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INDIAN ORGANIC CHEMICAL INDUSTRY: DECADES OF STRUGGLE AND ACHIEVEMENTS*

A V Rama Rao**

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Abstract

Organic Chemical Industry is the most important segment of chemical industry. It plays a significant role by producing chemicals that are useful for our day to day life and constitute a significant part of human endeavors. Organic compounds are structurally diverse and show enormous applications. They are important constituents of useful products such as Drugs & Pharmaceuticals, Dyes & Pigments, Agrochemicals, Polymers, Perfumes etc. The article dealt with the history of Indian chemical industry especially covering Drugs & Pharmaceuticals, Dyes and Agrochemicals and their successive role to Indian economy. The author also gave some specific examples of his contributions in developing some of the important technologies that went into commercial products.

Key words: Agrochemicals, Development of drug industry in India, Dyes stuff industry, Global chemical market, Indian chemical industry, Pre and Post independent era.

1. Introduction

Chemistry is the center to every thing in life and is a more knowledge based industry. Chemicals are essential for our day to day life. Right from food we eat, clothes we wear, buildings we live and the cars we drive, all require chemicals and enhance our quality of life.

Global chemical market is worth 3.4 trillion USD and Europe is the largest producer, but in recent years China is over taking. Chemical sales country wise in value is shown in **Table 1** for the year 2001 and 2011. Chinese sales went up from 8.1 billion Euros in 2001 to 26.8 billion Euros, while European sales showing downward trend.

Chemicals can be broadly divided as bulk chemicals (Petro chemicals, fertilizers, polymers etc.) and speciality chemicals (fine chemicals). They are defined as "a group of relatively high value, low volume chemicals and known for their end use application and / or performance enhancing properties". Globally their value is estimated ~ 740 billion USD and constitute 22% of all chemicals.

Organic chemical industry is one of the most important segments of the chemical industry. It plays a significant role by providing chemicals and intermediates as inputs to other down stream products like Pharmaceuticals, Dyes and Pigments, Agrochemicals, Leather chemicals, Perfumes etc.

Global organic chemicals production was around 400 million tons during 2010-2011. Their demand is increasing at nearly 6.5% p.a.

Indian chemical industry is valued at 108 billion USD (3% of the world sales) and likely to reach to 224 billion USD by 2017. Pharmaceuticals form a separate class and

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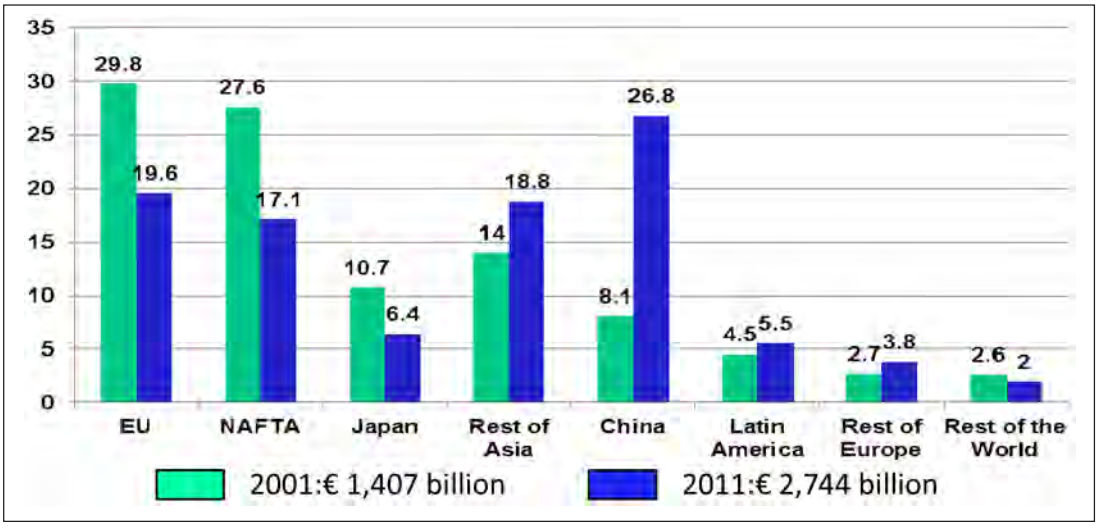
**7-102/54 Sai Enclave, Habshiguda, Hyderabad-500079; Email: corporate@avralab.com

Table 1



generally not included. Indian chemical sector is expected to grow and enhance our global competitiveness, increase domestic value addition, provide technical advantage and show sustained economic growth.

The present article is confined to Indian organic chemical industry covering speciality chemicals such as Drug and Pharmaceuticals, Agrochemicals, Dyes and Pigments. Several other speciality chemicals such as building materials, adhesives, perfumery chemicals, chemicals for electronic industry etc. are not included. Organic chemicals also cover consumer products such as soaps, detergents, cosmetics etc.

The development of pharmaceutical or for the first time a chemical industry in India was established during British rule and primarily due to indigenous efforts by a Professor of Chemistry from Calcutta University in 1892. Dr. P.C. Ray set up Bengal Chemicals and Pharmaceutical works, later incorporated in 1901. It became sick in 1970, Nationalized in December 1980 and once again declared sick in 1993 and more funds were released by the Government of India in March 2007, and kept going because of historical reasons. The next chemical and pharmaceutical company is Alembic Chemical works at Baroda, started by Rao Bahadur Amin. Realizing the need for vaccines, Acharya P.C. Ray established Bengal Immunity Company Ltd., at Calcutta in 1919, became public sector in October, 1984, but did not last long and closed the unit in April 2003. Prior to Indian independence many indigenous organisations started such as Calcutta Chemicals, Standard Pharmaceuticals, East India Pharmaceuticals, and Cipla. Later Unichem, Cadila, Indochem, Chemo Pharma, Sarabhai etc., have set up their companies. Virtually, no basic drug manufactured in the country. Formulations of common drugs are made and the annual sale in 1947 was ~ Rs.10 crores.

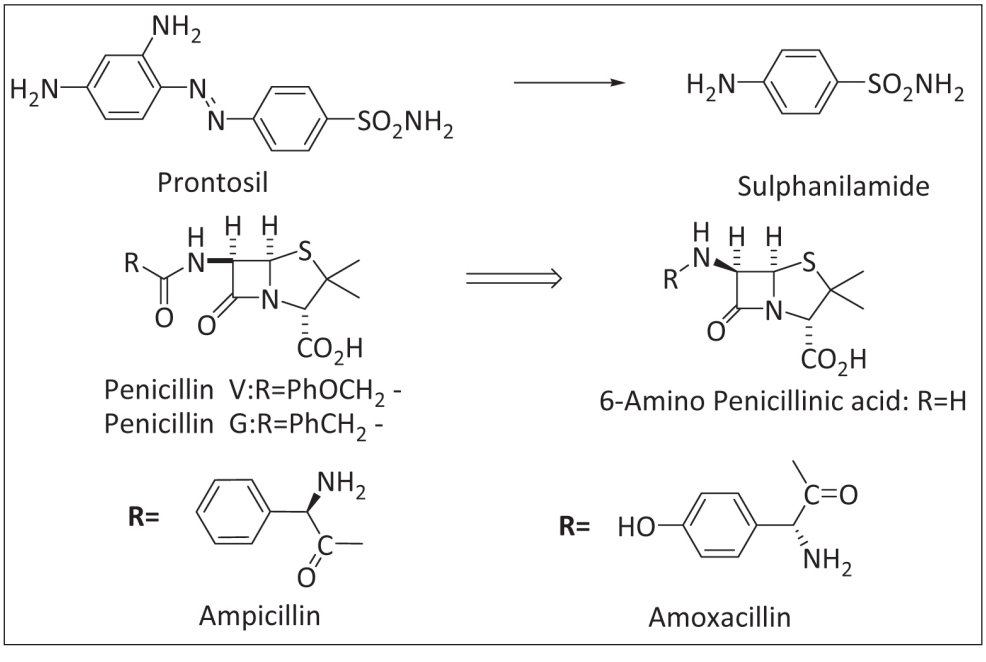
In US and Europe, modern drug development witnessed during 1930 to 1960, wherein breakthrough in the discovery of antibiotics and development of synthetic drugs have taken place. Thus in the early 1930's G. Domagk of Bayer in Germany tested various Azo-dyes against streptococci and discovered Prontosil as an anti bacterial agent. In late 1935, he gave it to his dyeing daughter due to streptococcal infection. She recovered although turned bright red. Prontosil was not active *in vitro* but *in vivo* it was converted to Sulfanilamide, the main active compound. This gave birth to various sulpha

drugs. Domagke was awarded Nobel Prize in 1939. Another major but accidental discovery was penicillin by Alexander Fleming working at St. Mary's Hospital, London in 1928. It took several years to commercialize this drug and finally achieved by the efforts of Sir Howard Florey and Chain. During Second World War, Penicillin was used for wound healing. Now a days Penicillin is more a starting material for the production of semi-synthetic antibiotics such as Ampicillin and Amoxicillin. During this period several synthetic products also entered the market, they include: vitamins, hormones, psychotropics, anti-histamines and new vaccines. However, in India many of these drugs are not made and not easily accessible at affordable prices.

By 1950, several multinational pharmaceutical companies started their units in India. Most of the active pharmaceutical ingredients (API's) were imported, formulated locally and marketed in India. They include Glaxo, Boots, Burroughs-Wellcome, Park-Devis, Lederle, Merck, Ciba, Hoechst, Roche, Wyeth etc. They all took advantage of the Indian patent act of 1911 and almost all new drugs were priced more compared to New York or London prices.

Post Independent in 1950, many private Indian companies were also set up. Indian Government realizing the need to produce essential drugs in the country, Hindustan Antibiotics at Pune in 1955 to produce Penicillin, streptomycin and their formulations with the aid of WHO-UNICEF. Similarly, Indian Drugs & Pharmaceuticals that incorporated in 1961 with the sole object of creating self sufficiency in respect of essential life saving medicines to the millions at affordable prices and not to make millions from the medicines. IDPL started manufacturing several synthetic drugs, such as Sulpha drugs, Vitamins etc. based on the know-how provided by the USSR Government. IDPL played a major role in developing a pioneering infrastructural role in the growth of Indian drug industry especially the bulk drug industry in Hyderabad.

After Independence, to manufacture any new drug was not possible because of prevailing system of product patents. The Indian patents were denied the use of several life saving drugs which were launched internationally. Many Indians at that time felt that the patent act of 1911 had to be changed. Indian companies came together and



formed the Indian Drug Manufacturers Association (IDMA) in 1961 with the sole aim of boosting the national sector. They fought to amend the 1911 patent act which resulted in the enactment of Indian Patent Act 1970, passed in September 1972. As a result "All product patents for drugs and agricultural chemicals were abolished and only process patents were allowed for a period of seven years from the date of filling or 5 years from the date of acceptance, which ever is earlier". It was a dawn of a golden age of the Indigenous pharmaceutical industry. In 1971, MNC's controlled over 71% of the domestic market out of the leading 50 pharma companies in India 33 were foreign and sales by way of formulations was Rs.3600 millions.

After enacting the new patent law, the then Prime Minister Indira Gandhi addressed all the CSIR Directors to initiate process development for drugs and agrochemicals and help the Indian industry for commercialization. Dr. B.D. Tilak, the then Director NCL, called various division heads and my self (as I happened to be an young project leader) and bluntly told us to initiate process development for some of the essential drugs. Most of the senior scientists did not take his advice seriously. Being myself a graduate of chemical technology, I felt the need to initiate process development of some essential drugs such as Diazepam and Chlordiazepoxide (Anti-anxiety agents) and best selling by way of value world over. I selected diazepam as the product of my choice and worked out a simple process of making in the laboratory starting from p-chloronitrobenzene and made the key intermediate, 2-methylamino-5-chlorobenzo-phenone in two steps in very good yield. From this intermediate, Diazepam can be made by simple two operations as shown in Chart 1. Roche, the original discoverer made 2-methylamino-5-chlorobenzephenone starting from p-chloroaniline in 5 steps involving tedious operations and in low

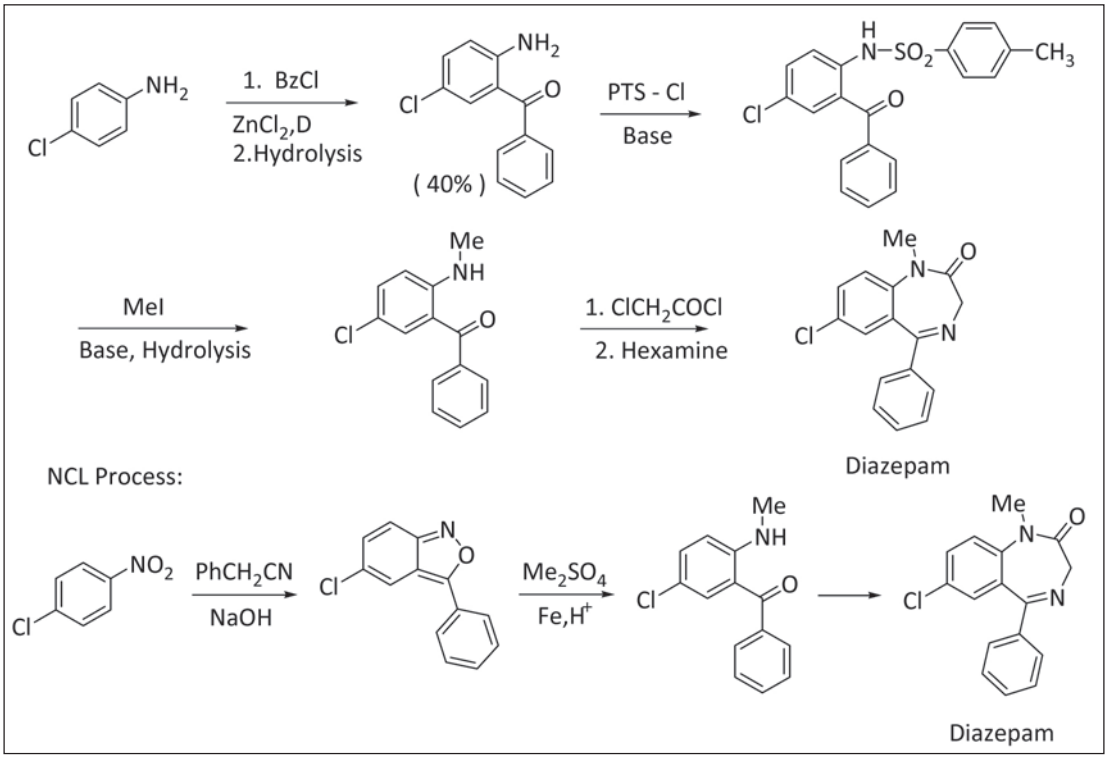


Chart 1: Original process of HOFFMAN-LA-ROCHE:
(USP. 3109843, dated 5-11-1963)

yields. In that year, I met Dr. Y.K. Hamied, who was then Director R&D in CIPLA and was impressed with my approach of making Diazepam and wanted to buy our laboratory process of making 2-methylamino-5-chlorobenzephenone. He came to NCL, negotiated with Dr. B.D. Tilak and made one time payment and exploited the laboratory process and introduced Diazepam in to Indian market. This is probably the first drug process technology went from a CSIR laboratory and commercialized with no problems. This initial break through the process technology, gave me enough confidence in taking such projects in my later years.

In 1972, multinational companies controlled 70% of the domestic pharmaceutical market and if the leading 50 pharma companies, 33 were foreign. Now the national sector occupies the leading positions and controls 80% of the market. The pharma sales were Rs.360 crores in 1972 and crossed Rs.1,00,000 crores (~ 1.2% of the world pharma market). Same way pharma exports crossed 60,000 crores as against Rs.200 crores in 1972. All this was possible due to the efforts of the indigenous pharma companies. Indian companies built up an enviable reputation for producing good quality drugs at affordable price. The main aim of the Indian companies was essentially to manufacture important and crucial drugs in India which were marketed internationally, but not available in our country.

From 1975 to 1977, I spent two years in Prof. E.J. Corey's group at Harvard University and worked on the synthesis of an anti-tumor compound, Maytansin. Before my return to NCL in 1977, I decided to work on two projects, one on fundamental research and the other on the process development for the isolating of Vinblastine and Vincristine from Vinca Rosea leaves (Chart 2). These projects were financed by the Science & Technology cell of Maharashtra State Government. We worked out a simple process of isolating Vinblastine by avoiding column chromatography and converted it to Vincristine by cromic acid oxidation. We also formulated these two anti-cancer compounds and got them tested their efficacy at Tata Memorial Cancer Hospital, Mumbai.

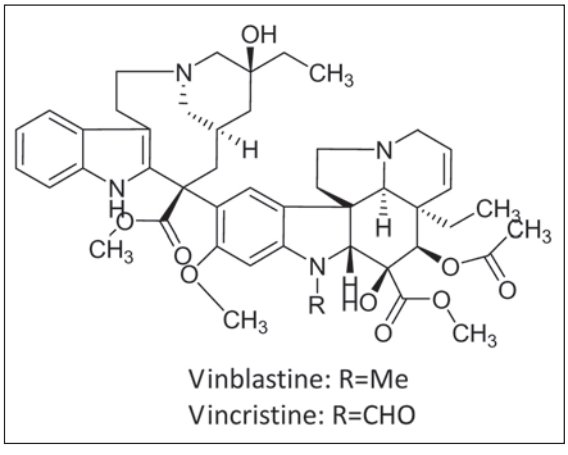
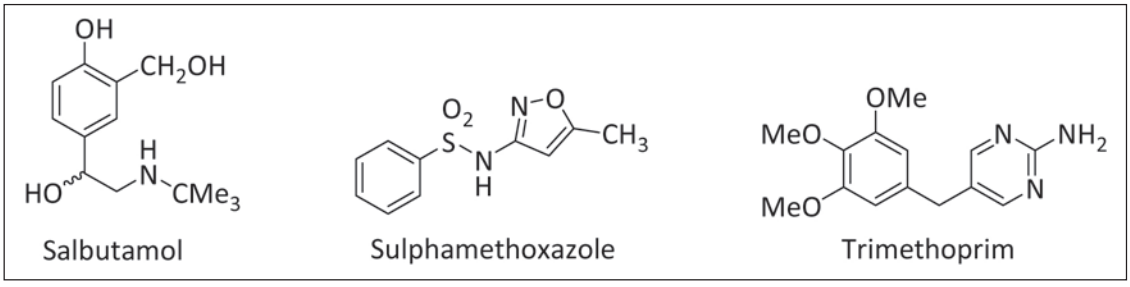


Chart 2: Vinca alkaloids (Vinblastine & Vincristine)

Dr. Y.K. Hamied was persuaded to market these products. Cipla implemented this technology in 1983 and donated 200 Vincristine vials to three of the leading cancer hospitals in the country. This act of our, paved way for Cipla to introduce several anti-cancer compounds in later years in the Indian market

On the advice of Dr. Y.K. Hamied, I became a scientific consultant to Cipla ever since I returned and also carried out several projects at NCL under sponsorship from them. One of the earlier projects was to manufacture the asthmatic drug Salbutamol. The process was first commercialized by 1979 and today Cipla is the leader in this and other Asthmatics, not only in India, but also supplying world over at affordable price. I also developed at NCL, processes for Sulphamethoxazole and Trimethoprim, Ibuprofen, β-Blockers such as Atenolol, Metoprolol and Chiral Timolol etc. and transfer them to industry. During my tenure as Deputy Director and head of the organic chemistry division at NCL, I revived the age old project of Vitamin-B6 and succeeded in finding a better way of manufacturing it



indigenously. The project on Vitamin-B6 was taken up by M/s. Lupin Laboratories on my persuation with Mr. D.B. Gupta (Chairman, Lupin) and commercialized by them in 1985.

In 1985, I moved to Hyderabad from NCL to take up the Directorship of the then RRL, which was subsequently renamed as Indian Institute of Chemical Technology. My personal group consisted of Research fellows used to work for the first one or two years on process development of important drug projects which we picked up from Indian pharma industries under sponsorship and develop a viable laboratory process and passed on to the respective industries and followed up till the product was commercialized by them. By this way all my Ph.D. students, not only trained in basic research, but also acquainted themselves in tackling industrial projects. We introduced for the first time in India, the Fluoro quinoline antibiotics, Norfloxacin and Ciprofloxacin. The two anti-cancer drugs, Etoposide and Mitoxantrone, some of the other projects were listed in **Table 2**.

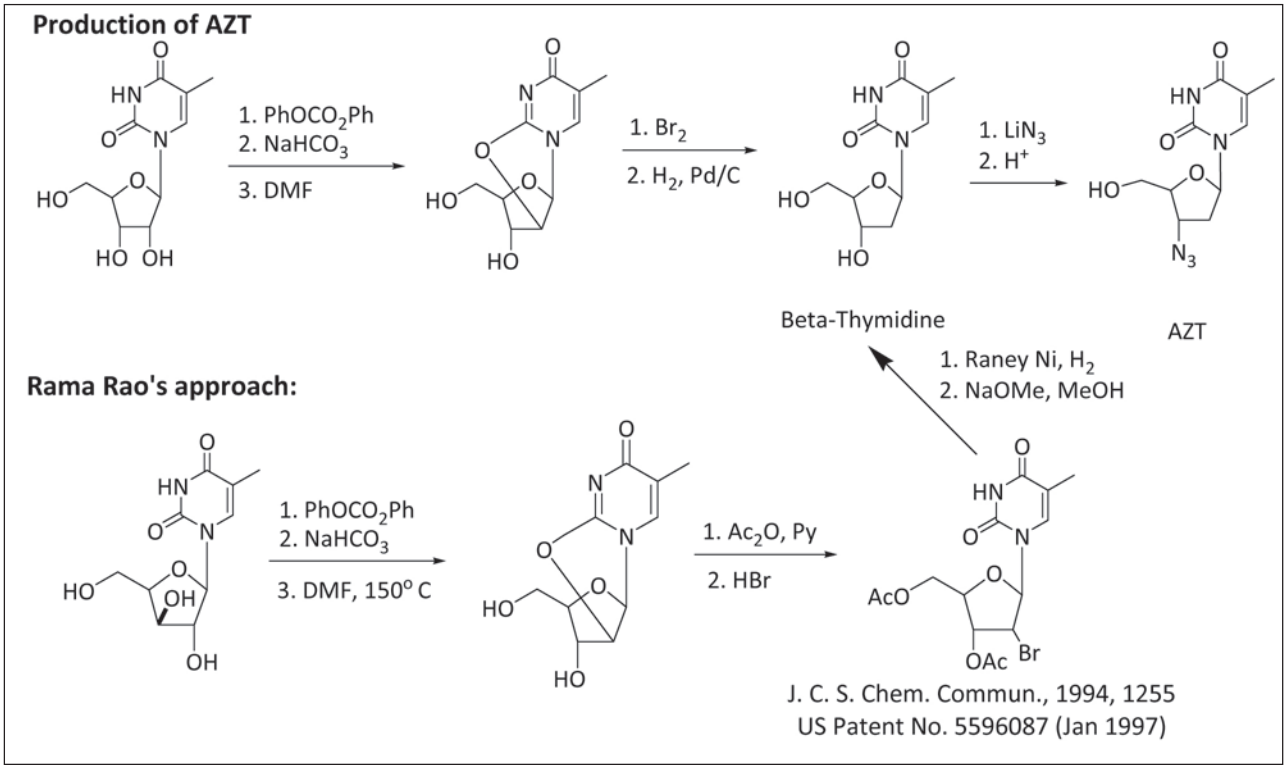
In 1988, the first AIDS (Acquired Immune Deficiency Syndrome), caused by the HIV virus death was reported in India and the need to develop the process for Zidovudine, commonly called AZT, the only available drug at that time for the treatment of HIV and AIDS was felt. Realizing that Indian population will face the epidemic in the near future, we developed a simple process for the production of AZT and convinced Dr. Y.K. Hamied to commercialize this drug in India. I was also instrumental in getting it approved for sale in India by the then Drug Controller of India and also impressed with the Government of India to allow importing β-Thiamidine in to the country with out duty. Cipla started commercial production of AZT in 1993 and marketed 100 mg capsules at 1/8th prevailing international price. Subsequently

Table 2

1965 – 85: National Chemical Laboratory, Pune

1985 – 95: Indian Institute of Chemical Technology, Hyderabad

1. Anti anxiety agent – Diazapam, Chlordiazepoxide and Nitrazepam
2. Anti asthmatic – Salbutamol and Terbutaline
3. Anti bacterial – Sulphamethoxazole and Trimethoprim
4. Analgeric & Anti inflammatory – Ibuprofen and Flurbiprofen
5. Anti cancer drug – Vinblastine and Vincristine, Etoposide and Mitoxantrone
6. Flurorquinolone antibiotics – Norfloxacin and Ciprofloxacin
7. Anti ulcer agents – Omeprazole and Lansoprazole
8. Anti malerial – Mefloquine
9. HIV & AIDS – AZT
10. Miscellaneous products – Astemizole, Gemfibrozil etc.



