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History of Science in India, Vol. III: Chemical Science

S. C. Pakrashi and Subrata Ghosh (eds.), The National Academy of Sciences, India (Allahabad) and The Ramakrishna Mission Institute of Culture (Kolkata), 2014; pages xxii + 222; Price: Rs. 250.

To commemorate the 150th birth anniversary of Swami Vivekananda, the National Academy of Sciences, India (NASI) and the Ramakrishna Mission Institute of Culture (RMIC) embarked on a venture of publishing an eight volume treatise on History of Science in India, the volume III of that series is on Chemical Science.

In the "Foreword" of the book it is stated, "The present volume provides a glimpse of many of our revered scientists, who laid the foundation of modern Chemical Science and explored new horizons in the field."

But from the nature and extent of coverage, I regret to point out that this compilation has hardly fulfilled the purpose, as it does not make an objective, unbiased and adequate coverage of many of the salient contributions in the different major disciplines of Chemical Science to make it a truly representative document, particularly with regard to developments since the 1950s of the last century to date. Indeed there are many glaring omissions of the contributions which are well recognised internationally as evident from their citations in various authoritative scientific literature, such as the "Annual Reports on the Progress of Chemistry" and "Specialist Periodical Reports" published by the Chemical Society, London (presently the Royal Society of Chemistry, UK), and several other publications on special topics brought out by the Pergamon Press, Oxford, and other renowned publishing houses. Such citations are more logical and objective criteria to judge the merit of scientific contributions rather than fellowship of science academies and awards of the CSIR etc. Contributions of several well-known Fellows of INSA although no less significant than those mentioned in this book, are missing. Many non–fellows of INSA have made acknowledged contributions which ought to have been mentioned in fulfilment of the objective of this compilation.

In the "**Publisher's Note**" it is stated, "History of Science in India (8 volumes) is meant for lay readers. Written in simple language, steering clear of difficult technical jargon, it aims at giving a clear understanding of the development of science in India, from prehistory down to contemporary times." The compilers therefore faced an uphill task, since an authentic, objective and meaningful presentation of many of the scientific developments in modern times in specialised fields can hardly be made in a form that can be understood and appreciated by those without the requisite background.

The matter in **pages 60-74** on "Application of Modern Physical Methods in the Structure of Elucidation Organic Molecules" (note the glaring misprint) surely cannot be presented in lay man's language. Moreover, this part is out of context, irrelevant and redundant for the purpose of highlighting the contributions of Indian chemists, as the text in these pages are only a survey of the developments of the techniques by scientists in other countries.

The first few chapters (not numbered) after "Introduction", viz. Chapters 2-6 covering the period ca. 4000 BC to ca. 1600 AD, is based on

(in a very abridged form) the "History of Chemistry in Ancient and Medieval India", edited by Prof. P. Ray and published by the Indian Chemical Society in the year 1956, being a revised version of Sir P. C. Ray's two volume treaties titled "*History of Hindu Chemistry*". In this revised version the title was justifiably changed since many of the salient contributions were made by Jains and Buddhists also; and if logically the Vedic Period is considered for emergence of Hinduism then the people of the earlier Prehistoric Periods including the Harappan Period cannot be considered Hindus, as per normal convention and perception.

In addition to the aforesaid treatise, a lot of valuable information on the subject is available in several other treatises (see "Progress of Chemistry in Ancient and Medieval India and its Impact on Medicine", D. Banerjea, Calcutta University, 2008, and references cited therein).

Some major lapses (errors and omissions) that I have come across in this book are mentioned below:

In **page xvii**, the Buddhist era is mentioned as 800 BC–1000 AD. But Gautama Buddha was born in the year 566 BC (see, *An Advanced History of India*, R.C. Majumdar et al., Macmillan, 4th ed., 1978) and Buddhism was based on his teachings. Hence, the mentioned starting date 800 BC is grossly incorrect.

In **page 14**, in connection with the views (ca. 1st century AD) of the Jains regarding chemical combination, it is mentioned that this has resemblance to the Dualistic Theory of Berzelius (1812 AD). While this is true, their further view that similar elements combine when they differ widely in the intensities of their properties also reminds us of its resemblance to the electronegativity concept of the modern period (1932) of Linus Pauling, but not mentioned in this book. Some of the ancient opinions on chemical reactions also have remote resemblance to concepts of chemical thermodynamics.

