivity towards CO₂ over CH₄.¹⁹ The adsorption capacities of the excluded gases N₂ and CH₄ were almost zero. The selective sorption of H₂ and CO₂ is attributed to the small aperture of the channels which discriminates these gases with small kinetic diameters from other gases which have larger kinetic diameters. This is a good example for molecular sieving effect. Also it should be noted that the adsorption properties may be distinct at different temperatures as the MOF exhibits different selectivity at different temperature.¹⁹

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Training seminar on “Environment and Human Health”

This seminar will be held on 22nd of January 2015 at Adamantane House, Rajagiriya. The seminar is co-ordinated by **Dr. L. S. R. Arambawela**. The resource persons will be **Professors H.D. Gunewardhana & Hema Pathirana, Drs Inoka Suraweera, Udaya Jayasundara & Ranjith B. Mapa, and Messrs L.P. R. J. Wijesinghe, Ananda Pannila & Ajith Weerasundara**. For more details please visit us on www.ichemc.edu.lk or contact IchemC office.

Diploma in Laboratory Technology in Chemistry (DLTC), 40th Batch (2012/14)

Honours Pass (09)

M. S. Latheef, D. S. Fernando, P. M. Rathnayake, D. S. L. Sumanathilake, R. A. D. N. Sandunika, M. S. D. Fernando, S. R. De Silva, M. N. A. Nasra, M. L. F. Azriya

Merit Pass (41)

C. R. D. Fernando, G. D. B. H. T. Senadeera, M. C. I. B. Herath, A. H. M. G. W. C. D. Amunugama, G. Ganesathasan, W. P. D. Tharaka, I. U. Elpitiya, C. M. Mallawaarachchi, W. P. S. Perera, P. N. Sarawanage, M. R. P. Perera, A. S. F. Fazna, M. S. F. Shanaz, A. H. P. Nazreen, R. A. Gamaethige, U. A. Siriwardana, A. A. S. C. Perera, H. M. A. Y. Herath, M. S. Rislal, R. Gayathiri, H. S. Denagamage, N. D. K. Samaraweera, K. T. A. C. Nishshanka, P. P. T. N. Fernando, M. H. F. Sharmila, V. D. P. B. R. Suwaris, K. A. Daladawatta, E. M. K. K. Ekanayaka, R. Rajendran, A. D. Kodithuwakku, G. G. D. Rukmal, G. M. H. Krishanthi, T. G. Paranamana, N. T. K. Geethika, P. K. I. M. Jayaweera, I. D. N. Dayarathna, L. R. M. S. Gunathilake, A. J. A. Jahan, H. P. Weerakkody, T. H. D. H. M. Jayasekara, A. V. N. Jayawardana

Ordinary Pass (30)

M. H. F. Nazira, K. V. S. Madhushika, H. C. G. Fernando, D. G. A. J. Gunasekara, I. N. K. Walagamage, B. F. Bushra, M. K. S. P. Wijeratne, M. R. A. Ahsan, H. A. Priyangika, D. B. Athauda, A. G. P. G. Priyadarshana, K. W. W. M. M. K. B. Waidyanayake, J. M. D. M. Dhanushka, A. Chandren, A. R. L. F. Maseeha, M. H. N. Madushanka, S. D. Karunaratne, T. S. Joseph, M. L. Munasinghe, F. F. Cassin, S. M. Riyas, A. G. K. S. K. Kaluwelgoda, S. D. L. S. Rukmal, A. Pirashanthi, H. R. M. Abeysekara, M. M. Hilmy, P. L. Weeraman, S. P. Kodithuwakku, A. A. A. I. Gunasekara, R. K. G. N. H. Gunasekara

DLTC Overall Prize List-2014

First Prize - G C N Jayasuriya Award for the Best Performance - Mr. M S Latheef

Second Prize - Mr. D S Fernando

Third Prize - Mr. M S D Fernando

Mr. Rohan K Fernando Prize for the Best Performance in Industrial and Food Chemistry Mr. M S Latheef

P. D. Luckmal De Zoysa Prize for the Best Performance in Clinical Laboratory Technology

Mr. M S D Fernando

Dilanka Fernando & Sajeevani Narasinghe Award for the Overall outstanding performance Mr. M S Latheef

Planar Chromatography

Dr. Udaya Jayasundara

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

1. Introduction

This is the simplest chromatographic technique in which the solid phase is placed in an open planar surface such as a sheet, paper or a glass. The mobile phase is always a liquid. Planar chromatography is mostly used for the separation of organic mixtures. Having said that, the steps of a given planar chromatography procedure such as sample application, chromatogram development, registration of chromatogram, and its evaluation (or extraction of important parameters) cannot be presently performed using commercially available devices or chromatographs. It means, that planar chromatography analysis cannot be completely automated. However, Planar Chromatography is still in practice as a head start to the separation sciences.

