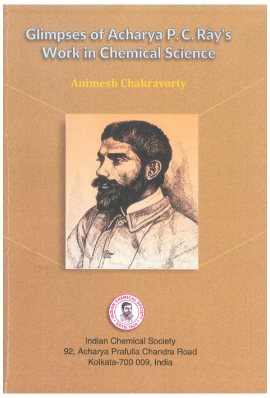


Glimpses of Acharya P. C. Ray's Work in Chemical Science. Animesh Chakravorty. Indian Chemical Society, 92, Acharya Prafulla Chandra Road, Kolkata 700 009. 2019. xi + 136 pages. Price: Rs 250.

The book under review is about the father of modern Chemistry in India, Acharya P. C. Ray (1861–1944). It is written by one of the oldest and most famous inorganic chemists in India. In that respect, it is an historical document.

Ray was a versatile man who contributed enormously as a teacher (at Presidency College, Calcutta and later Science College, Calcutta University), as an entrepreneur (founder of Bengal Chemical Company), as a historian of chemistry and also as a serious researcher. Many of the earlier authors who wrote on Ray's life was so obsessed with his ideals and social contribution, that Ray's contribution as an original chemist is vastly obscured in the hero worship.

This book tries to eliminate the lacunae by discussing, in detail, Ray's contribution to research in chemical science. In fact, Ray had so much impact in contemporary chemistry that some of his papers published in lesser journals were highlighted in *Nature*. The total number of papers published by Ray is quite impressive. He published as many as eight papers in *Nature* and most of his papers were published in the *Journal of Chemical Society Transactions* (*JCST*), which was the best journal of chemistry in those days.

Throughout his life, Ray worked independently. He received his DSc degree from the Edinburgh University at the age of 26, for his works on double–double sulphates. This resulted in a single authored paper in *Proceedings of Royal Society of Edinburgh*. When Ray started his works on synthetic inorganic chemistry, many structural and spectroscopic techniques were not available. That is why some of his earlier interpretations were corrected later. For instance, X-ray crystallography of his 'double-double' sulfates revealed that they were actually mixed crystals of two double salts and did not involve any fundamentally new lattice or phase.

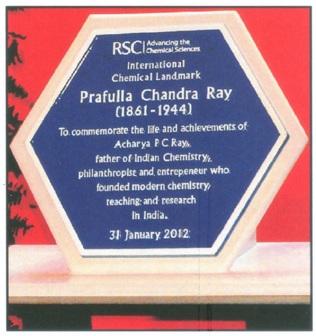
His famous work on mercurous nitrite was carried out at Presidency College, Kolkata and was originally published in the *Bulletin of Asiatic Society* in 1896. It was immediately highlighted in *Nature* (1896) as, 'The journal of Asiatic Society scarcely have a place in our library. The current number, however, contains a paper by P.C. Ray on mercurous nitrite that is worthy of note.' Three independent X-ray crystallographic study of mercurous nitrite, carried out in 1985, 1986 and 2011, confirmed Ray's results. He showed that dry mercurous nitrite crystals, free from mother liquor and dried are stable for an indefinitely long time. However, if left in contact with the mother liquor, they slowly get converted to a white basic salt. This was confirmed in 1966 by Potts *et al.* (*Inorg. Chem.*, vol. 5, p. 1066). Continuing on his interest on nitrites, Ray synthesized pure, crystalline mercuric nitrite in 1904. Though it is unstable even in dry atmosphere, Ray reported synthesis of interesting stable complexes of mercuric nitrite, with many ligands. Crystal structure of some these compounds or their analogues were reported much later.

Ray also made major contributions on the thermal decomposition of ammonium nitrites, alkylammonium nitrites and nitrous acid. Ammonium nitrite is well known to decompose on moderate heating. The major decomposition products are nitrogen and water with a small contribution of second decomposition route to ammonium nitrate, nitric oxide, ammonia and water. Through meticulous vapour pressure measurements, Ray demonstrated on careful heating to 70°C in moderate vacuum, a part of the ammonium nitrite also sublimes unchanged. The *Nature* magazine hailed it as, '…a further accomplishment in determining the vapour density of this very fugitive compound'.