In **pages 15-17** there is mention of some information available in the *Arthaśāstra* of Kautilya and this is followed (in pages 17,18) by those in the *Caraka Saṃhitā* and the *Suśruta Saṃhitā.*

In **page 14** both these *Saṃhitās* are mentioned as compilations of the 1st century AD which is unacceptable. The original *Saṃhitās* are not available, the extant *Saṃhitās* are redactions of later periods (4th-5th cent. AD), and it is reasonably believed that the original *Caraka Saṃhitā* was a product of the 3rd cent. BC and the original *Suśruta Saṃhitā* was surely of an earlier period, since in the *Caraka Saṃhitā* the treatment is much more systematic and logical, and there is greater emphasis on experiments, observations, holding of discussions and seminars, indicating its modernity over that of the *Suśruta Saṃhitā*.

In the brief summary of the contents of the *Saṃhitās* there is no mention of the lime soda process of making caustic alkalis, although this is significant and as same process was developed in Europe many centuries later.

In the *Arthaśāstra* the extent and depth of coverage is such that it is definitely of a period later than that of the *Caraka Saṃhitā*, and many prefer the date as 3rd century AD for the *Arthaśastra*. This was therefore not authored by Kautilya who was the Prime Minister of King Chandragupta (4th cent. BC) of the Mauryan dynasty, but by another bearing the same name. There are quite a few examples of persons having the same name belonging to different periods of time viz. two Nagarjuna, two Bagbhata, more than one Charaka, etc. Indeed Caraka was the title of a class of wandering Physicians who travelled from place to place offering treatment (like the Mobile Health Care Service of the present time).

In the *Arthaśātra* there is elaborate mention of methods for processing and purification of ores, of rather advanced metallurgical processes for extraction of several

metals and their purification, testing of precious metals like gold and silver to check adulteration and cheating by goldsmiths, making of several varieties of fermented drinks of superior quality, flavour and taste, mention of several gemstones, qualifications for Superintendents (*Adhyakṣās*) of Mines, etc., which are indicative of its considerable modernity over that of the *Caraka Saṃhitā*.

In **page 26**, about the famous iron pillar at Mehrauli in Delhi, the purity of the iron is mentioned. But even highly pure wrought iron left exposed to open air for over 1600 years and still remaining rust-less is impossible. It is obvious that a thin protective coating of magnetic oxide of iron was deliberately imparted to the surface of the metal by a high temperature chemical operation, a technique developed several centuries later in Europe. Iron was known in ancient India since ca. 1500 BC and this ought to have been mentioned.

In **page 38**, extraction of zinc from calamine, as mentioned in the *Rasaratnākara* (of Nagarjuna, ca. 8th-9th century AD), is stated but without mention of the fact that this was achieved in India much before it was achieved anywhere else in the world. In China extraction of zinc from calamine was achieved in the 16th cent. AD and in Europe in the 17thcent AD (see, "Discovery of the Elements", H. M. Leicester (Ed.), *Journal of Chemical Education*, Easton, Pa, USA, 7th ed., 1968). There are many such examples of India's primacy such as making of brass (by smelting a mixture of copper and zinc ores with charcoal as fuel, developed in ca. 500 BC, but in Europe in the 1st century AD), which is not mentioned in the book. Brass is mentioned in page 49 of the book, quoted from a compilation of a much later period, viz., the *Rasaratnasamuccaya* (14th century AD). Similarly, there is no mention that antimony extraction from stibnite was achieved in India in the 12th century AD (vide *Rasendracuḍamaṇi*). In Europe this was achieved in the 17th century AD (see, "Discovery of the Elements", loc. cit.).

In **page 44**, there is only cursory mention of sulfuric acid (*Dahajala*), *aqua regia* (*Sankhadravaka*, incorrectly spelt *Samkhadrvaka*) and of calomel which do not reflect their antiquity in India.

Sulfuric acid was originally made in India by distillation of alum (*Rasārṇava*, 12 cent. AD, and *Rasaprakāśasudhākara*, 13th cent. AD) and later on by distillation of green vitriol (Rasaratnasamuccaya, 14th cent. AD) but in Europe in the 16th cent. AD by the same process. It was then named an "essence"; the name "*Dahajala*" first appeared in *Dhātukriya* (17th cent. AD). Aqua regia (*Sankhadravaka*) is mentioned in this book, but this was more appropriately also named "*Mahadravaka*" because of its ability to dissolve all metals known at that time (16th cent. AD).

Preparation of calomel in the 16th cent. AD as a product of reaction of mercury with *aqua regia* is only mentioned in the book. But much earlier to that (as mentioned in *Rasarārṇava*, 12th cent. AD, and *Rasaprakāśasudhākara*, 13th cent. AD) this was made by heating a mixture of alum, rock salt, borax, red ochre (ferric oxide) and mercury and collecting the calomel as a sublimate. Based on our modern knowledge we realise the role of each of these ingredients, and it is amazing that in such an early period this recipe was found out presumably after a lot of painstaking experiments and observations. Uses of calomel as an aphrodisiac and for treatment of leprosy are mentioned in the *Rasaprakāśasudhākara* (13th cent. AD), but not mentioned in this book; its use in the treatment of syphilis (*phiringaroga*) is mentioned in the treatises *Rasapradipa*, *Bhāvaprakāśa* and *Arkaprakāśa*, all of 16th century AD (two of which are mentioned in this book).

It would have been more illustrative, informative and appealing if all such developments were highlighted (in a Tabular form) vis-a-vis their developments in other places of ancient civilizations and in medieval Europe, to

highlight India's primacy and prominence in the knowledge of science in ancient and medieval periods.

Incidentally, in all places (pages 30 et seq.) the element S has been spelt as "sulphur" and similarly the spellings "sulphide", "sulphuric acid" and "sulphate" have been used as per earlier practice of the English school. But this is inappropriate, since over a decade ago the International Union of Pure and Applied Chemistry recommended use of the spellings "sulfur", "sulfide", "sulfuric acid" and "sulfate" and this is now used all over the world in scientific literature.

In **page 45** of the book only four *yantrās* (apparatus) are mentioned, out of about 30 such items described in detail in the *Rasaratnasamucccaya* (14th cent. AD); several of these are also mentioned in earlier treatises such as *Rasaratnākara* of Nagarjuna (ca. 8th-9th cent. AD). Most of these closely resemble the apparatus used in the chemical laboratories in the19th and even the early 20th centuries; the distillation apparatus is very similar to what is used even in the present time; these ought to have been mentioned.

In **page 48** the following statement "….science in India moved in a wrong direction with the spread of the practice of alchemy…and as a result the progress of science in India began to decline…" is hardly tenable. Contributions of the renowned alchemists like Nagarjuna provided much impetus to the progress and advancement of knowledge in chemistry. In fact the alchemists of India, like their counterparts in all other regions of the world, played a significant role and provided much ammunition for the advancement of chemistry. Alchemy did not at all retard the progress of science in Europe, rather it provided impetus to the emergence of modern chemistry in Europe since the time of Robert Boyle (17th cent. AD).

With the decline of Buddhism there was emergence of a decadent and degenerated form of Hinduism under priestly control that discouraged rationality and reasoning with its consequent adverse effect on the spirit of inquiry and urge to acquire knowledge which retarded the progress of science. The foreign invasions since the12th cent. AD led to destruction of many of the seats of learning which was also a contributing factor for the decline.

In this connection the following extracts from Sir. P. C. Ray's writings may be worth quoting:

> "I am as proud of the glories of the Hindus of old days as anybody….". "Roughly speaking the period 800 BC to 800 AD has been the most rational age of India – an age of prolific of the best specimens of Hindu brain-power." "With the decline of Buddhism the Brahmins began to recover their lost ascendancy. But these later-day Brahmins were the degenerated off-springs of those to whom we owe the rich treasures of the Upanishads and the six systems of philosophy." "In its very nature a priestly disposition restricts learning and renders progress impossible." "The spirit of inquiry now received a rude shock."

In the rest of the book, **page 76** onwards, devoted to presentation of contributions of Indian chemists since the last decade of the 19th century up to the present time, the coverage is indeed most disappointing.

Before mentioning some of the major lapses I wish to point out that names of some renowned persons have been written with spellings different from those used by them, which is improper. Thus, in page 78, Sir Asutosh Mookerjee's name is written as Asutosh Mukherjee. In page 88, name of Priyadaranjan Ray (P. Ray) is written as Priyada Ranjan Ray (P. R. Ray), although under his photograph (very poor quality reproduction) the name appears correctly.