Planar Chromatography can be classified as follows:

1. Paper Chromatography (PC)
2. Thin-Layer Chromatography (TLC)

1.1. Paper Chromatography (PC)

Separation in PC is fundamentally same as the TLC. However, these papers are manufactured from highly purified cellulose with a close control of porosity. Out of these two methods, the TLC is widely used and the rest of the article will be mainly focused to TLC.

1.2. Thin-Layer Chromatography (TLC)

TLC involves a stationary phase, a mobile phase, and a container which can hold the mobile phase. An experimental setup of a typical planar chromatography is shown in Figure 1.

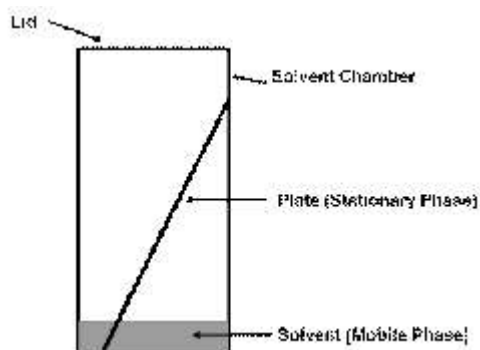


Figure 1. A generic experimental set up of a planar chromatography system.

There are various chambers that have been

employed for the development of planar chromatograms. The chromatographic chambers can be classified according to the,

- i. Volume of vapor inside the chamber.
- ii. Direction of mobile phase migration.
- iii. Configuration of the chromatographic plate in the chamber.
- iv. Degree of automation of chromatogram development.

Each of the above will be briefly discussed below. Those who are interested may refer the reference section for further information.

- i. Volume of vapor inside the chamber:

There are two main types of the chambers commonly used as normal (conventional) chambers (N-chambers) and sandwich chambers (S-chambers). Depending on the type of the plate which we discuss later in the text, there would be some modifications to the dimension of the chamber.

- ii. Direction of mobile phase migration:

This can be further classified as linear development in which solvent migrates through a rectangular or square plate from the bottom edge to the top edge and radial development (including circular and anti-circular) where the mobile phase is delivered at the center of the chromatographic plate and its front migrates toward the periphery of the adsorbent layer or vice versa. These types are shown in Figure 2.

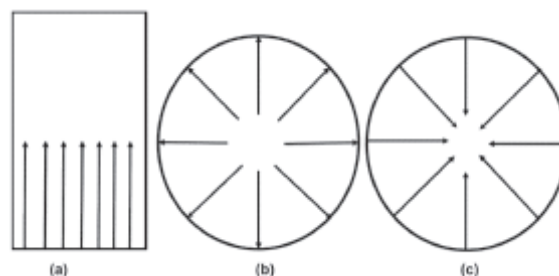


Figure 2. The modes of development of the mobile phase. (a) Linear development (b) Radial (circular) development (c) Radial (anti-circular) development. The arrows show the direction of the solvent front.

- iii. Configuration of the chromatographic plate in the chamber:

If the chamber is placed horizontally then the chamber is called as horizontal chamber whereas if the chamber is placed vertically, then the chamber is called vertical chamber. There are specially designed chambers for either case.

iv. Degree of automation of chromatogram development:

Even though it was mentioned in the beginning of the text that this processes cannot be automated, certain steps which are not directly involved with the plate may be automated such as temperature and humidity control, eluent and vapor phase delivery to the chromatographic chamber, and drying the chromatographic plate.

2. Theory

Similar to other types of liquid chromatography, separation in planar chromatography is based on either adsorption or partition. However, there is a difference between column chromatography and planar chromatography. That is the presence of a third phase in the planar system which is the atmosphere or gaseous vapors located above the surface. In order to obtain reproducible separation, it is necessary to control this phase as well as the stationary phase and the mobile phase.

2.1. Mobile Phase: This is generally a solvent that flows through the supporting medium.

2.2. Stationary Phase: This is a layer or coating on the supporting medium that interacts with the analytes. The supporting medium is a solid surface on which the stationary phase is bound or coated.

2.3. Adsorption Chromatography

Adsorption is a characteristic property of surfaces, particularly solid surfaces. Adsorption in Thin Layer Chromatography occurs at the surface of the particles of the stationary phase, which are in contact with the mobile phase. There are several forces involve in adsorption processes such as van der Waal's forces, dipole interactions, and other weak interactions like hydrogen bonding. No matter what type the interaction is, in chromatographic separations the adsorption process must be reversible. This is because the ultimate goal of chromatography is to separate complexes to respective components. Several factors affect in adsorption chromatography such as;

- Polar groups
- The structure of a compound

- System temperature

If the system temperature is controlled to a constant, then it can be assumed that the adsorption interactions depend only on the solute concentration at the adsorbent surface and its concentration in the mobile phase. This can be written in terms of the distribution coefficient, K , for adsorption chromatography.

$$K = \frac{c_s}{c_m} \quad (1)$$

where, K is the partition coefficient, c_s is the substance concentration in the stationary phase, and c_m is the substance concentration in the mobile phase.

Here K has dimensions.

2.4. Partition Chromatography

The separation in partition chromatography depends on the relative solubility of the sample components in two immiscible solvents which are brought into contact with each other. This can be shown as in the Nernst's distribution law as in equation (2).

$$K = \frac{c_s}{c_m} = \frac{V_m m_s}{V_m m_m} \quad (2)$$

where K is the partition coefficient, c_s is the substance concentration in the stationary phase, c_m is the substance concentration in the mobile phase, V is the volume of the stationary or mobile phase, and m is the substance mass in the stationary or mobile phase. Here K does not have dimensions.

For better separation, the value of K should be between 1 and 10 in partition chromatography. Further, Nernst's law indicates that the quotient between the concentration of each substance in the mobile phase (c_m) and the stationary phase (c_s) at a given temperature is also a constant.

3. The qualitative evaluation of separation

In TLC, there is a way to determine the separation qualitatively. The Retardation Factor or Retention Factor (R_f) is used for this purpose. This is a dimensionless numerical value. There are two different ways to calculate this value as empirical retention factor and thermodynamic retention factor. These two methods will be discussed in detail in the preceding sections.

3.1. Empirical Retardation Factor (R_f)

This is the most commonly used and it is easy to use as this involves a mathematical calculation. The TLC plate is placed in a solvent chamber and the development will be started from the immersion line as shown in the Figure 3.

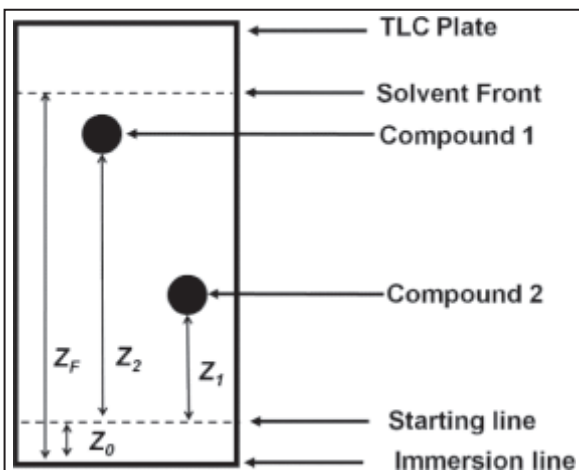


Figure 3. A Typical TLC plate with a two component mixture. Where, Z_0 is the difference between the starting line (where the sample is applied), Z_1 is the distance travelled by the component 1 from the starting line, Z_2 is the distance travelled by the component 2 from the starting line, and Z_F is the distance travelled by the solvent front from the starting line. All these distances can be measured by a ruler and usually in centimeter units.

Using Figure 3, the R_f value for component 1 can be calculated as follows.

$$R_f = \frac{\text{Distance migrated by the component 1}(Z_1)}{\text{Distance migrated by the solvent}(Z_F - Z_0)} \quad (3)$$

The R_f value will always be in the range 0 to 1.

3.2. The Thermodynamic Retardation Factor (R'_f)

Densitogram can be used to get an empirical R_f value but the thermodynamic value, R'_f , (also known as the true R_f value) which correctly represents the behavior of the substance in the separation system. The thermodynamic value is defined as the fraction of time the analyte is dissolved in the mobile phase (t_m) to the total development time ($t_m + t_s$). This can be mathematically represented as follows:

$$R'_f = \frac{t_m}{t_m + t_s} \quad (4)$$

However, the relationship between the mass of the substance in the mobile and stationary phases is independent of time. If constant distribution between phases is assumed, the mass distribution for an analyte is described by,

$$R'_f = \frac{m_m}{m_m + m_s} \quad (5)$$

where, m_m is the mass of the substance in the mobile phase and m_s is the mass of the substance

in the stationary phase.

The equations (5) can be re-arranged as follows;

$$R'_f = \frac{V_m}{V_m + \frac{c_s}{c_m} V_s} \quad (6)$$

where, c sample concentrations in the stationary or mobile phase and V is the stationary or mobile phase volumes. If the partition coefficient (K) is substituted, then the Martin-Synge equation can be obtained as in equation (7).

$$R'_f = \frac{1}{1 + K \frac{V_s}{V_m}} \quad (7)$$

In fact, this can be further simplified to yield,

$$R'_f = \frac{1}{1 + K'} \quad (8)$$

where K' is a constant and equal to the term

$$K \frac{V_s}{V_m}$$

The empirically measured values and the thermodynamic values are only identical only if one of the following conditions can be applied.

- Phase ratio remains constant for the whole layer
- Mobile phase composition does not change during development
- Stationary phase is free of solvent prior to development
- Solvent front velocity is the same as the mobile phase velocity at the spot position

Looking at these statements, it is clear that this would never happen in the real world. Therefore, empirically measured values are always smaller than the thermodynamic values.

In general, the R_f for a compound is a constant from one experiment to the other only if the chromatography conditions are kept constant. In other words, the results can be reproduced.

- solvent system
- adsorbent
- thickness of the adsorbent
- amount of material spotted
- temperature

4. Plates

A TLC plate is a sheet of glass, metal, or plastic which is coated with a thin layer of a solid adsorbent (usually silica or alumina) and in white color. These

are commercially available and come in 5 cm x 20 cm sheets. Each large sheet is cut horizontally into plates with desired size (usually 5 cm tall by various widths). Wider the plate, more the samples can be run on a plate. Plate handling should be done very carefully as the coating of adsorbent can easily be damaged and get dirty.

5. Applying Samples on Plates

Before the sample is applied onto the plate, measure 0.5 cm from the bottom of the plate and draw a line across the plate at the 0.5 cm mark using a pencil. This is the origin or the starting line on Figure 3. The sample will be spotted on this line. Special precautions must be taken not to disturb the adsorbent layer. When multiple samples are run, it is a good practice to label or name the samples on the plate below your line. If it is not possible to do so, make sure to have some sort of identification. The samples should be spotted with a reasonable spacing such that samples will not overlap. Keeping at least 1 cm spacing would be a good practice. As in other techniques, the sample should be carefully applied on the plate because the resolution of the chromatographic system is dependent on the size of the starting zone (spot) of the solute. The sample can be applied to the stationary phase by spotting, dipping, spraying, or sampling through a syringe. Conventional application of sample mixture on the chromatographic plate can be performed with calibrated capillary or micro-syringe.

6. Developing the Plate

The prepared TLC plate as mentioned above is then placed in the developing container as explained in introduction section. The solvent or the mobile phase will rise up the TLC plate by capillary action. Special care must be taken to keep immersion line below the starting line as in the Figure 3 for successful development. Let the plate develop until the solvent is about half a centimeter below the top of the plate if the whole plate can be used. Special attention should be paid during the development process and the plate should be removed from the container right after a reasonable separation is noted and let it dry. The solvent front should be marked immediately with a pencil which allows the user to calculate the retardation factors.

7. Visualize the Spots

Once the plate is dry, it is ready to be viewed for separation of compounds. If there are any colored

spots, first circle them and identify if possible. However, most samples are not colored and hence special visualization techniques may be needed. UV lamp is one such way to observe them. Handling of UV lamp should be done by a trained person to avoid serious injuries.

8. TLC coupled with Other Techniques

Some of the test molecules should be detected as soon as possible due to their fleeting existence in atmosphere. Some of them are listed as follows:

- i. Hyphenated techniques such as TLC coupled to UV diode array detection and to mass spectrometry provide on-line extensive structural information on the metabolites prior to isolation.
- ii. Combination of planar chromatography (TLC) with bio-molecules specific detection by diode array scanning (DAD), mass spectrometry (MS), nuclear magnetic resonance (NMR), and Fourier transform infrared spectroscopy (TLC-FTIR).
- iii. Multidimensional planar chromatography (MD-PC) combined with diode array detection (MD-PC-DAD) and HPLC-DAD for separation, detection, and qualitative and quantitative determination of bio-molecules.

9. Troubleshooting TLC

Even though, TLC is an easy procedure there could be several issues whether the user is an experienced or an inexperienced person. Therefore, it is good to know some common problems encountered in TLC:

1. **The compound runs as a streak rather than a spot:**
This indicates the sample was overloaded. Then, the sample should be diluted and re-run the TLC. Another possibility is that the sample might consist of many components.
2. **The sample runs as a smear or a upward crescent:**
This is very common with compounds which possess strongly acidic (carboxylic acids) or basic (amines) groups. An addition of ammonium hydroxide for amines or acetic acid for carboxylic acids to the eluting solvent could resolve this problem.
3. **The sample runs as a downward crescent:**
The plate was not in good shape and damaged at some point.
4. **Many random spots are seen on the plate:**
This is due to careless spotting of compounds.

5. **No spots are seen on the plate:**

This could be due to either compound concentration was enough or the compound was too dilute. Sometimes UV light may not be able to capture them. In that case another detection method may be needed such as staining or exposing to iodine vapor. Another reason for a spot free plate could be due to the experiment did not go as well as planned. There could be other reasons as well for this problem.

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Safety in a Chemistry Laboratory

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The chemistry laboratory is one of the homes for great discoveries. This does not mean the person behind the discovery should sacrifice his or her life in that home. However, the nature of laboratory work can be dangerous if proper safety precautions aren't taken. While every effort has been made to eliminate the use of explosive, highly toxic, and carcinogenic substances from experiments, still there can be unavoidable hazards associated with the use of a variety of chemicals and glassware. Therefore, the chemists are expected to learn and adhere to several safety guidelines to ensure a safe laboratory environment for both themselves and the people around them. This article presents some of the general safety rules that a chemist should adhere. Additional safety precautions should be announced and may be altered according to the experiments where a potential danger exists.