In 1914, after retiring from Presidency College, Ray joined Science College of Calcutta University, created by Sir Asutosh Mookerjee. There, Ray was the first Palit Professor of Chemistry and C. V. Raman was the first Palit Professor of Physics. At Science College, Ray initiated studies on organic thio-compounds. With simple aliphatic thiols RSH, Prafulla Chandra was able to isolate crystalline nitrites of type $RSHgNO_2$ which constitute a new thiolato family of mercury similar to the known thiolato-mercuric halides, RSHgX. The latter, is now known to be, generally polymeric and gives rise to inorganic polymers. For instance, in the acetate complex $MeSHg(O_2CMe)$ each metal atom of the $(\text{-Hg-SMe-})_n$ chain is chelated to one acetate ligand which additionally interlinks the chains.

Ray showed that the reaction of $RSHgNO_2$ with alkyl iodides (RI) yields a mixture of nitro-alkane, alkyl nitrite and a yellow crystalline solid. Ray initially assigned the yellow solid to be $[R_2S_2, HgI_2, RI]$ that was later corrected to $[R_2S, HgI_2, RI]$. Earlier, in 1900, Smiles had suggested a monosulfonium structure for these compounds based on hexavalent sulphur. Using electrical conductivity data in acetone, Ray showed that these compounds are uni-univalent electrolytes. This prompted him to reject the hexa-valent sulphur model of Smiles and to conclude that the $[R_2S, HgI_2, RI]$ species are actually trialkyl sulphonium salts of tri-iodo mercury(II), $[R_3S][HgI_3]$. Subsequently, many others researchers confirmed this. The tri-iodo mercury(II) anion is a rare example of tri-coordination among transition metal complexes of simple ligands. This is almost invariably cited as an example in leading textbooks of inorganic chemistry. However, it is hardly mentioned that this was first proposed by P. C. Ray.

Prafulla Chandra made early contributions towards platinum metal chemistry of sulfur ligands. Upon treating iridium tetrachloride ($IrCl_4$) with dialkyl sulphides (R_2S) in ethanol, he found the metal to be reduced to the trivalent state affording



International Chemical Landmark Plaque.

a compound of composition [$IrCl_3$, $3R_2S$] isolated in two isomeric forms differing in colour and in solubility in organic solvents (published in 1932 and 1933). The more soluble isomer is orange yellow in colour while the less soluble isomer is red. On the basis of composition, stability and non-electrolytic nature of the yellow isomer in acetone solution, Prafulla Chandra concluded that it is a hexa-coordinated compound [$IrCl_3(Et_2S)_3$] and suggested that the red isomer is of similarly composition. He assigned *cis* (*fac*) and *trans* (*mer*) geometries for the yellow and red isomers respectively. Subsequent NMR and other physical studies, however, confirmed that the yellow species is actually the trans isomer and the red one was actually a dimerization isomer. Though this early assignment of Ray was discarded, it is Ray's original synthetic work that generated interest in these compounds. Ray's iridium work was indeed pioneering and finally led to the highly interesting family [$MX_3(R_2S)_3$] where M = Ru, Os, Rh or Ir and X = Cl or Br. Ray was active till the end of his life and continued to publish papers. Just a few years before his death in 1944, physicist (K. S. Krishnan, Van Vleck) started applying magnetic measurements and quantum mechanical theory to inorganic compounds.