In **page 81**, in 3rd paragraph, it is mentioned that after the foundation of 'The Indian Chemical Society', Sir P. C. Ray's office was used also as office of the Society. This is contrary to facts. The Society functioned from the room of Prof. J. N. Mukherjee, the first Secretary of the Indian Chemical Society. Another statement in that paragraph that the Indian Chemical Society is now situated in three rooms in the first floor of the chemical laboratories of the University College of Science, constructed with P. C. Ray's donation to the Calcutta University is factually incorrect in some respect. Since one of the two compilers of the book is a Life Member of the Society and served the Society as a Council Member for some years, such an incorrect statement is most astonishing. Three rooms were constructed, but in the second floor (third floor as per US convention) of the southern wing of the Sir Taraknath Palit building with a donation of Rs.10,000 made by Sir P. C. Ray to the Calcutta University (reported in The Amrita Bazar Patrika, dated August 3, 1929), two of which were allotted (rent free) for a "permanent habitation" of the Society and the other used by the University. The Society is housed in these two rooms with additional space made available by covering the wide balcony in front of these two rooms as permitted by the then Vice-Chancellor Prof. S. N. Sen, in response to an appeal made to him by Prof. D. Banerjea, the then Secretary of the Society, in the year 1973. Also in the 4th paragraph in the same page a factually incorrect statement appears. Prof. Meghnad Saha (incorrectly written Prof. Meghnath Saha) collected donations for a function to celebrate the 80th birthday (not the 81st birthday, stated in the book) of Sir P. C. Ray on a grand scale, like the one held on his 70th birthday which was attended by may eminent citizens of Calcutta including Rabindranath Tagore. But such a celebration was not held and the reason for that, which I refrain to point out, is mentioned in a biographical document on Sir P. C. Ray which was published by the Indian Science News Association in the year 1986, jointly authored by Prof. Santimoy Chatterjee and Prof. Amitava Sen.

In a publication of a book on "History of Science in India" one expects objective, unbiased and factually correct presentation highlighting the progress and developments that had taken place in different areas of chemical science in India with the names of those who made the contributions, rather than an account of individual contributions of a few, selected rather arbitrarily with flawed logic. The compilers ought to have viewed the panorama by looking through a wide open window rather than through a small hole in the window panel.

In the coverage of Organic Chemistry there is over emphasis on chemistry of natural products, with mention of the work of some individuals quite elaborately, but far less elaborately some significant ones. The coverage of Inorganic Chemistry shows merely the "the tip of the iceberg", and the same is true of Physical Chemistry with inadequate coverage. There is practically no mention of contributions in Analytical Chemistry, a field in which there are several flourishing schools in different regions of India since the 1920s. Names of many of the Indian chemists who surely made substantial contributions in these three areas are sadly missing (some of them were/are also FNA). In some cases statements of contributions of individual workers are lacking in factual accuracy and adequacy.

In **page 80** it is mentioned that P. C. Ray published his discovery of mercurous nitrite in the year 1986 (astounding printing error, the year should be 1896). There is no mention that in later publications [*J. Chem. Soc*., vol. 71(1897):337-344; vol. 87(2005):171-177] he claimed the compound to be so stable that it could be recrystallized from hot water. But more recent works of a few distinguished Inorganic Chemists (two of USA) have shown that mercurous nitrite is too unstable for isolation [see, D. Banerjea, *Eur. Chem. Bulletin*, vol.3.2(2014):146-148, and references cited therein]. It ought to have been mentioned that P. C. Ray reported several sub-normal compounds of gold and platinum. If the

structures of these are elucidated by modern techniques, several of these are likely to turn out to be cluster compounds and that would establish P. C. Ray as a pioneer in the field (see D. Banerjea, 2014, loc. cit.). This class of compounds is receiving much international attention since the 1950s for their numerous applications.

In **page 88,** the twist mechanism of racemization of tris-chelate complexes proposed (intuitively) by. P. Ray is mentioned; but contrary to the statement, this was not the first racemization mechanism proposed; this was the first twist mechanism for racemization proposed. Experimental evidence in support of this has been furnished by some scientists in the USA and also by D. Banerjea (which ought to have been mentioned to lend credence to the proposal and intuition of the proposer). The statement in the same page that D. Banerjea was Palit Profesor of Chemistry is incorrect. He was Sir Rashbehary Ghose Professor of Chemistry and not the Sir Taraknath Palit Professor of Chemistry of Calcutta University. Apart from the twist mechanism of racemization, P. Ray made several other very notable contributions which are well acknowledged, viz. rubeanic acid (dithio-oxamide) and quinaldinic acid as microchemical reagents. In fact, rubeanic acid is the most sensitive reagent for detection of Cu(II) ion known so far (detection limit 3 ppb), and with quinaldinic acid P Ray estimated Zn(II) in snake venom. P. Ray prepared a complex compound of Ag(III) with ethylenedibiguanide (mentioned in many advanced level books) which is the most stable compound of Ag(III) known so far; its thermodynamic and kinetic stabilities were experimentally demonstrated by D. Sen et al. and D. Banerjea et al. respectively, and these were surely worth mentioning. P. Ray also demonstrated using radioisotope tracer the identity of the conventional covalent and coordinate bonds in complexes, which was one of the earliest such work. P. Ray also prepared (first such example) a stable complex of Ni(IV) with paraperiodate. Several co-workers of P. Ray also made notable contributions in different fields of Inorganic Chemistry and Analytical Chemistry of which there is no mention.

