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From the Editor's Desk

Opportunities and Challenges in Electrochemiclas

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The future research work will be mainly directed towards energy conservation for both inorganic and organic electrochemiclas combined with the combating or preventing pollution problems that exist in the production of these chemicals. Since electrodes happen to be the most important for the production of electrochemical products, development of various types of electrocatalytically activated electrodes suitable for each process / reaction, from the point of view of specificity, selectivity and longer life, is actively engaging the attention of researchers all over the world. With the advent of cheaper and better corrosion resistant materials, the fabrication of the electrolytic cells will become easier. Using updated mathematical models, it may be possible to do the scale-up more scientifically. Now ion-selective separators/membranes and solid polymer electrolytes with the utilization of higher temperatures and pressures in the operating conditions of cells will be major contributors to operate processes more efficiently.

Among inorganic electrochemicals, the major electrochemical industry all over the world is caustic soda – chlorine and already the global energy gloom, which had set in then the fuel price were soaring, brought about considerable developments with acceleration to this important field of technology by introducing the electrocatalytically activated metal oxide coated titanium anodes in the existing industries and also by developing membrane cells using perfluoro-type cation exchange membranes. The other important improvements that are taking place in this field for further lowering of energy are: catalytic hydrogen cathode, porous oxygen cathode, combination of fuel cells and concentration of alkali. The zero mercury process for mercury cells and retrofitting of polymer-stabilized asbestos or microporous membranes based on Teflon (PTFE) are also simultaneously worked out for avoiding pollution problem in the existing mercury and diaphragm cells are working now.

Another major industry where some innovations are being made is the production of chlorates where the use of electrocatalytically activated metal oxide coated titanium anode and use of modular construction of electrolysers have already made headway. However, the catalytically activated cathode and avoidance of chromate (to avoid pollution) and utilization of hydrogen (hydrogen lift cells) are some of the important problems to be talked immediately.

Hydrogen being the fuel of the future is produced by water electrolysis, in view of abundance of water as raw material. However, the electrolysis of water is still inefficient from the energy point of view. Researchers are already directed towards this by developing electrocatalytically active electrodes including spinels and perovskites type oxides, thermochemical hydrogen, sea water electrolysis and high temperature and high pressure water electrolysis. Still we will have to go a long way in achieving the nearer to the theoretical voltage of the cell. Recent research is focusing on utilization of non-precious metal catalysts in electrolysis for hydrogen production. Very recently water oxidation by photo-electrochemical method of producing hydrogen also started to reduce the cost of hydrogen production.

Electroorganic synthesis has been a subject of intensive study. Though a large number of compounds have been attempted, only a very few industries are existing. The major problem in this area is the non-availability of suitable separators/membranes needed while scale up is done. With the advent of perfluoro type membrane, at least some processes can become industrially feasible. Electrolysis is best applied to projects with anticipated production volume less than 10,000MT/year. Above this level, catalytic processing usually becomes more cost effective than electrolysis. Indirect electrooxidation or reduction procedures are currently the subject of intensive study in view of development of innovative synthetic methods of industrial organic chemicals. In this the effective recycling of the electron carriers or mediators as a redox system can made the process cost effective and in certain cases, with least pollution problems. The recent development of modified electrodes, (incorporation of oxidizing and reducing agents eg. Ti/TiO_2;Ti/Cr_2O_3), whose surface can get oxidized and reduced, can be the line of approach in future to carry out several specific oxidation and reduction reactions.

The production of electrofluorinated compounds is becoming important in view of their multisided applications and the pursuit in the field of electrofluorination of organic compounds will be done with more vigor on a global scale.

With the possible use in applications such as electrochromic displays, storage batteries and sensors, the electroactive properties of polyaromatic by electropolymerisation has become the subject of research for the present and future. There are a large number of electroactive polyaromatics like polyaniline, polypyrrole, polythiophene, polyvinyl compounds etc., the challenges in this field are: synthesis of polymers capable of withstanding extreme conditions of temperature and pressure, polymer blends/alloys, polymer exhibiting good electrical conductivity, superconductivity etc., Use of micelles and phase transfer catalysis for environment of rates of heterogeneous reactions can also be challenging tasks.

Biomass, another alternative source of energy, is renewable. The electrochemical investigations of polymeric constituents of biomass and their derived degradation products have opened up a new vista in the electro organic field. Electrochemical studies of carbon dioxide non-saccharidic alcohols, monosaccharides, lignins etc., have already been attempted. Some of the major challenges of the future in using electrochemistry for converting biomass are: to utilize polymeric raw materials as feed stock, to degrade biomass by the mildest means possible (enzymatic hydrolysis, chemical catalysis or electrolysis) to sub units that are amenable to electrochemical transformation to more valuable products.

Economics will play a key role and hence the attempts should be to produce biomass more cost effectively. The technologies viz., biomass conversion and electrochemistry, being dynamic fields, need a better understanding of the future developments in both the fields.

From the electrochemical engineering point of view, though many new designs of reactors like filter press flat plate cell, capillary gap cell, pumped slurry cell, packed bed cell, fluidized bed cell, undivided foam cell, tubular flow cell, three compartment cell, Swiss Roll cell etc., (which will all increase mass transfer) have been developed, the applicability of each cell for a specific reactions is still in the infant stage. Solid Polymer Electrolyte (SPE®) Electrolyser technology has to be developed for commercial operation not only for chlor alkali and hydrogen but also for organic synthesis.

When the Indian conditions are seen there are some major problems, which are not normally common to developed countries. For examples, the frequent shut down of electricity greatly affect not only the production but also the life of catalytic type of electrodes. The cost of electricity is much higher in India as compared to most of the countries. Some of the materials of construction are very costly. As the demand is also less, only smaller size plants had to be operated. These are some of the inevitable bottlenecks that come in the way of our country's growth.