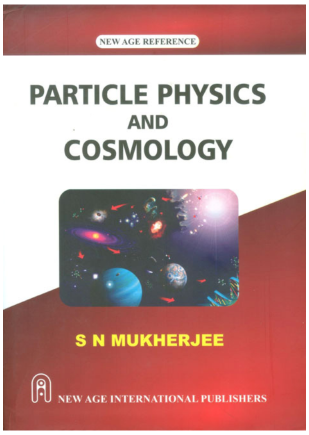
I recall that in the IUPAC meeting held at Puerto Rico in 2011, the IUPAC President proposed that each country should celebrate the International Year of Chemistry, not only for the centenary of Madame Curie's chemistry Nobel, but also for a National Hero in Chemistry. Some of us suggested to the RSC representative that whether India and UK may jointly celebrate the 150th birth year of PC Ray honouring his strong UK connection. This was immediately approved by RSC President Professor Yellowless, who was a Professor of Inorganic Chemistry at Edinburgh, Ray's alma mater. On 31 January 2012, RSC installed an International Chemical Landmark Plaque at Presidency College 'To commemorate the life and achievements of Acharya P. C. Ray, father of Indian Chemistry, philanthropist and entrepreneur who founded modern chemistry teaching and research in India.' Interestingly, this was the first RSC Plaque outside Europe and USA.

In summary, the reader of this book will have a first-hand report from a top modern inorganic chemist about Ray's research contribution. This book is not blank hero worship. It is a dispassionate analysis of Ray's contribution to a wide area of inorganic chemistry and how it impacted later research.

I recommend this book to all college and university library as a dispassionate analysis of Ray's chemistry.

KANKAN BHATTACHARYYA

Department of Chemistry,
Indian Institute of Science Education and Research, Bhopal,
Bhopal 462 066, India
e-mail: kankan.bhattacharyya@gmail.com



Particle Physics and Cosmology. S. N. Mukherjee. New Age International (P) Ltd Publishers, 7/30A, Daryaganj, New Delhi 110 002. 2019. x + 480 pages. Price: Rs 999.

This is a handy book of less than five hundred pages for the beginning student, published by New Age International. It introduces the basics of the topics, mentioned in the title, aimed at the advanced undergraduate and the starting graduate student. It is an admirable attempt since, though there are quite a few tomes covering Particle Physics and Cosmology separately and in more detail, it is hard to find one combining these two subjects at this level.

The first chapter, entitled 'Synthesis of micro- and macro-cosmos' and introducing some fundamental notions as well as defining several basic quantities in both areas, is quite readable. I especially liked the six tables at the end. There are, however, a couple of minor glitches. The expression for Planck time is given without defining it as $L_{Pl}c^{-1}$ and that for the Planck temperature (with a c^2 missing from the numerator) is given without explaining anywhere that k is not the space-time curvature index, used in chapter 8, but rather the Boltzmann constant. Also, a short section on Feynman diagrams (with which students at this level may not be familiar) is sorely missed here since these are drawn in several parts of the book later without any explanation.

The second chapter provides a clear and useful summary of basic elastic and deep inelastic lepton–hadron processes and also touches upon different types of colliders used in high energy physics. Unfortunately, accelerators with fixed targets as well as e^+e^- colliders are mentioned only cursorily. I also wish that the Further Reading list here were more extensive. It is sad to see Feynman's 'Photon–Hadron Interactions' omitted. Moreover, Close's 'Quarks and Partons' should have been included here rather than at the end of chapter 1.

Chapter 3, covering beta decay within the Fermi theory, is beautifully written. It sets the right historical perspective and covers all pertinent experiments – clearly showing the author's mastery over the subject. The V–A theory is properly developed while the neutrino sections are nicely presented and include discussions of all relevant past, recent as well as current experiments. I wish, though, that the author had clarified the distinction between a Dirac and a Majorana mass of a neutrino. While the tritium beta decay spectrum can measure either, neutrinoless double beta decay can only provide information on the latter.

Chapter 4, entitled 'Fundamental Interactions', is somewhat misnamed; it should have been called 'Gauge Theories of Strong, Electromagnetic and Weak Interactions' since it deals with only those theories. Gravitational interactions, though fundamental, are excluded here. I think that quantum chromodynamics merited a longer discussion. In particular, confinement is just mentioned briefly; the linear rise of the quark potential at large distances is shown in a graph but not explained. