Issue 1

JRCS

Journal of Rasayanatva- The Chemical Society of Hansraj College

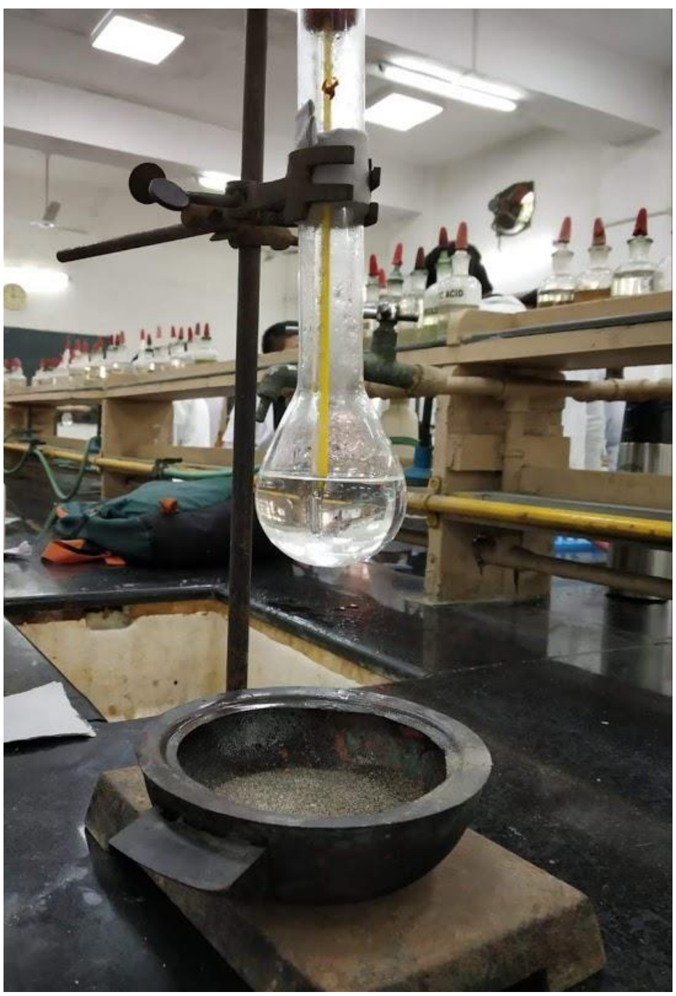
Department of Chemistry
Hansraj College
Delhi University-110007

Research Newsletter: Issue 1

EDITORS' REMARK

Aloha Readers!

Being a student of chemistry has always fascinated us because unlike other subjects, where the object of study can be seen or observed, we enjoy no such powers. We work on molecular and atomic levels without seeing them. Their essence can only be felt and enjoyed making it one of the toughest subject to work with. Yet it attracts thousands of people towards itself because of its tremendous power to change the world. The atomic bomb that changed the course of history, the nuclear power plants which revolutionized the electricity supply, the plethora amount of medicines which has advanced the medical field and what not. Right from cosmetics to the cosmos, everything has a chemistry of its own. The list of achievements of chemistry is a never ending one.



It has been almost a year and struggle with this pandemic is still not over. Scientists, researchers and scholars are all aiming towards the development of vaccine to curb this pandemic and their only ray of hope is an integrated approach in fields of biomedicine using biochemistry and cheminformatics. The way these research applications are revolutionizing this field gives everyone a hope that it is for sure possible to curb this pandemic. These achievements come from a scientific temperament which develops gradually over years and as a result of acquiring knowledge related it. The Chemical Journal of Rasayanatva helps the students to foster in them this scientific rationale in their formative years. This journal is an initiative to do so. It is the first time that any college society is launching their own journal so we hope to get immense love from all our readers. We welcome all constrictive criticism regarding this journal. You can always mail us your suggestions at editorial.board.rasayanatva@gmail.com.

Happy reading!

Editors-in-chief

Kirti Kashyap 'Taijas'

Prashansa Mehta

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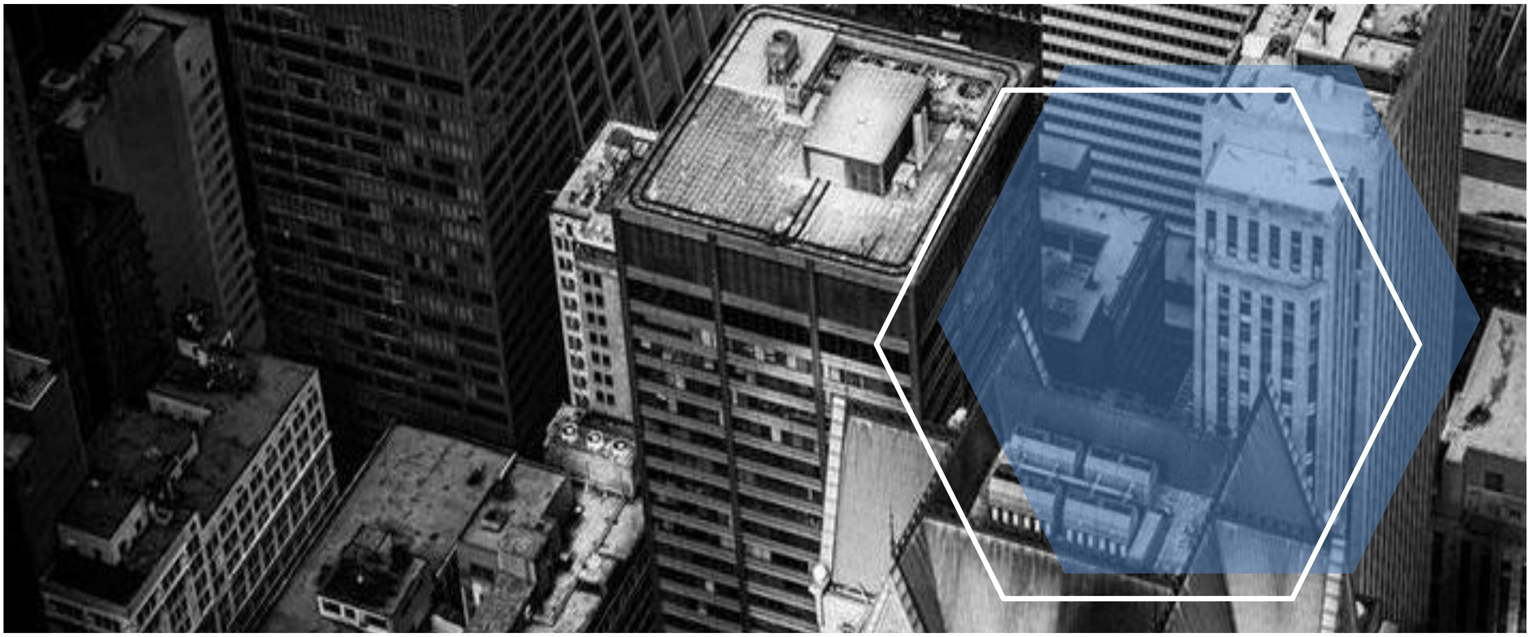
Table of Contents



POST COVID CHALLENGES AGAINST INDIA

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Coronavirus disease 2019 (COVID-19) pandemic, caused by a novel coronavirus, SARS-COV-2, is of unprecedented public health concern . The WHO declared this COVID-19 mass scale infection as pandemic after more than 200 countries and territories were infected. To combat this disease, the Government of India imposed a lockdown in most districts of the 22 States and Union Territories where confirmed cases were reported from March 24, 2020 onwards. The Government of India has claimed success in the fight against the coronavirus pandemic, stating that the number of cases would have been more if the nationwide lockdown had not been implemented. India has 8,13,972 active cases; 63,79,018 total recovered patients; 111774 total death; 90090122 total tests done from day 1 as noted on 14 Oct. 2020. Herein, we aim to discuss the impact of lockdown in response to the COVID-19 pandemic on social, economic, health, and healthcare systems in India.