Cipla came out with triple single dose cocktail "TRIOMUNE" at a price of less than $1 per patient per day against $12,000 per patient per year (combined price of such combination), Cipla offering this cocktail to 43 countries through WHO, and other NGO's help. Today several other Indian companies are also offering cheap HIV drugs to more than 90 countries.

In 1994, India joined the World Trade Organisation and accepted TRIPS mandate. The Indian Patent Act of 1970 ammended on 26th December 2004, which came into effect from 1st January 2005. As a result product patents were allowed for all sectors. Licences of right deleted, it also allowed micro-organisms to be made patentable, pre and post-grant opposition provision included in the act. One important clause concerning compulsory licences for domestic use as well for export against third party licences was also permitted.

Some of the post 2005 I.P. issues include drugs with incremental changes not worthy of exclusive rights. As a result Indian Supreme Court did not permit the validity of patent of Novartis Anti-cancer drug, "GLIVEC" (Imatinib) as it was an improved version and not a new invention. However, this drug received patent in 38 countries. India also issued its first compulsory licensing in March 2012, when NATCO Pharma won the right to manufacture Bayer-AG anti-cancer drug "NEXAVAR". Similarly Indian Health ministry recommended for compulsory licensing of three anti-cancer drugs, namely Trastuzumab (for Breast cancer) Ixabepilone and Dasatinib (for Leukemia). They will be available for a fraction of original price.

The present API market in the world is ~120 billion USD (Total pharmaceutical sales $860 billion). It is very competitive as there are more than 2000 firms and 5000 manufacturing sites. Cipla in India is one of the first companies to fully develop and manufacture APIs and laid foundation for the pharmaceutical industry. In India they manufacture 200 generic APIs and

reaching more than 140 countries world wide. Dr. Reddy's (Founded by Dr. K. Anji Reddy, who came out from IDPL in mid 1970's and started his own venture and became the largest pharma company in India during his life time) is another leading API manufacturer producing more than 60 APIs. Ranbaxy, the leader in India produces 100 APIs and present their facilities in 65 countries. Aurobindo, another Indian leading API manufacturer produces more than 200 APIs and exporting to 200 countries. Sun Pharma, the fast growing Indian company manufactures 200 APIs at nine different places located in Hungary, Israel, US etc. The Indian Pharma made head way in Generics and offered drugs at affordable prices.

India attained self sufficiency in manufacture of bulk drugs, but unfortunately, Indian drug makers depend up to 70% of imported key raw materials. We were importing key raw materials worth 800 million in 2004 and this figure went up to 3.4 billion USD in 2012-13. China accounts 58% in value and 80% by volume. This is due to cost advantage of import of these intermediates. It is time for the Government intervention to step up large scale products complexes catering the current needs and future requirement.

Till I retired, I was involved in basic research which helped young chemistry Ph.D. students to become leaders in their own right. Today they have occupied senior positions in both academic and industrial R&D organisations world over. Some of them preferred to become entrepreneurs and started industrial units to manufacture a wide variety of chemicals.

On my part, after retirement at the age of 60, I decided to become an entrepreneur and started Avra Laboratories to take up research as business proposition. We attracted sponsored projects from G.D. Searle and a biotech company based on Cambridge in USA. Both have provided advances of 1,00,000 and 50,000 USD respectively and a small shed was provided by Mr. Neterwala of Dai-Ichi Karkaria at Nacharam Industrial estate in Hyderabad. Avra succeeded in these two projects and with the profits earned, Avra built its own facility (Unit-1) in 2000. Avra has grown with time and now employs 500 people and having three regular production facilities. Avra's Unit-2 is recently approved by US FDA for manufacturing purpose. Avra launched in 2005 an anti-cancer drug Irinotecan by total synthesis. This is the first and only example of replacing natural product Camptothecin, the natural product that goes into Irinotecan. Avra exports the key intermediate SN-38 that goes to make Irinotecan to US and European markets. Avra is the first organisation to realize the potential of research and manufacturing services (CRAMS) and even today more than 50% of our earnings come from CRAMS. Today there are more than 500 companies operating in India valued 8 billion USD and further growing.

2. Synthetic Dyes

Humans have always used colors to decorate themselves, their garments, their dwellings and other possessions. India has for centuries been producing natural colours to dye fabrics. Even during the Mohenjo-Daro civilization, there is evidence tha natural colours were applied to textiles, pottery and other items. Similar archeological data is found in China, the Fertile Crescent in the Middle East and parts of Europe. A prime motive of the East India Company to come and trade with India was to procure Indian natural dyes. They included Indigo (Blue), Madder (Yellow & Red), Kermes (Red) and Lac dye. The chemistry of these natural dyes were known before the end of 19th Century. But the structure of Lac dye eluded scientists for more than five decades after its isolation.