As a thought, I am wondering how many laboratories in Sri Lanka are using the following guidelines to safeguard laboratory workers.

Attire

- Safety goggles (splash free) **must be worn at all times** while in the laboratory.

This rule must be followed whether you are actually working on an experiment or simply do writing in your lab notebook. I have personally seen most people find this as an awkward statement. In fact, a person enters the lab should be equipped with goggles. Figure 1 shows the difference between a safety glass and splash free goggles. The splash free

goggles are recommended for all chemists who involve work in wet chemistry. The safety glasses have other uses and some chemistry laboratory may alter these if, wet chemistry is not practised.



Figure 1: (a) Safety glass and (b) Splash free goggles

- Contact lenses are **not** allowed.

Even when worn under safety goggles, various fumes may accumulate under the lens and cause serious injuries or blindness. If there is a problem with vision, the best remedy is to wear corrective glasses and then the goggles over that. Or there are specially designed goggles available which acts as a corrective glasses as well as the goggle at the same time.

- Closed toe shoes and long pants **must be worn** in the lab.

Sandals (Figure 2) and shorts are not allowed in a chemistry laboratory. Though this seems to be a simple rule, this would cause life threatening dangers. Lab coats could be an alternative but still no shorts or mini skirts should be allowed inside the active chemistry laboratory under any circumstances.



Figure 2: Open toed versus closed toed in lab

- Long hair must be tied back when using open flames.

This is important when someone is working in an environment where fire involves. However, in some laboratories, it is recommended to put on specially designed caps to cover the head so that there will not be any hair or head related injuries possible.

- Gloves must be worn.

Choosing the appropriate hand protection can be a challenge. However, these limit the exposure of the skin to chemicals.

Apart from the Personal protective equipments (PPE) mentioned above, there can be ear protections and face shields as well. However, those are not commonly used in general laboratories.

Beside the above mentioned PPEs, there are some important things that anyone work in the laboratory should follow. These are explained in the preceding section.

Conduct

- Eating, drinking, and smoking should be strictly prohibited in the laboratory.
- No unauthorized experiments are to be performed. If someone is curious about trying a procedure not allowed in the given procedure, he or she should consult with laboratory instructor or superior.
- Never taste anything. Never directly smell the source of any vapor or gas; instead by means of your cupped hand, waft a small sample to your nose. Do not inhale these vapors but take in only enough to detect an odor if exists.
- Any personal belongings should not be taken or left on the lab benches and stools. There should be a separate area before someone enters to a laboratory to keep them safely such as hook racks and lockers. The users must be aware that lab chemicals can destroy personal belongings.
- Hand should always be washed before entering and leaving the lab.
- Learn where the safety and first aid equipment are located. This includes fire extinguishers, fire blankets, and eyewash stations. In fact, these should be introduced by the instructors in the very first laboratory but hardly this is practiced.

When it comes to the handling of chemicals and equipments most chemists have a minimal knowledge

or they do not want to practice what they know.

Handling of Chemicals and Equipments

- Consider **all** chemicals to be hazardous (including distilled water). Material Safety Data Sheets (MSDS) or currently called Safety Data Sheets (SDS) should be available in the lab for all chemicals in use regardless whether it is a teaching or research laboratory. If multiple laboratories are conducted at the same time and the same chemicals are used in all laborites, it is better to keep those MSDS or SDS in the stock room which is the most common place that everyone involved can attended. MSDS/SDS will inform you any hazards and precautions which you should be aware.
- Always the user should be aware with what chemicals are being used. They must carefully read the label *twice* before taking anything from a bottle. Chemicals in the lab should be marked with National Fire Protection Association (NFPA) hazardous materials diamond labels. The user must be taught to interpret these labels. In some teaching laboratories, chemicals are identified just by names. Some times they do carry prefixes like “conc” for concentrated and “dil” for diluted. It should be kept in mind that the name of the chemical is just ONE of FIVE (name, concentration, date of manufactured, date of expiration, and the person who made the solution) most important things that should appear on a label if someone is altering the concentration of the original reagent. Otherwise, the manufacture provided label should always visible to the user.
- Always the chemist must dispense the amount needed for the experiment. Wasting chemicals is a bad practice as almost all chemicals are associated with production cost. Having said that, excess reagents are **never** to be returned to stock bottles. If someone took too much (by accident), dispose of the excess to the recycle can or a vessel assigned for that. The goal is to make sure the original bottle is contaminate free and avoid any risks that may take place during placing back.
- Dispose of chemicals should be done properly. There should be waste containers which are labeled depends upon the type of chemical. Usually it is assumed that only water may be put in the lab sinks.
- Many common reagents, for example, alcohols and acetone, are highly flammable. Therefore,

they should not be used **near open flames**.