SOCIAL CHALLENGES

Close physical interactions in crowed places, pushing and jostling are extremely common that are major obstacles in 'social distancing', which remain necessary during this pandemic. Crowd on religious places, traveling (e.g. 'herds' of migrants on buses), liquor shops, violating the lockdown and become one of the reasons for spreading infection. The lack of proper provision for food safety had hardest impact of lockdown and the implemented schemes were inadequate to deal with the scenario. Under government scheme, Pradhan Mantri Garib Kalyan Anna Yojna (PMGKAY), Food Corporation of India allotted above 12.96 lakh metric tones of food grains to fight against the pandemic situation. Women have been at greater risk from the health perspective. Resource limitations for women has brought a situation where they tend to neglect their own requirements while prioritizing the life and the budgets of others in the family and issues like menstrual hygiene, mental health and nutrition do not feature in the list of priority.

Social stress caused by lockdown resulting from travelling restrictions and disruption of cultural celebrations, limited healthcare facilities and interruption in regular immunizations in hospitals leading to anxiety and fear among the population. Inadequate infrastructure, leading to ill-equipped healthcare employees who are fighting endlessly to treat the COVID patients and protect themselves from infection at the same time are all quite visible. Nonetheless, if appropriate measures are not implemented in time, the virus of racism will inherently remain in the mind-sets of people, with a threat to peace and stability of the society.

IMPACT ON HEALTH AND HEALTHCARE SYSTEMS

According to Global Health Security Index, India is ranked 57 in year 2019 for pandemic preparedness based on their ability to handle the crisis, on other side US, UK, Brazil, and Italy ranked 1, 2, 22, and 31, respectively, indicating India is more vulnerable to the pandemic fatalities. Morbidity and mortality due to COVID-19 in India are largely attributable to co-morbid conditions such as non-communicable diseases (NCDs) even young individuals with early-onset of NCDs are very much prone to have COVID-19 infection.

The lockdown could also be a cause of weight gain during the COVID-19 pandemic, because of poor physical activity, increased snacking and consumption of calorie-dense foods. Weight gain and obesity could increase the severity of COVID-19 and may increase the risk of development of diabetes and cardiovascular disease in the future. The death related to Human Immunodeficiency Virus (HIV) infection, TB and malaria over 5 years may increase by up to 10%, 20% and 36%, respectively, compared to a scenario without COVID-19 pandemic. The reasons include: interruption of antiretroviral therapy, reductions in timely diagnosis and treatment of TB and reduced prevention activities including interruption of planned net campaigns for malaria.

According to report published in June 2020, the capital of India, New Delhi reported over 1000 cases/day when 8,500 hospital beds dedicated to 17,712 active covid-19 cases. In October 14, 2020, Delhi has 21,218 hospital beds (including general, ventilators, non-ventilators, ICU) for 21,490 active cases.

India's low investment (1.3% of GDP) in the healthcare sector could be one of the reason for its vulnerability to COVID-19. This contrasts with other developing countries such as Brazil, which spends 7.5% of its annual GDP on health, Bhutan, which has allocated 3.6%, and Bangladesh, which dedicates 2.2%. According to the Health Ministry, data released in October 2019, there is one doctor for every 11,082 people, which is more than 10 times the doctor-patient ratio. The WHO mandates that the doctor to the population ratio should be 1:1,000 while India had a 1:1,404 ratio as of February 2020.

VIOLENCE AGAINST HEALTHCARE WORKERS

The statement on 18 August by International Committee of the Red Cross (ICRC), more than 600 incidents of violence, harassment, or stigmatization took place between Feb 1 and July 31, 2020 against health-care workers, patients, and medical infrastructure. Although the patients and the medical infrastructure were often targeted, 67% of incidents were directed at the health-care workers. Above 20% involved physical assaults, 15% were incidents that occurred as fear-based discrimination, and 15% were verbal assaults or threats as categorized by ICRC.

ECONOMIC IMPACT

India is going through a critical time particularly, economy crisis and high rate of unemployment, however Government is trying to implement majority of the schemes to overcome the situations. This economic slowdown could exacerbate malnutrition. All the sectors *viz*. transport services, public and private offices, factories were affected during lockdown and some of remained completely shut-off and very limited and conditional mobilization was permitted. The early lockdown implemented by Indian Government was a foresighted step with an intelligent approach.

The pandemic scenario has disruptive impact on Indian economy. Ministry of Statistics and Programme Implementation declared India's growth in the fourth quarter of the financial year 2020 moved down to 3.1% . CRISIL reported that this will maybe be India's most noticeably awful downturn since freedom. As per Nomura India Business Resumption Index, financial movement tumbled from 82.9 on 22 March to 44.7 on 26 April 2020. By 13 September 2020, the financial movement was almost back to pre-lockdown. Unemployment rose from 8.75% in March to 23.52% in April 2020, and then back down to 6.67% in September. It is estimated that 12.2 crore people have lost their jobs during lockdown while many of them are getting reduced salaries.

Farmers who develop perishables, particularly leafy foods, are as of now facing the warmth of the pandemic situation with costs falling, decrease in mass interest from inns and eateries. According to Ministry of Statistics, the first quarterly GDP of FY2020-21 declined to 26.9 lakh crore compare to 35.35 in FY2019-20. On 28 April 2020, the former Chief Economic Advisor (CEA) Arvind Subramanian said to the that India should prepare for a negative growth rate in FY21. State Bank of India research predicts a contraction of over 40% in the GDP in the first quarter (Q1) FY21. The expected GDP contraction in the FY21 will not be uniform and it will be determined by various parameters such as state and sectors. Exports in April 2020, were USD10.36 billion, as compared to USD 26.07 billion in April 2019, exhibiting a negative growth of -60.28 percent.

In the start of May, Duvvuri Subbarao, a previous RBI lead representative, said that India could anticipate a V-formed recuperation. By mid-June, unemployment levels were back to pre-lockdown levels. Online sales reached pre-COVID level sales by June end . GST collections recovered to INR 90,917 crore in June from INR 62,009 crore in May and INR 32,294 crore in April 2020, reflecting a rise in consumption. By 13 September 2020, Nomura India's Business Resumption Index showed that economic activity was nearly back to pre-lockdown levels.

There is a need to learn from impact of our unorganized financial planning, encouraging of investment in healthcare sector and considering other health issues by the policy makers to fight against another pandemic scenario efficiently. There is also a need of minimizing psychological and social distress among people, which can be accomplished with joint efforts from Government and individuals.

The author acknowledges his research advisor, Dr. Brijesh Rathi for enormous encouragement and support.

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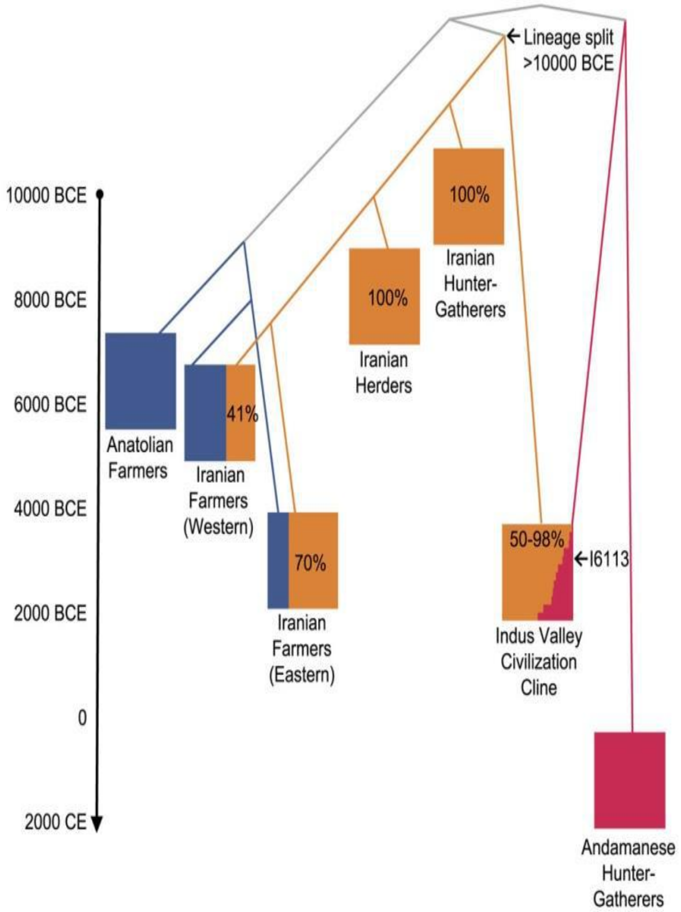
RECONSTRUCTING PAST WITH ANALYTICAL CHEMISTRY

BY ABHISHEK SAINI (Department of Chemistry, Hansraj College)

We all are possessed—not by some revengeful soul but by our own DNA. Our very existence depends on its necessity to replicate and ability to mutate (change its configuration). Even though we die, our DNA survives either in our children or in nature for years to come. If you don't believe me, well you might want to hear what this 4500 years old lady had to say about her ancestors; obviously she is dead but her DNA isn't.

The genetic information (genome) collected from a female skeleton found in Rakhigarhi (Indus Valley Civilization) reported absence of Anatolian gene that belonged to the Iranians who migrated to Southeast Asia but instead had a mixture of Iranian and South Asian genome. This suggests a new theory for their ancestry being derived way before the lineage of the Iranians and South Asians separated back in time, which concludes that farming in South Asia arose from local hunter-gatherers rather than from large-scale migration from the West by the Iranians as per the earlier hypothesis. Researchers perform a variety of experiments to validate these findings and often use analytical techniques like DNA extraction and DNA sequencing to obtain sufficient data in order to compare different DNAs from different time periods.



In DNA extraction, the bones being studied are cleaned of any dirt followed by drilling to obtain a fine-grained powder of the specimen. A small amount of this powder is treated with extraction solution and left overnight (in the dark) at 65° Celsius with slow rotations that ruptures the cell and nuclear membrane forcing the DNA to aggregate in the solution. This solution is then treated with binding buffer and silica suspension which helps the DNA to bind with the silica particles and remove contaminants in order to obtain a pure DNA sample with the help of centrifugation.

In DNA sequencing, the DNA sample is heated to separate the DNA strands and then cooled for the primer (short piece of synthesized single-stranded DNA) to bind to the single-strand of DNA sample. The temperature is again raised to allow DNA polymerase (enzyme) to synthesize the DNA strand until a dye-labeled dideoxy nucleotide is added instead of a normal DNA nucleotide. This terminates the synthesis and generates different DNA fragments that are passed through a tube where a laser setup allows the attached dye to be detected.

A shorter fragment travel faster and gets detected first. The color of the dye detected allows us to sequence the DNA, one nucleotide by one, resulting in the complete DNA sequence. A DNA comparison provides vital proof about our ancestors, extinct and evolution. Now, the question arises—what else does this DNA hide? What mysteries will it unravel in the future? These questions will certainly intrigue scientists for the coming years in this field.

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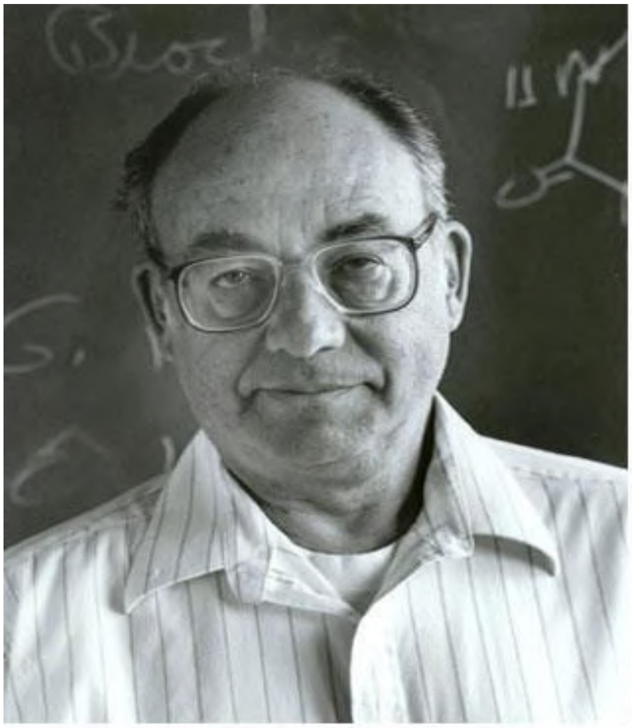


MILLER UREY EXPERIMENT

BY YASHIT VERMA (Department of Chemistry, Hansraj College)

ORIGIN OF THEORY OF ORIGIN OF LIFE

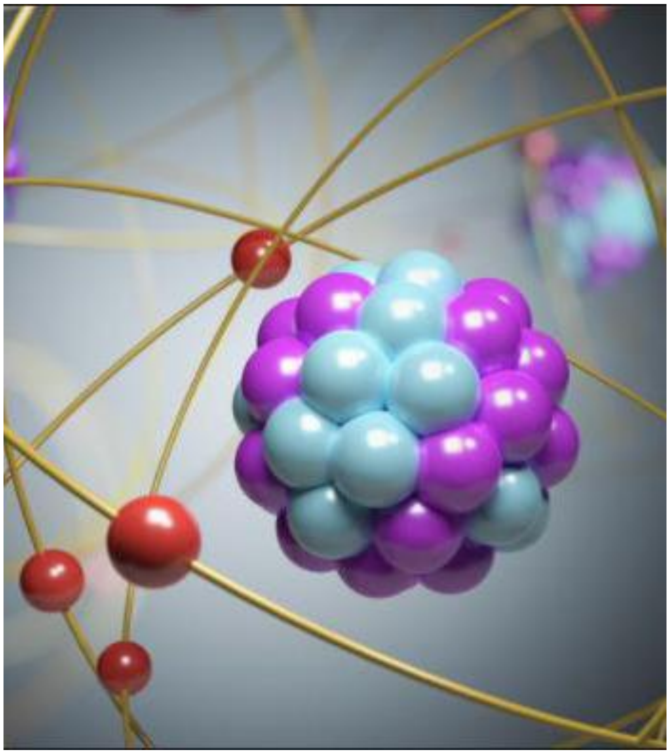
Numerous theories have been suggested as in order to explain the origin of life, some famous theories include introduction of alien species and others include the idea that life can be spontaneously arise from non living matter(Aristotle).

Another theory "Theory of chemical evolution" suggests that Origin of life on earth is the result of a slow and gradual process of chemical evolution that probably occurred about 4 billion years ago.

Stanley L. Miller, born in 1930 in Oakland, the father of prebiotic chemistry, and Urey, born in 1893, Noble prize winner tried to explain the same by creating the same conditions as the earth had 4.5 billion years ago.

HYPOTHESIS

Organic compounds that serve as the basis for life were formed when the earth had an atmosphere of methane, ammonia, water and hydrogen.



THE EXPERIMENT

An apparatus was build to mimic early earths Atmosphere Requirements: NH3, CH4, H20, and H2 must be circulated past an electric discharge

COMPONENTS:

•A sterile 5-liter glass flask with NH3, CH4, and H2 gasses

•A 500ml sterile glass flask with H20 (heated to induce evaporation)

•Two electrodes used to generate electrical sparks

Method:

•Two flasks were connected in an apparatus to allow constant cycling of components

•Apparatus was run continuously for a week

•After 1 week of cycling, the boiling flask was removed and HgCl2 was added

•Ampholytes (amphoteric molecules that contain both acidic and basic groups) were separated

•Addition of Ba(OH)2 and in vacuo evaporation to remove amines

•Addition of H2SO4 and in vacuo evaporation to remove acids

•Paper Chromatography used to identify amino acids

CONCLUSION

This experiment supported the possibility of the origin of life through chemical evolution. Chemical Reactions Justifying the results:

Atmospheric Components

$CO_2 \rightarrow CO + [O]$ (atomic oxygen)

$CH_4 + 2[O] \rightarrow CH_2O + H_2O$

$CO + NH_3 \rightarrow HCN + H_2O$

$CH_4 + NH_3 \rightarrow HCN + 3H_2$

The formaldehyde, ammonia, and HCN then form amino acids and other biomolecules:

$CH_2O + HCN + NH_3 \rightarrow NH_2\text{-}CH_2\text{-}CN + H_2O$

$NH_2\text{-}CH_2\text{-}CN + 2H_2O \rightarrow NH_3 + NH_2\text{-}CH_2\text{-}COOH$ (glycine)

AFTER DEATH OF MILLER

Following a severe stroke in 1999, Jeffrey Bada (one of Stanley Miller's previous graduate students) inherited boxes of experimental samples from Miller's lab. Later researchers have been able to isolate even more different amino acids, 25 altogether. Bada has estimated that more accurate measurements could easily bring out 30 or 40 more amino acids in very low concentrations, but the researchers have since discontinued the testing. Miller's experiment was therefore a remarkable success at synthesizing complex organic molecules from simpler chemicals, considering that all known life uses just 20 different amino acids.

AFTERMATH OF MILLER UREY EXPERIMENT

This experiment inspired many others. In 1961, Joan Oró found that the nucleotide base adenine could be made from hydrogen cyanide (HCN) and ammonia in a water solution. His experiment produced a large amount of adenine, the molecules of which were formed from 5 molecules of HCN. Also, many amino acids are formed from HCN and ammonia under these conditions. Experiments conducted later showed that the other RNA and DNA nucleobases could be obtained through simulated prebiotic chemistry with a reducing atmosphere. The Miller Urey experiment was a breakthrough in understanding origin of life and backs up Darwin postulates about theory of evolution.

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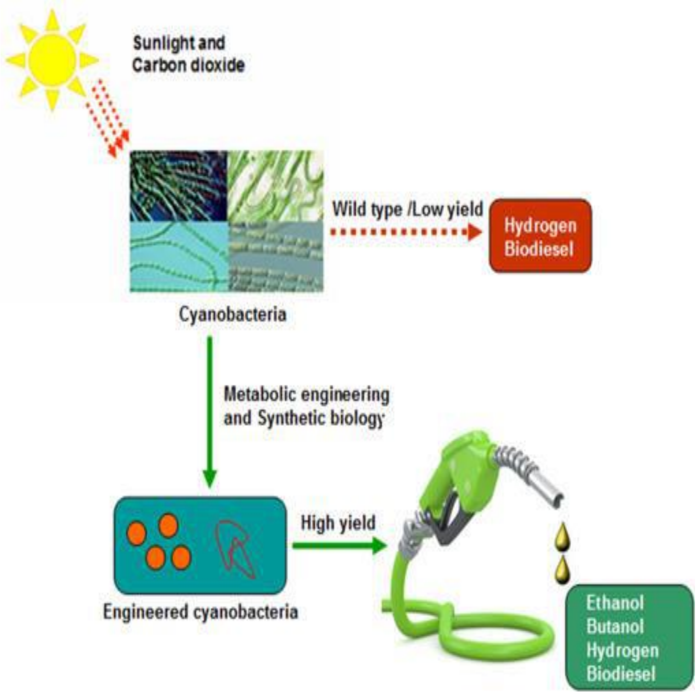
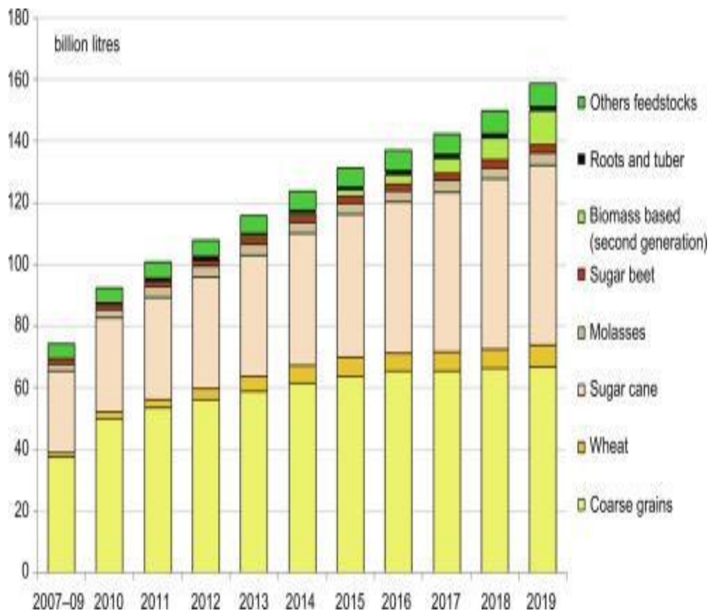
CYANOBACTERIA CONVERSION OF FATTY ACIDS TO FUEL

BY SARTHAK KAUSHIK (Department of Chemistry, Hansraj College)

As per the increase in population day by day, human beings must learn to cultivate and renew energy sources in the same way that we do for food. The ability of biology to renew and reproduce holds great promise for sustainable fuel production if it can be effectively and sustainably harnessed.

Cyanobacteria have great potential as a platform for producing biofuel because of their swift growth, ability to fix carbon dioxide gas, and their genetic tractability. In addition to that they do not require fermentable sugars or arable land for growth and so competition with cropland would be greatly deducted.





What do we need is biological fuel production that functions orthogonally to food production at the same pace and scale. The use of plant derived lignocellulose derived from agricultural waste as a source of fermentable sugars is an option favoured by many current and rising start-up companies.

Cyanobacteria have already been engineered to produce a number of different biofuel related compounds; for e.g. synechococcus elongatus sp. strain PCC 7942 (S.elongatus) was engineered to produce ethanol with the addition of a pyruvate decarboxylase and an alcohol dehydrogenase, redirecting carbon from pyruvate successfully.

The science talks about the common feedstocks used in the first and second generations of biofuel include sugarcane, sunflower, switchgrass, wheat, sesame seeds and soybean etc. These sources are used to produce different liquid forms of energy including alcohols (ethanol, propanol and butanol) and vegetable oil. The major issue of these energy crops is based on the competition with our food sources for farmland and water. To overcome this problem, the third generation envisions a non-food biomass source for energy supply.