Lac dye is the pigment found in the lac resin produced by the insect *Coccus Lacca* on certain trees in Bihar. The dye referred as Laccaic acid was isolated in 1887 and was considered as

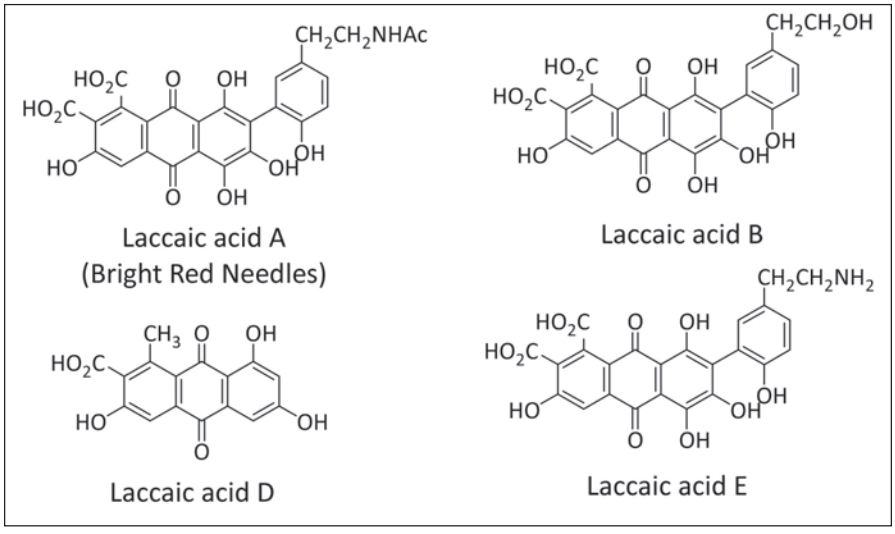


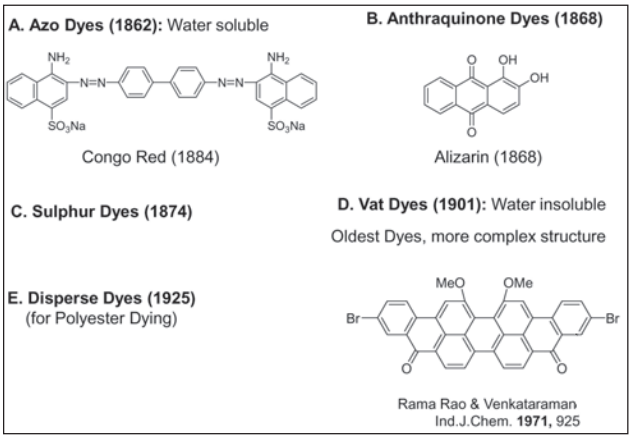
Chart 3

one compound, but my work in Prof. Venkataraman's group at NCL led to the separation of four products, two of them are major, named Laccaic acid A and Laccaic acid B. The two minor compounds are Laccaic acid D and Laccaic acid E present in less than 10% of the total dye. All the structures of these Laccaic acids have been shown in Chart 3.

The first synthetic dye, Mauveine was obtained in 1856 by W.H. Perkin in an attempt to synthesize Quinine. He founded the first factory to manufacture synthetic dyes in Greenford, near London. The most important natural dye from India was Indigo and its first synthesis was reported by Adolf Von Baeyer in 1879 and commercialized in 1890. Baeyer received the Nobel Prize in chemistry in 1905 for this contribution. The synthetic Indigo replaced the natural product and by 1914 only 4.1% of the total production of dyes came from plants.

The first synthetic dye in 1856 and subsequent years other class of dyes entered the market and the last class of reactive dyes appeared in 1956 by ICI, UK as shown in **Table 3**. The basic manufacturing process has remained same over the years. All production plants are operating in batch wise. Methods have been improved in control, isolation and workup. They have been replaced by spray dryers, agitated thin film dryers, falling film evaporators, etc. Research was mainly focused on the dye application on polyester, cotton and polyamide fabrics. Another focus of R&D efforts is to achieve very high fixations of reactive dyes on cotton so that the colour should not go into effluent.

2.1 Classification of Dyes



2.2 Indian Dyestuff Industry

Indian textile industry originally was using natural dyes which were slowly replaced by synthetic dyes imported from Europe. Arlab was the first dye stuff company founded in India in

Table 3

Ciba, Europe	1856 to 2006	Sold off business to Huntsman in 2006
Bayer, Europe	1863 to 1995	Dystar was born in 1995 and acquired byKiri Dyes in 2010
Hoechst, Europe	1863 to 1995	
BASF, Europe	1863 to 2000	Merged with Dystar in 2000
Crompton and Knowles, USA	1864 to 2000	Acquired by Yorkshire in 2000
Sandoz, Europe	1886 to 1995	Spun-off Clariant in 1995
Yorkshire, Europe	1890 to 2004	Closed
ICI, UK	1920 to 1996	Sold off business to BASF and Atul in 1996
Mitsui, Japan	1920 to 1997	Merged with BASF in 1997
Mitsubishi, Japan	1920 to 1999	Contract with Dystar
Nippon Kayaku, Japan	1920 to 1996	Contract with Yorkshire
Sumitomo, Japan	1920 to 1995	Closed
Clarient, Europe		
Dystar, Europe		

1940. More industries came into operation, producing all variety of dyes in and around Bombay which is now Mumbai. Many of these were located in Gujarat. Two main well known dyestuff industries in Mumbai, Indian Dye Stuff Industry and Amar Dye Chem along with ATIC at Bulsar were well known.

Today the Indian dyestuff industry comprises of about 950 units consisting of 50 in the organized sector and the rest are unorganized. Most of these industries are small and capable of manufacturing standard quality. They are meeting 90% of the domestic requirement. They operate at low margins due to scale of operation, high interest cost, high power cost and inflexible labour laws. On the contrary, Chinese plants operate larger size plants, water, power and finance are available at cheaper rates, coupled with flexible labour laws. As a result, many of the dyestuff industries in India have shut down. Several old plants have consolidated and are operating from China.

The estimated world production of dyes is around 120,000 MT/year, valued at USD 5 billion and 75% of them are produced in China. Top Chinese manufacturers include Dyestar (USD 0.8 billion), Huntsman (USD 0.5 billion), Clarient (Ex.Sandoz USD 0.2 billion) and Everlight (Taiwan). Indian companies produced around 130,000 MT/year valued at USD 0.6 billion. Among them Atul produces mostly vat dyes valued Rs.400 crores, Colour Tex (Disperse dyes) Rs.1000 crores, Magmani (Reactive dyes) and Jai Chemicals (Reactive dyes). There are more than 900 small scale units in SSI units in India and most of them located in Gujarat (80%) and Maharashtra. Dye manufacture is the most polluting industry. **Table 4** gives Indian and Chinese industries (1950-2012)

2.3 New applications of Dyes and Colourants

New developments in the area of dyes are directed in the high technology areas such as Solar cells, liquid crystals, printed circuit boards, semiconductors, etc. Many of the chromophores used in such applications were made more than 50 years ago and found to be of less use as dyes in textiles. These compounds are now finding new applications.