- Always pour acids into water. If you pour water into acid, the heat of reaction will cause the water to explode into steam, sometimes violently, and the acid will splatter.
- Never store nitric acid with acetic acid even though a separate location is assigned for acids in a teaching or research laboratory.
- If chemicals come into contact with your skin or eyes, **flush immediately** with copious amounts of water and consult with your instructor.
- Never point a test tube or any chemical containing vessel that you are heating at yourself or your neighbor as it may erupt violently.
- Clean up all broken glassware immediately and dispose of the broken glass properly. The cleaning process should be handled by an experienced person and never touch any piece of broken glassware. For any breakage or chemical spill the designated person should be contacted.
- Burners should never be left unattended. They should be turned off whenever they are not in use. If there is a reason to leave the lab for a short time with the burners on, have someone to take care of it or place a notice that anyone enter the lab can

easily see.

- Whenever, the analytical instruments are used, it should be logged and the instrument must be cleaned. In fact, it is good practice to clean any analytical instrument before and after use.
- Hot glasses and warm chemicals should be handled very carefully as these can easily put someone in trouble.
- If an experiment should be left overnight running, that should be clearly labeled and the permission should be obtained from your supervisor.

The goal of this article is to provide some background knowledge about safety associated with a chemical laboratory. I believe this will be helpful if anyone needs to design a safety manual for students.

In general, there are safety quizzes given to students once they are explained the safety in a chemistry laboratory.

PS

The materials present here are exclusively obtained from my training as a graduate student and a scientist in a contract research organization in the USA.

Graduateship Examinations in Chemistry, 2014

LEVEL 3 – AWARDS LIST

First Prize & Mandrupa & Oleap Fernando Hall Opening Scholarship	Ms. M S N Ranasinghe
Second Prize and Susila Jayaweera Memorial Scholarship	Ms. A V K Munasinghe
Third Prize & Graduateship Silver Jubilee Scholarship	Ms. L A Wijesekera

MERIT BURSARIES (*in order of merit*)

Ms. A. S. N. Kurian, Ms. D. S. Yapa, Ms. H. K. C. K. Halloluwa, Mr. P. V. Y. Cooray, Ms J. P. S. Vidyani

IChemC President's Scholarship in Level 4 awarded for the Best Overall (Theory) Performance in Levels 1, 2, & 3
- Ms. A V K Munasinghe

LEVELS 3 & 4 SUBJECT PRIZES FOR BEST PERFORMANCES

Dr. S Laksman De Silva Memorial Trust Prize for Physical Organic Chemistry	Ms. M S N Ranasinghe
E G Somapala Prize for Food Chemistry & Technology	Ms. S A M Gayathri
Denzil & Christobel Fernando Commemoration Prize for Agroindustries	Ms. S Balachandrarajan, Ms. Y M R De Silva
Prof. Eugene De Silva Prize for Industrial Chemistry and Technology	Ms. J A Vanlangenberg
A M Jayasekera & Kusum Aththanayaka Family Prize for Separation Science	Ms. D M K C Dissanayaka
Marina & R O B Wijesekera Prize for Molecular Biology and Biotechnology	Mr. A A D N Perera, Ms. R S G Corea
CCS Prize for Further Topics in Physical Chemistry	Ms. A V K Munasinghe
Mr. & Mrs. E Gajanayake Memorial Prize for Atomic Absorption Spectrometry	Mr. N M C N Navarathna
Mr. P. Rohan K. Fernando Prize for Industrial Safety & Environmental Technology	Ms. A V K Munasinghe
Dr. Sudath Kumarasinghe Memorial Prize for Special Topics in Physical Chemistry	Ms. A S N Kurian
Prof. P P G L Siriwardene Memorial Prize for Further topics in Inorganic Chemistry	Ms. A S N Kurian
CCS Prize for Petroleum and Petrochemicals	Ms. Y M R De Silva, Ms. H K Maduwage

Graduateship Examinations in Chemistry, 2014

LEVEL 1 – AWARDS LIST

First prize and Nandawathie Jayaweera Memorial (Open) Scholarship	Ms. K Chandrakanthan
Second prize and Charles Jayaweera Memorial (Open) Scholarship	Ms. L N Dayarathna
Third Prize and Prof. R S Ramakrishna Memorial Scholarship	Ms. M K B K Perera
Fourth Prize and Dr. Dilanjan and Ms. Gowrie Soysa Scholarship	Ms. A M O H Amarasinghe
	Ms. P S Ishtaweera
Second Charles Jayaweera Memorial (Southern Province) Scholarship	Ms. Y V A R Mihirika
Second Nandawathi Jayaweera Memorial (Southern Province) Scholarship	Ms. G K M M Abeythunga

MERIT BURSARIES (*in order of merit*)

Ms. V S Samarasiri, Ms. K M Wijesinghe, Mr. W S D Fernando, Ms. I V Handungoda, Ms. H S K Jayawardena