Cyanobacteria possess certain characteristics which have entitled them to be one of the most promising feedstocks for bioenergy generation:

•They can contain considerable amounts of lipids, which are mainly present in the thylakoid membranes.

•They possess higher photosynthetic levels and growth rates compared to other algae and higher plants.

•Cyanobacteria grow easily with basic nutritional requirements; they are able to survive if exposed to air [N2 (nitrogen-fixing strains) and CO2], water and mineral salts (especially phosphorous-containing salts) with light as the only energy source.

Over many years scientists have learned more and more in the field of research of cyanobacteria, from detection of cyanobacteria in various compounds to the current status of balancing and matching of production to the metabolism of the host and much more.

In conclusion, significant progress has already been made in this area since interest in cyanobacteria was adopted. The success of upcoming generation of biofuels will rely on the advances in metabolic engineering to optimize the existing energy-related pathways and to reduce the stress on the genetically modified organisms. An efficient and budget-friendly fuel production from biomass should decrease our current reliance on conventional energies which are both scarce and polluting.

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3. IMAGE SOURCE

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DEVELOPMENT OF LITHIUM ION BATTERIES

BY TANISHKA SHARMA
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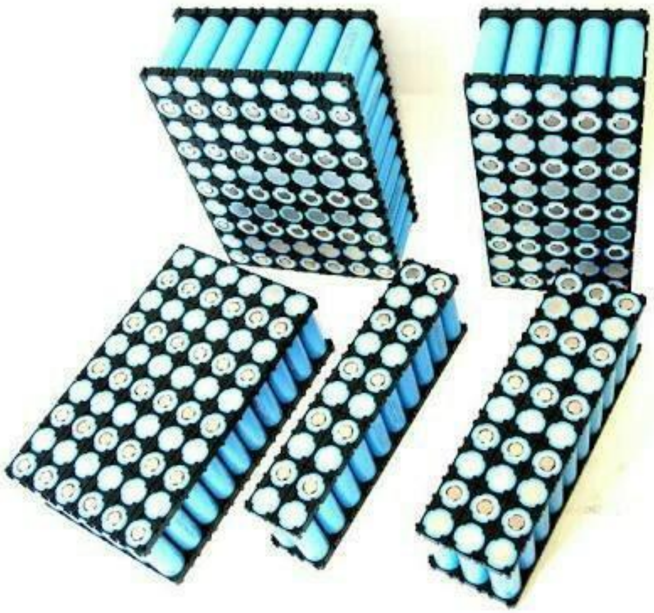
ABSTRACT

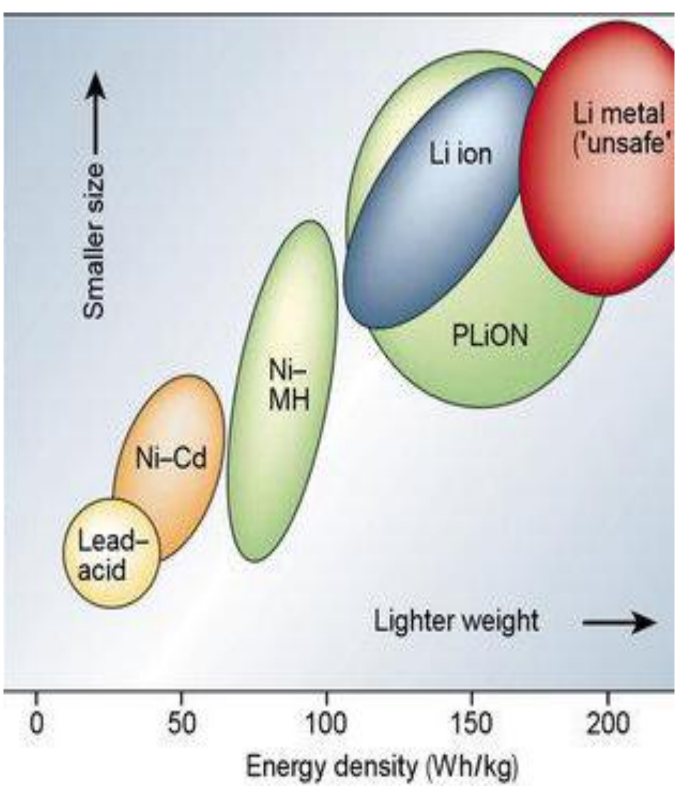
Lithium ion batteries are electrochemical devices that are widely used as power sources. Research on LIBs started in the early 1980s and the first commercial Li-ion battery was used in 1991. Since then a great volume of research has far been done to risen the performance of these batteries. Electrodes with higher rate capability, higher charge capacity and sufficiently high voltage can improve their performance. This article reviews the early technological innovations and then discusses the latest technology and research on Li-ion batteries.



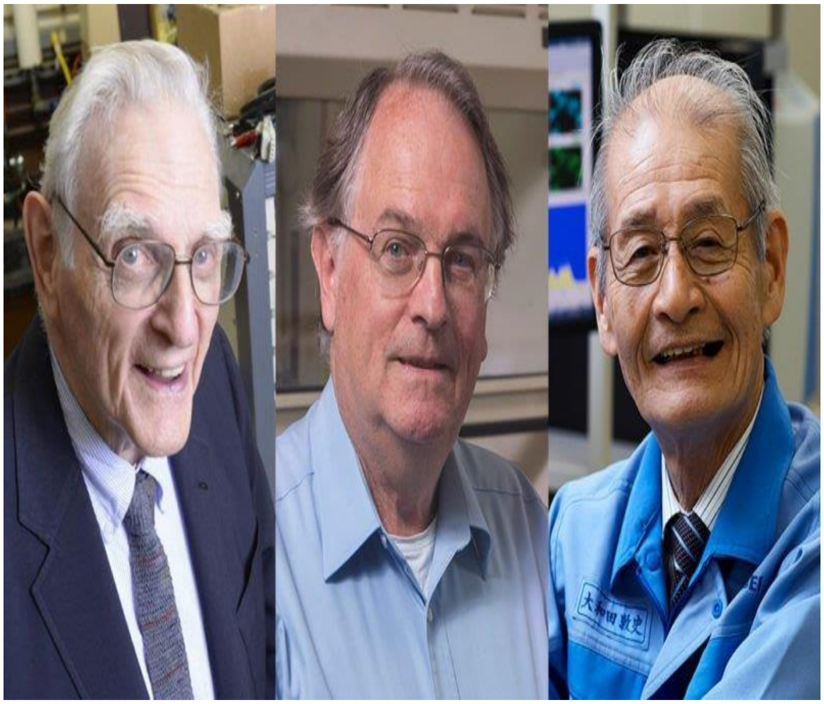
INTRODUCTION

Lithium ion batteries are drawing vast attention in past few decades due to its high energy density, low self discharge property and are now used in everything from mobile phones to laptops to electric vehicles. They have also enabled the development of long-range electric cars allowing them to expand their market in electric and hybrid vehicles. Its ability to store significant amount of energy have made it useful in storing solar and wind power.

Figure 1.



The high cost of lithium ion batteries, shortage of Lithium and transition metals used in these batteries made many people doubt in the development of Lithium ion batteries. At the same time the advancement of Lithium ion batteries in comparison to other commercial rechargeable batteries clearly shows that these batteries will continue to be dominant in rechargeable batteries. ***Figure 1*** *compares the energy densities of different commercial rechargeable batteries* which shows the superiority of Li-ion batteries over others. Another important aspect of Lithium ion batteries is related to battery safety. The misuse leading to fire and explosions have highlighted the importance of battery safety. These few disadvantages have triggered the wave of extensive research and development of Lithium ion batteries.