The world market for colourants used in electronics and electrophotographic industries is around USD 15 billion. They are made in Europe, USA and Japan. Their requirements are in kilo quantities but highly priced. Bayer, BASF,

Table 4

Atul, Indian	1952	Operating, bought 50% stake in M.DohmenIn 2011
IDI, Indian	1960 to 2001	Closed, JV with CIBA in 1977
Amar Dye Chem, Indian	1965 to 1985	Closed
Sudarshan, Indian	1970	Operating, Organic Pigments
Everlight, Taiwan	1972	Operating
L G Chem	1975 to 2001	Closed, sold-off to M.Dohmen
Chinese Producers	1975	Operating
Colourtex	1990	Operating
Meghmani	1985	Operating
Indo Chem	1990 to 2008	Closed
Metro Chem	1976 to 2008	Sold off to Huntsman in 2008
Kiri Dyes	1995	Acquired Dystar in 2010, JV with Longsheng In 2008

Sumitomo, Mitsubishi, Eastman Chemicals, etc. are engaged in their manufacture.

In recent years there has been a significant progress in new display technology. These dyes are used in guest host display (guest is a liquid crystal and the host is dye) and are dominated in the market. Ex: Azo, antraquinone and perylene dyes normally find in the guest-host crystal displays. Laser dyes play an important role in having a few lasers with wide spectrum rather than several thousand each with narrow brand width. They belong to coumarins, Rhodamine, Cresyl violet, Nile blue and Cyanine that were used as dyes more than 70 years back.

Another class of dyes are used for optical data storage. They are mostly conventional dyes that are suitably modified (Ex: Cyanines and related dyes and Triarylmethanes and related products). In India none of these new application dyes are made. Steps should be taken to initiate such programs.

3. Agro chemicals

In the 1960s India faced almost a famine type of situation and we had to import wheat from USA as part of a PL-480 grant. It was during this period Dr. Norman Borlaug introduced in India, Mexican high yielding wheat seed in Punjab resulting in high yield of crop thereby initiating Green Revolution in the country. It was also during that period India adopted IR-8, a semi-dwarf rice variety developed by the International Rice Research Institute by which rice yields went up to 5-6 times more per hector by having fertilizers and pesticides for crop protection coupled with better irrigation facilities. Thus India became self-sufficient in its food production and soon became a major exporter. Norman Borlaug was awarded Nobel Peace Prize in 1970. During that period, it was Prof. M.S. Swaminathan who was responsible for this green revolution in this country and is regarded as the Father of the Indian Green Revolution.

In recent years Indian demand for food grains is growing due to increase in population and at the same time there is constant decline of cultivable land in the country. This aspect is forcing the Government to look into farm yield improvement and reduction in crop losses due to pests.

India is the world's largest producer of fresh fruits, vegetables, major spices, castor seeds, jute, etc. It is also the second largest producer of rice, wheat, cotton, pulses, sugar cane coconuts, etc.

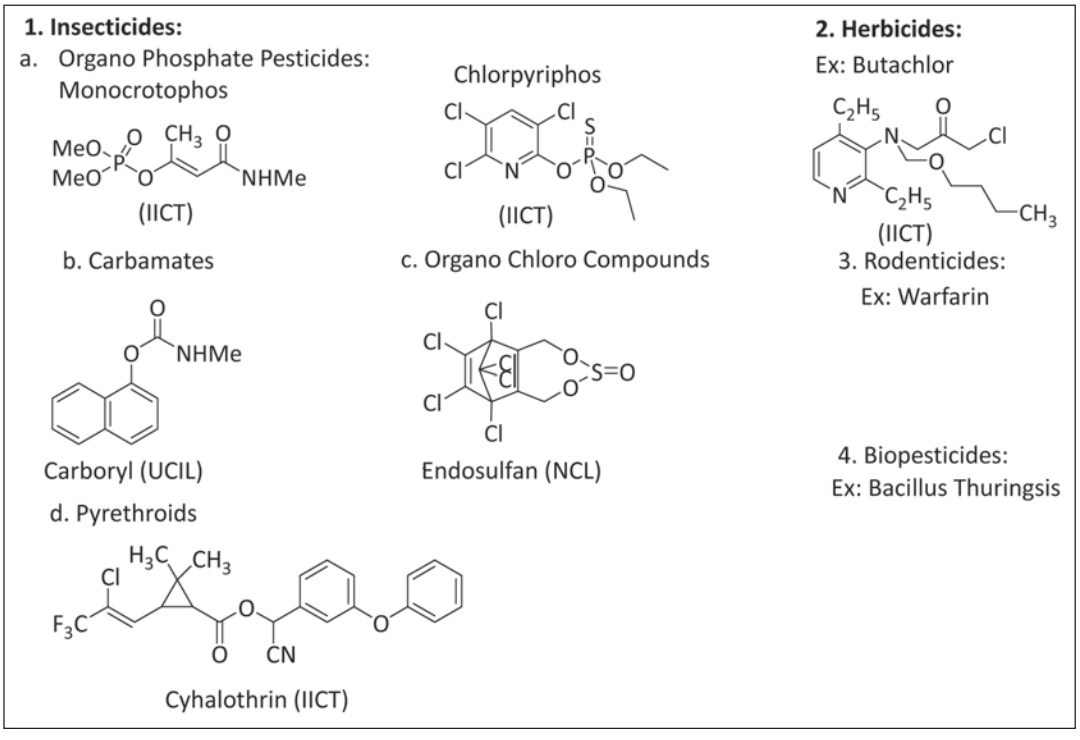
The Indian pesticide industry has developed substantially and contributed significantly towards crop protection and public

health. They consist of insecticides (65%), herbicides, fungicides, etc. forming 16% and 17% respectively. Recently the use of bio-pesticides is steadily growing (4.2%) and expected to grow 10% in the coming years. India in addition is meeting its own requirement (in value terms it is USD 4.25 billion and expected to grow at 12% p.a.). India is also a predominant exporter of pesticides to USA, Europe and many African countries (50% of its products). Global generic market of pesticides is USD 45 billion and India is the 4th largest producer after USA, China and Japan. India produces 1256 technical grade formulations, 60 of them are in the organized sector, 10 are multi-national companies and the rest of 800 in SMEs.