SUBJECT PRIZES

Graduate Chemist Alumni prize for General & Inorganic Chemistry	Ms. A M O H Amarasinghe
Emerine Fernando Memorial prize for Principles of Physical Chemistry	Ms. K Chandrakanthan
Bennet prize for Mathematics for Biological Science Students	Ms. H S K Jayawardena
Somawathie Mathew Memorial prize for Biology for Physical Science Students	Ms. K Chandrakanthan
Prof & Mrs S Sotheeswaran Prize for Principles of Organic Chemistry	Ms. A M O H Amarasinghe
	Ms. K Chandrakanthan
Mr & Mrs J M Ranasinghe Banda for Application of Mathematics in Chemistry	Ms. P S Ishtaweera
Prize for Analog & Digital Electronics for Chemists	Ms. K Chandrakanthan
Prize for Fundamentals of Physics for Chemists	Ms. K Chandrakanthan

LEVEL 2 – AWARDS LIST

1 st Prize & W F Peiris Memorial Trust Scholarship	Ms. U K M Bopitiya
2 nd Prize & Professor W Pearlyn D Perera Commemoration Trust Scholarship	Ms. A A S V Fernando
3 rd Prize & Professor G C N Jayasuriya Memorial Scholarship	Ms. K H D Perera
4 th Prize & Family Leelarathna Scholarship	Mr. P B G Danushka

MERIT BURSARIES (*in order of merit*)

Ms. N Gunawardhana, Ms. M S De A Goonatilleke, Ms. K D S S Perera, Ms. K A M C Kodituwakku, Ms. H R Atapattu, Mr. H R N Silva, Ms. K R M S Ratnayake, Mr. D C A Perera

SUBJECT PRIZES

Professor J N Oleap Fernando Prize for Physical Chemistry	Ms. A A S V Fernando
Professor Samitha P Deraniyagala Prize for Inorganic Chemistry	Ms. K D S S Perera &
	Ms. U K M Bopitiya
Professor Siromi Samarasinghe Prize for Organic Chemistry	Ms. K D S S Perera
Yogaranee and Family Prize for Analytical Chemistry	Mr. D N N De Silva
Professor Jayantha Welihinda Prize for Biochemistry I	Mr. D N N De Silva
Henry Ashmore Pieris Memorial Prize for Introduction to Management, Economics & Finance	Ms. A A S V Fernando

Graduateship Examinations in Chemistry, 2014

32nd Batch of 106 Graduate Chemists Pass out in 2014

First Class Honours (07)

Ms. D M K C Dissanayaka, Ms. N U Darmaratne, Ms. K M Perera, Ms. J A Vanlangenberg, Ms. A M G A Ranasinghe, Mr. S A K James, Mr. C D R Pathirana

Second Class Honours (Upper Division) (33)

Ms. S Anantharajah, Mr. T B Alahakoon, Ms. A M J S Amarasinghe, Ms. A H T Y M Ariyasinghe, Ms. C M Chandrasekaran, Ms. R S G Corea, Ms. S D De Mellawa, Mr. R T de Silva, Mr. K N S Fernando, Ms. W S M Fernando, Mr. H M G K E Herath, Ms. P P D Jayapala, Ms. W A I U Jayawickrama, Mr. M A T N Karunarathne, Ms. P P Lakshani, Mr. S A G Liyanage, Ms. H K Maduwage, Mr. M D K N Manathunga, Ms. S Marks, Ms. A Megalathan, Mr. N M C N Navarathna, Mr. R M Pethiyagoda, Mr. K M Pillai, Ms. L L Pitigala, Ms. K A P A Premathilaka, Mr. O T R Ranaweera, Mr. P P M Rodrigo, Ms. H L Samarasinghe, Ms. P A A R Silva, Ms. V S Thrikawala, Ms. M B S Weerawardena, Ms. S Balachandrarajan, Ms. F N A Refaideen

Second Class Honours (Lower Division) (21)

Ms. S D Ranasinghe, Mr. K C M L Alvitigala, Ms. R S S Chandrasiri, Ms. M H De Silva, Ms. E Sanuja, Ms. M W A M S Fernando, Ms. G A K V Ganepola, Ms. K K R R Gunawardena, Ms. A S Dulanjalee, Mr. D M T Nirmal, Mr. W A A R P Perera, Ms. S D Ranasinghe, Mr. H A Senanayake, Mr. N A K L Senevirathne, Ms. S H A Udariika, Ms. S Vithusini, Mr. P M Wadanambu, Ms. M S H Wickramasinghe, Ms. I K L N K Yatiwella, Mr. K Nirmala, Ms. B S Y Perera

Third Class Honours (19)