Apart from the Calcutta school, notable contributions on various aspects of Coordination Chemistry and in other areas of Inorganic Chemistry were made (which are well acknowledged) by inorganic chemists in many other centres of research in India, but there is no mention of any of them (some of whom were/are FNA also) or their contributions.

In connection with Magneto-chemistry, there is mention (in page 90 of the book) of contributions of K. S. Krishnan, but no mention of the contributions of D. M. Bose who proposed a relationship to express the magnetic moments of compounds of 3d block metals, which bears his name, and this is mentioned even in text books because of its far greater significance. P. Ray also made well-acknowledged salient contributions in Magneto-chemistry.

In **page 92**, it is mentioned that R. C. Mehrotra did "…..extensive research on organo-metallic compounds…" He did extensive research on metal alkoxides, metal-beta- diketonates, etc., all having only metal—oxygen bonds and no metal—carbon bond. As per international convention a metal compound having an organic moiety is not considered as an organometallic compound unless there is at least one metal—carbon bond in the molecule. This does in no way undermine the contributions, but in a compilation of this nature scientific precision and accuracy is most desirable.

It is since the early 1950s that mechanisms of reactions of metal complexes is receiving much attention internationally, with ca. 15 per cent of annual contributions in Inorganic Chemistry being in this field at present. In India research in this area was initiated in the year1957 in the Indian Association for the Cultivation of Science (IACS), Kolkata, by D. Banerjea who and his coworkers

later continued such studies in the University College of Science, Kolkata.

Since the early 1960s a few other centres of research in the field emerged, notably Utkal University, Bhubaneswar (R. K. Nanda, A. C. Dash), IIT, Kanpur (P.C.Nigam) and Central Leather Research Institute, Chennai (M. Santappa, D. Ramasami; T. Ramasami, whose name appears in page 94 of the book, is a product of this school). Most of the contributions of all these groups were fairly extensively cited in the annually published "Specialist Periodical Reports on Inorganic Reaction Mechanisms", published by the Royal Society of Chemistry, UK, since1969; "Mechanisms of Inorganic and Organometallic Reactions" (a multivolume treatise) published since 1983 by the Plenum Press, New York, USA; 'MTP International Review of Science: Inorganic Chemistry", Series 1, vol. 9, published by Butterworths, UK, 1972, etc.

Subsequently such research activities were continued at the IACS, Jadavpur University, Kalyani University, Burdwan University, Visva Bharati University (Santiniketan) and IIT (Mumbai) by former students and coworkers of D. Banerjea. But there is no mention of such contributions in this book, although this is one of the frontier and flourishing areas of research in Inorganic Chemistry at present.

Mechanistic studies of redox reactions, mainly of organic substrates with inorganic oxidants, have been carried out extensively at several centres, notably at Allahbad University (S. P. Mushran and others), University of Rajasthan, Jaipur (Y. K. Gupta), J.N.V. University, Jodhpur (R. N. Mehrotra, K.K. Banerji) and these were also well cited in literature. Unfortunately there is no mention of these in this book.

Up to the 1980s much of the work in Inorganic Chemistry was mainly on the chemistry of the d- and f-block elements. Some chemists of the younger generation are now contributing to the chemistry of the s- and p-block elements; other areas of activity are in nuclear chemistry, inorganic-macromolecular chemistry, bioinorganic chemistry, environmental chemistry, solid state chemistry, etc., of which there is practically no mention.

In **pages 130** and **137** the pioneering contributions of S. R. Palit in Polymer Chemistry are only mentioned. But later in his life, S. R. Palit developed much interest in Electrochemistry and published a few papers on "Non-Faradaic Electrolysis" in which he reported some very fascinating observations and offered interpretations thereof [S. R. Palit, *J. Indian. Chem. Soc*., vol.51, (1974):636-642 and references cited therein], but there is no mention of this significant contribution.

It is also regrettable that there is practically no mention of the recent developments (of the last two decades) and contributions of the younger generation of chemists (35-45 age group) who have been contributing significantly in different disciplines of chemical science.

Chemistry today is a multi-disciplinary science and no person, even if exceptionally eminent, can be expected to have knowledge of developments in areas other than those of his own limited field of interest. Hence compilation of a publication of this nature ought to have been entrusted to a board of scientists with expertise covering all the major areas of chemistry, rather than two organic chemists.

However, the compilers could have produced a more authoritative and representative document if they had invited brief write-ups from chemists of different disciplines working at various research centres in India.

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