John B. Goodenough, M. Stanley Whittingham and Akira Yoshino have won the 2019 Nobel Prize in Chemistry.

The development of Lithium ion batteries was a result of intensive research and contribution of many great scientists. The foundation of these batteries was laid during the 1970s. Whittingham discovered the ability of titanium disulphide to house lithium ions and used lithium's strong drive to release electrons in creating a first Lithium battery which boasted just 2 Volts. The commercialization of Whittingham's battery was unsuccessful due to the problems of lithium dendrite formation that could cause a battery to short-circuit and explode. In later 1970s, Goodenough doubled the potential of the battery by replacing metal sulphides with metal oxides. In 1985, Yushino eliminated pure lithium from the battery entirely and successfully created the first commercially viable battery. Their work was rewarded with the 2019 Nobel Prize in Chemistry by the Royal Swedish Academy of Sciences.

A great volume of research has been done in choosing efficient electrode materials. The development of ceramic coating to the separator or the positive electrode has had a beneficial effect on preventing internal short circuiting. For example, the Sumitomo separator used by Panasonic and Tesla Motors involves a complex coating with ceramic particles as well as an aromatic polyamide. $LiCoO_2$ and $LiFePO_4$ are widely used in commercial Lithium ion batteries because of their good cycle life. The incorporation of silicon into graphite particles has marked an effect on the specific capacity of the negative electrode. The use of solid as an electrolyte material has improved the performance of lithium ion batteries.

CONCLUSION

A remarkable progress has been made in Lithium ion batteries since 1980s in terms of capacity, energy and cost reduction. Since these batteries are the first choice source of portable electrochemical storage, researches are still going to overcome the deficiencies of present day Li-ion batteries. As new materials and strategies are found, Li-ion batteries will no doubt have an ever greater impact on our lives in the years to come.

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INDIA FAR AWAY FROM UTILIZING ITS ATOMIC RESOURCES FOR PUBLIC WELFARE

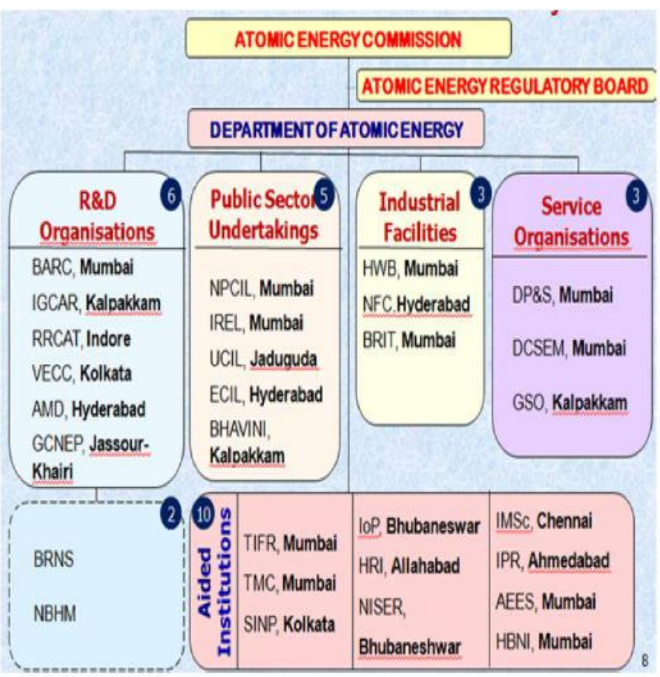
BY SUMIT (Department of Chemistry, Hansraj College)

ABSTRACT

Atomic energy is rich source of clean energy and Nationally Determined Contribution (NDC) of India to United Nations Framework Convention on Climate Change (UNFCCC) justifies its intention to enhance the country's clean-energy capacity. The Department of Atomic Energy (DAE), established in 1954, focuses on research, development in the areas of nuclear energy and supports research in nuclear science. India's agreements with IAEA have resulted in limited breakthroughs in the last decade. This article briefs the availiblity and utilization of *Atomic Energy* in India by public and factors affecting them.

INTRODUCTION

Major part of energy production in India depends on the fossil fuels. The emissions from thermal power plants contains Green House Gases which are hazardous to health indirectly. Thus, many initiations have been taken by country to reduce the use of carbon based fuels and enhance the use of cleaner fuels. Research is being conducted in thr field of thermonuclear fusion and relevant related fields. The revolution in the field of *Atomic Energy* was started with the set up of research and development centre, in 1954, now called *Bhabha Atomic Research Centre* (BARC), at Trombay. After that, many milestones have come in light in the field of *Nuclear Energy Production*. Nationally Determined Contribution (NDC) of India has set up the goal to reduce the Green House Gases (GHG) emissions by 33-35 % by 2030 along with increase the clean energy production to 40 % of total current capacity.

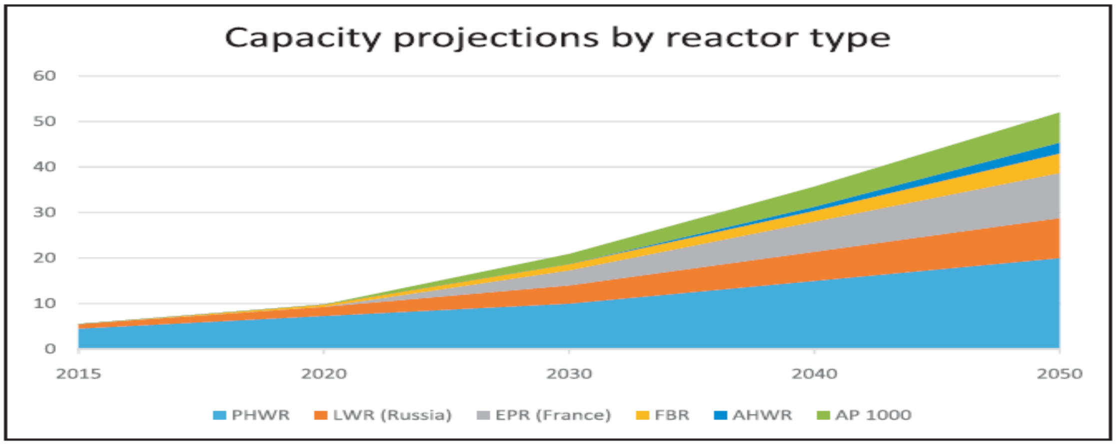


ORGANISATIONAL STRUCTURE IN FIELD OF ATOMIC ENERGY

Many organisations have been set up after establishing Bhabha Atomic Research Centre (BARC) namely Indira Gandhi Centre For Atomic Research (IGCAR), Atomic Minerals Directorate For Exploration and Research (AMD), Tata Institute of Fundamental Research (TIFR), Institute for Plasma Research (IPR). Heavy Water Board (HWB) has been established for the production of heavy water, Nuclear Fuel Complex (NFC) for nuclear fuel, zircaloy components and stainless steel tubes. Nuclear Power Corporation of India Limited (NPCIL) is focuses on manufacturing of nuclear power plants based on thermal reactors, Uranium Corporation of India Limited (UCIL) on mining of uranium ore, Bhartiya Nabhikia Vidyut Nigam Limited (BHAVINI) on setting up fast reactors.