Indian pesticide sales by category wise; insecticides is by way largest consumption of approx. 70% followed by fungicides (17%), herbicides (12%), rodenticides (1%).

In recent years many new pyrethroids, especially some fluorinated pyrethroid esters have entered the market which have shown good activity when applied to soil. These are used in place of organophosphate soil pesticides. Examples include, Tefluthrin, Bifenthrin and Acrinathrin. A new class of respiration inhibitors are also now available. These kill pests by preventing oxidative phosphorylation. Examples include, Pyridaben and Tebufenpyrad. Some compounds, such as Fenpyrorimate have shown that they are inhibitors of an enzyme in the electron transfer chain from oxidative metabolism to the phosphorylation process. Aryl heterocycles are a new class of neurotoxic insecticides, of which Fipronil, the first compound in this along with some other in the series have shown greater activity than synthetic pyrethroids. We should explore new avenues, so that Indian pesticide industry could offer broad based product availability for use for national and international markets.

The big problem currently hampering agricultural growth is that of depriving the farmer access to the latest pesticides which are safe for use but facing our own regulatory hurdles. Inspite



of the fact that several of the new insecticides have been used for several years in advanced countries, our government agencies are not allowing them to be registered, although they are chemically equivalent and with the same quality as those introduced in the global market. During my tenure as Director of IICT, I highlighted this problem on several occasions to various departments, the need to simplify the mechanism for licensing such products based on chemical equivalence and the impurity profile based on data collected from the first two years of introducing these products. It was unfortunate, we lost time and the industry, as well as the farmer was deprived of these benefits.

During the last three decades, we built an abundance of technological skills with the second largest skilled manpower globally with low operating costs. We produce all varieties of equipment. We have improved our communication systems and information technology is fast growing in our country. In addition, we have a highly evolved legal system although slow at times. However, our main constrains are: weak infrastructure, delivery schedules are disturbed by frequent power failure and several bureaucratic delays. We frequently encounter transport hassles and delays. In addition we see excessive and unethical competition and one thing very common is theft or pilferage of in-house technology.

3.1 Exports

Pesticide exports are constantly rising. During the past three years the growth is 10 to 15% and is expected to enhance further. Many Indian companies like United Phosphorous, Gharda Chemicals, Excel Industries, Rallies, etc. have opened their offices in Europe and Australia to ensure quick deliveries. Many other Indian companies are in the process of opening their establishments all over the world. To meet the necessary registration formalities, Indian companies have set up full fledged registration departments and also made arrangements with GLP laboratories for generating data for registration.

Gaining foreign registration is not an easy task for the Indian companies. It involves high investment and is time consuming. However, some Indian organisations are getting accreditation from European authorities for toxicology.

3.2 Liberalisation

With liberalisation in 1991, rapid changes are taking place in the Indian industrial scenario. The old mind set is not going to work. Liberalisation has come too soon for many of the Indian industries and caught them unawares. When China began its liberalization process, the local industry was given a fifteen year time frame to adjust. Our planners want to achieve the same in just 5 years which is the main reason why in general domestic industry across the board is dying. Several changes have to be brought. One of them is the revision of labour laws. We have to train our work force to meet the demands of changing scenario. Further our tax laws have also to be modified. Reduction of indirect tax will increase the demand.

3.3 World Pesticide Market

The global market for generic pesticides is steadily increasing. The current market is USD 17.5 billion which is likely to increase to USD 27 billion by the year 2005 – a strategic growth of 54% in value. This aspect should be taken into account by the Indian pesticide manufacturers. In 1996, the world agrochemical market was valued at USD 33.5 billion of which 17.8 billion was the generic market accounting for 53.2% of the total market. Further, the generic market is concentrated in relatively few active ingredients. The top 44 active compounds account for USD 11.9 billion *i.e.* 67% of the total generic agrochemical market. The remaining 33% of the generic market is accounted for by around 300 individual compounds. In the next few years a whole host of

active ingredients are set to come off patent. This will give Indian industry access to a variety of low application. I hope that our Indian pesticide industry will take advantage of this opportunity.

The Ministry of Agriculture needs to streamline its rules and permit our manufactures to export new products and generics that are not registered in India to export to other countries, if their laws allow them for import. Our bureaucrats need to understand that nowhere in the world, do exporters need to register their export products. India is the only country where we follow age old rules. This is one aspect where the Government quickly needs to make suitable amendments that facilitate our exports of newer molecules, not registered in India, thereby enhancing our foreign exchange earnings.

Backward integration and diversification is a must, to make our products more competitive and cost effective, up-gradation of our technologies is essential. Several of our industries have already worked out ways of making products cost-effective. As our Indian industries have built excellent production facilities for the production of pesticides and their intermediates, I feel it is also time for them to diversify into other chemical sectors especially into fine chemicals segment. This is possible because, we have talented and trained manpower, who can take up such challenging tasks. We have to strengthen our R&D activities. The Indian Pharma industry is more tailor made and needs a variety of fine chemicals as raw materials and many of them are imported. For example, we import almost all fluorinated intermediates needed for pharma industry. Similarly, several pyrethriods need fluorochemicals and one could diversify into this area. Another area which is rapidly growing is chiral molecules, for both pharma & pesticidal products. Some of us could initiate and build expertise in this emerging area which will offer immense potential to become global players. Some of us were involved in developing technologies for a variety of chiral molecules and this expertise should be exploited by this sector of the chemical industry.

4. Concluding Remarks

I have tried my best to cover organic chemical industry in India, especially the important sectors of Drugs, Dyes and Agrochemicals. The growth in this area is unlimited and every effort is to be made by academic and industrial organisation and Government of India to see that we will emerge as global leader in the next two to three decades.

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