Ms. S M S H Samarakoon, Ms. T M Dayarathna, Mr. H L L P De Silva, Ms. D S D Dharmagunawardana, Mr. H T H Hasitha, Mr. K P D E A Kumara, Ms. D C P Manampari, Ms. M W H A Manaweera, Ms. D D L P Minidukula, Ms. D S P Munasinghe, Ms. U B D Perera, Ms. M Ranjan, Mr. S W I P Sanjeewa, Ms. W L Watagodagedara, Ms. W M S Wijekoon, Mr. W V J Lakshan

Pass (26)

Ms. K A A N Bandara, Ms. S Babyarane, Ms. C K Dharmawardana, Ms. K G P N Gamage, Ms. J M I S Jayasundara, Ms. M H Y K S Shantha, Mr. D C Batuwangala, Ms. W A D Fernando, Mr. H M N A Herath, Ms. M M C P Marasinghe, Ms. G L A Mashika, Mr. P S D Perera, Ms. A R M Nilmini, Mr. N P Wickramasinghe, Ms. T I Kariyawasam, Ms. E T D Jayasinghe, Ms. L S A Perera, Mr. N Y Abeysirigunawardene, Ms. T A I N Fernando, Ms. M K Samaradeera, Mr. W K M Jayaweera, Ms. A Ratnakumar, Ms. F Z M Ismail, Ms. T A V Sandeepanie, Mr. R D W Seneviratne, Mr. W M C Jeewananda

Overall Examination Awards -2014

1 st	Shireen Jayasuriya Memorial Gold Medal	Ms. D M K C Dissanayaka
2 nd	Graduateship Silver Jubilee Award	Ms. N U Darmaratne
3 rd	Graduate Chemist (25 th Batch Passing out) Silver Jubilee Award	Ms. K M Perera

Overall Excellence Awards covering all levels

Prof. J K P Ariyaratne Award for Inorganic Chemistry	Ms. K M Perera
Prof. Leslie Gunatilake Award for Organic Chemistry	Ms. D M K C Dissanayaka
Haniffa Award for Physical Chemistry	Ms. N U Darmaratne
Prof. Saman & Asoka Patiratne Award for Analytical Chemistry	Mr. N M C N Navarathna

Overall Best Performer Awards (Practical)

First: Professor RS Ramakrishna Memorial Award	Mr. O T R Ranaweera
Second: Mr. & Mrs. K Sivarajah and Family Award	Mr. M A T N Karunarathne
Second: B A Jayasinghe Memorial Award	Ms. K M Perera
Fourth: CCS Awards: Ms. J A Vanlangenberg	
Good Performer CCS Awards	Ms. W A I U Jayawickrama, Mr. H M G K E Herath, Ms. M W A M S Fernando, Mr. S A K James

Levels 3 & 4 Overall (Theory) Prizes

First: RSC (Sri Lanka Section) Award	Ms. N U Dharmaratne
2 nd : Professor and Mrs. H W Dias Award	Mr. C D R Pathirana
3 rd : Rasanthika Nayomi Jayatissa memorial Prize	Ms. K M Perera, Ms. A M G A Ranasinghe

44th Annual Sessions of the Institute of Chemistry Ceylon 2015

Theme:

Chemical Sciences in Food Safety and Security

Date: 17th - 19th 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



RSC NEWS

THE ROYAL SOCIETY OF CHEMISTRY SRI LANKA SECTION

1. Membership

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

Category

Number

CChem, FRSC	11
FRSC	05
CChem, MRSC	10
MRSC	20
AMRSC	08
Affiliate /Under Graduate.	<u>06</u>
Total Membership as at July 2014	<u>60</u>

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 Synthesis	Dr. Chayanika Padumadasa	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/-)





Academic Board of the College of Chemical Sciences - 2014/2015



Seated (L to R) : Prof. (Ms) S A Deraniyagala, Dr. (Ms) L S R Arambewela, Dr. A A P Keerthi, Mr. E G Somapala, Mr. H S M Pieris, Mr. S C D Fernando (Asst Secretary), Mr. N I N S Nadarasa (Registrar), Prof. J N O Fernando (Chairman), Prof. H D Gunawardhana (President, IChemC), Prof. M D P De Costa (Dean, CCS), Mr. M R M Haniffa (Vice Chairman), Dr. (Ms) Chandani Udawatte (Secretary for Educational Affairs), Prof. K A S Pathirathne, Mr. K R Dayananda, Prof. (Ms) Sujatha Hewage, Prof. (Ms) Priyani Paranagama

Standing (L to R): Dr. (Ms) H I C de Silva, Ms. Nalini de Silva, Dr. (Ms) Dinusha Udukala, Prof. (Ms) Ramani Wijesekara, Dr. (Ms) T Gobika, Dr. U K Jayasundara, Dr. (Ms) R Kandiah, Dr. R Parthipan, Dr. U S K Welivegamage, Dr. Infas Mohammed, Dr. M N Kaumal, Mr. P R K Fernando, Dr. W G P Ariyananda, Mr. A M Jayasekara (Additional Deputy Registrar)



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