STATUS AND PERFORMANCE OF NUCLEAR POWER PLANTS

The first nuclear power plant at Tarapur with two Boiling Water Reactors (BWRs) was commenced along with Pressurised Heavy Water Reactors (PHWRs). Eighteen PHWRs in Kalpakkam (MAPS), narora (NAPS), Kakrapar (KAPS) and Tarapur (TAPS-3&4) Kaiga (KGS) and Rrawatbhata (RAPS) are currently operating. One more project, with a power of 1000 MW is in progress in co-opertion with Russian Federation. Two units of 700 MW PHWRs at Kakrapar, are in progress. The Fast Breeder Test Reactor (FBTR) 40 MW at Kalpakkam is operating. 500 MW advanced Fast Breeder Test Reactor (FBTR) is in its trials. DAE has set up 30 KWh neutron source reactor KAMINI at Kalpakkam.



CONCLUSION

India's Advanced development in the field of Atomic energy is much strong. Native PHWRs are cost effective and provides India chance to master nuclear technology. India can expand the construction of nuclear reactors, if it can operate 700 MW PHWR technology. However, budget available is only for 4 GW more of PHWR capacity. India needs to push for native reactors to ensure it becomes a great power in Atomic energy. India can become a champion in Atomic and Nuclear energy by adopting native and foreign reactors in the world. Still, India has a long way to go to be a super power in the field of Atomic energy and use it for public welfare.

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STRATEGIES FOR LOW ENERGY RECYCLING OF PLASTICS

BY PRASHANSA MEHTA (Department of Chemistry, Hansraj College)

ABSTRACT

About 400 million tones of plastics are produced per annum worldwide. End-of-life of plastics disposal contaminates the waterways, aquifers and limits the landfill areas. Therefore methods like Feedstock recycling, biological recycling, mechanical recycling, industrial energy recovery, municipal solid waste incineration, pyrolysis, subcritical and supercritical fluid technology are employed which contribute significantly to the low energy recycling of plastics.

INTRODUCTION

For the past 50 years, plastic materials have been integral to the modern economy, which is apparent from the popularity of this material. This increasing quantity of material has provided myriad applications of remarkable practical nature but with a significant environmental cost. Waste plastics are classified into the hydrocarbons containing no heteroatoms e.g. polyethylene, polypropylene and polystyrene; and, hydrocarbons containing heteroatoms, e.g. polyvinylchloride, acrylonitrilestyrene-butadiene resin (ABS) and polyethylene terephthalate. From 2006 to 2016, the volumes of plastic waste collected for recycling increased by 79%, energy recovery increased by 61% and landfill decreased by 43%. Opportunities for waste plastics and their impact on the environment are discussed below.

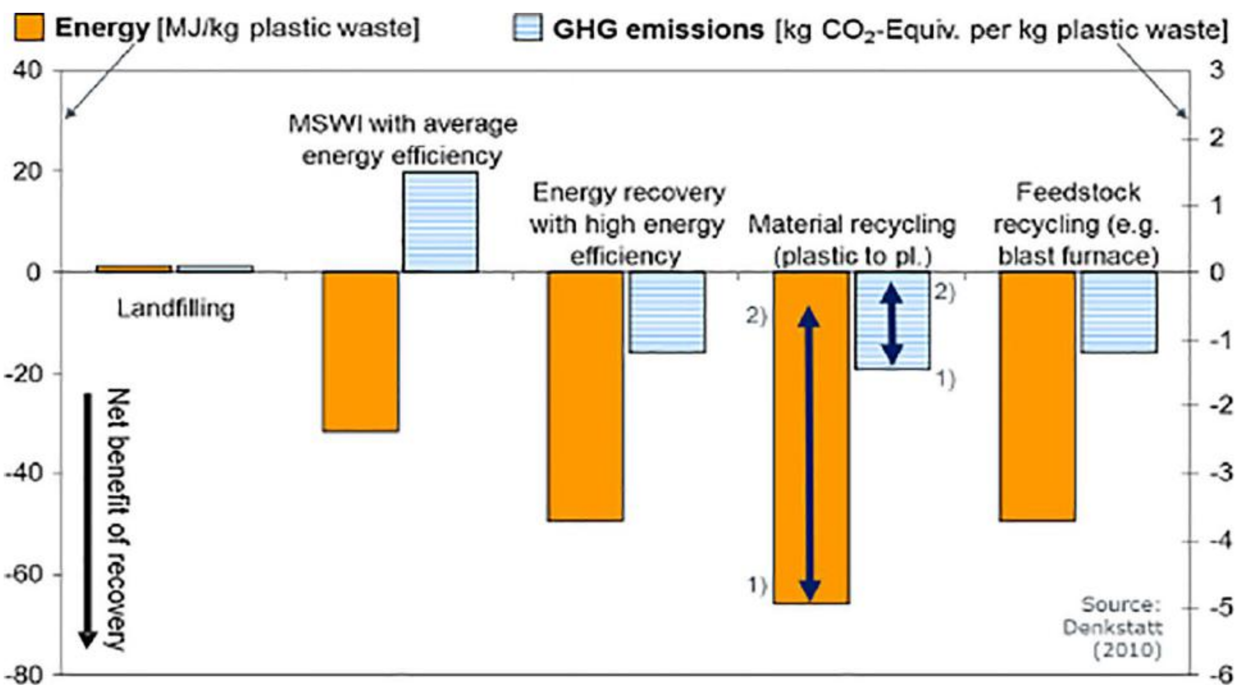

Fig 1 Net-energy/GHG- effects of recycling, recovery and disposal processes for LDPE [1] (Harald Pilz, 2014)

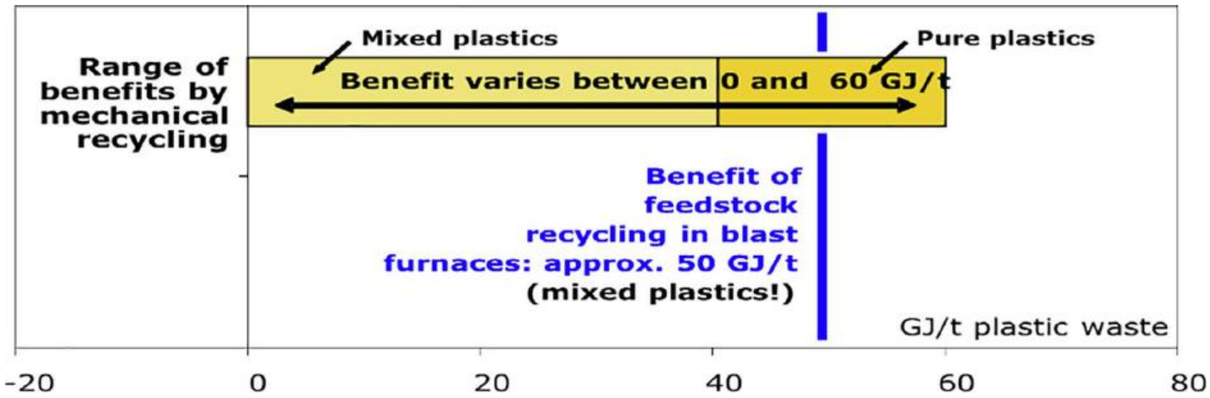

Fig. 2. Saved energy resources using different recycling processes [1] (Harald Pilz, 2014).

1. Industrial energy recovery: Plastics have heating values in excess of 40 MJ/kg, due to high carbon, hydrogen and low ash content. Energy claimed from EOL plastics is converted as heat, steam or electricity. Industries such as cement kilns, fluidized bed, paper industry and coal fired power stations utilize the energy recovered from the mixed plastic waste directly substituting fossil fuels.

2. Incineration of municipal solid waste (MSWI): Energy efficiency of MSWI plants using mixed plastic waste, is less than the industrial energy recovery process. Incineration results in net positive CO2 generation, steam and cinders.

3. Pyrolysis: Pyrolysis can treat mixed and dirty plastics. It results in dechlorination, breaking of C–C and C–H bonds or recombination of gases, liquids and solids to provide new cross-linked structures similar to high energy radiolysis products. Thus, high energy radiolysis is recommended as a recycling option for waste plastics. Biofuel produced during pyrolysis can substitute fossil fuel with no toxic or harmful emissions.

4. Biological Recycling: Biodegradable polymers photo-degrade in six weeks to convert back to the biomass under suitable conditions.

5. Mechanical recycling: High environmental benefits are realized when ‘‘pure” polymer waste fractions are recycled mechanically. Mechanical recycling can save resources up to 60 MJ/kg recycled plastic waste.

6. Feedstock recycling in blast furnaces: Examples of suitable streams for feedstock recycling include laminated and composite plastics, low quality mixed plastics streams and contaminated plastics. Thermoplastics find application in blast furnaces due to their phase transformation at high temperature melt state. Thermo plastic wastes replace metallurgical coke up to 40% in iron and steel making as a reducing agent and fuel .Therefore, replacing pulverized coal with waste plastics in the blast furnace iron making process is beneficial to increase productivity. Waste plastics in BF increases the H2 content within and in the off gas exiting the furnace.

7. Subcritical and Supercritical fluid technology for recycling waste plastics:
Developments of chemical recycling of waste plastics by decomposition reactions in subcritical and supercritical fluids is reviewed from fundamental investigations to commercial scale processes. Condensation polymerization plastics are relatively easily depolymerized. Cross-linked polymers can be recycled by selective decrosslinking reactions. Fiber reinforced plastics can also be recycled by depolymerisation to yield monomers.

CONCLUSION

The article summarizes various end of life options for plastics and environmental benefits offered. Recycling offers competent waste management strategy for waste plastics. All such energy recovery processes use only the best available technology to ensure they are safe, environmentally-responsible and efficient installations.

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ABOUT THE SCIENTIST

GEROGE ANDREW OLAH

Hungarian born American chemist, George Andrew Olah, who died on 8 March, was born on 22 May 1927. He was a prolific researcher. The central theme of his career was the pursuit of structure and mechanisms in chemistry, particularly focused on electron-deficient intermediates. He was awarded the Nobel Prize in Chemistry 1994 for his work on carbocation chemistry (carbocations are unstable chemical species in which a carbon atom bears a positive charge). He pioneered the use of superacids to stabilize carbocations, and used NMR spectroscopy to demonstrate the existence of nonclassic carbocations. He was also highly active in the field of methane and carbon dioxide conversion and the "methanol economy". He leaves behind a large body of work comprising almost 1500 papers and twenty books for the scientific community. Some selected works have been published in three aptly entitled volumes, Across Conventional Lines. This article highlights his phenomenal journey which transformed the understanding of organic chemistry and reactions.

George Olah studied organic chemistry at the Technical University of Budapest. He completed his doctorate in 1949 under Géza Zemplén, a former student of Nobel prize winning chemist Emil Fischer. He began his career at the Technical University as an assistant professor, and in 1954 became head of organic chemistry and associate scientific director at the Central Research Institute of the Hungarian Academy of Sciences in Budapest.

In 1957, Olah joined the Dow Chemical Company in Sarnia, Canada. At that time, the company was manufacturing polystyrene using a reaction (the Friedel–Crafts type electrophilic substitution) that involved carbocations. This was where Olah achieved his breakthrough in producing long-lived carbocations, the work won him the Nobel Prize in Chemistry in 1994. At Dow, Olah had realized that 'superacids' — billions, even trillions, of times stronger than 100% sulfuric acid can stabilize carbocations. In 1965, he became a professor at what is now Case Western Reserve University in Cleveland, Ohio. There, a lab member decided to try such an acid on a Christmas candle. As if by magic, it cleaved the wax into long-lived carbocations. In subsequent papers, Olah called the substance magic acid. Before Olah's work, carbocations were known only as fleeting intermediates existing for microseconds or less in acid catalyzed transformations. Olah stabilized them and so elucidated their structure using low-temperature nuclear magnetic resonance (NMR) spectroscopy, and later using X-ray analysis. His genius paved the way to an understanding of hydrocarbon reaction mechanisms, which in turn led to improved processes for refining oil and gas.

Olah proposed a clear demarcation between 'trivalent' carbenium ions (for example, CH_3^+), in which the positively charged carbon center forms bonds with three other groups, and carbonium ions (such as CH_5^+), in which the carbon forms bonds with five or more other groups. He showed that the two types of ion are both intermediates in electrophilic reactions, but in different ways. (The former involves electrons donated from π orbitals, as found in double bonds, and the latter involves donations from σ orbitals, a 'nonclassical' situation in which two electrons are shared by three atoms.) This important distinction had not been previously established. Olah's work overturned the long-held assumption that a carbon atom could bind to no more than four other atoms. He proved the existence of the 2-norbornyl cation, a non-classical ion proposed by his friend Saul Winstein. Olah used low-temperature NMR and superacids to establish the non-classical structure of this carbocation at the center of the debate over classical ions and non-classical ions. Olah's studies on compounds containing carbon atoms with more than four bonds led to a new area of 'hypercarbon chemistry'. He extended the types of reaction that were possible by showing how to activate electron-seeking species, or electrophiles, into superelectrophiles.

His work on fluorine chemistry helped thousands of researchers to study and develop many fluorinated pharmaceuticals. About 25% of all drugs currently on the market are fluorinated compounds. In 1977, Olah moved with his group to the University of Southern California in Los Angeles, where he founded the Loker Hydrocarbon Research Institute. His post Nobel research with long-time collaborator Surya Prakash focused on green fuels derived from carbon dioxide capture and recycling. In particular, they worked on methods to convert natural or shale gas efficiently to methanol, a clean-burning renewable liquid fuel that can be used in place of petrol and diesel, and as a feedstock for petroleum-derived products. This new approach not only solved our long range dependence on decreasing fossil fuels (oil, gas, and coal) but also at the same time promised to mitigate global climate change (warming) caused significantly by derived greenhouse gases such as carbon dioxide and methane.Carbon dioxide is now converted to methanol commercially at the George Olah Renewable Methanol Plant near Grindavík, Iceland.

After reports that carbon ions had been observed in space, he suggested that methanol could have had a key role in the evolution of complex building blocks of biology, and eventually of life. His Nobel-prize winning work on carbocations has led to applications including better oil and gas refining, new methods for synthesizing small molecules and the discovery of drugs and materials. He was also awarded the Priestley Medal, the highest honor granted by the American Chemical Society and F.A. Cotton Medal Award for excellence in Chemical Research of the American Chemical Society in 1996. Olah's immense breadth of knowledge has been captured in his well recognized books notably: Beyond oil and gas: The Methanol, Superelectrophiles and their Chemistry, Superacid Chemistry, Hydrocarbon Chemistry and many more.

As Paulo Coelha wrote in his book Alchemist, "And, when you want something, all the universe conspires in helping you to achieve it, George Andrew Olah managed to prove this. Inspired and guided by an inspiring vision he worked tirelessly to revolutionize the field of science and Organic Chemistry in particular. A life of Magic Chemistry is an autobiography of George Olah which will guide us through his remarkable journey. . His fascinating researches are and will always be celebrated.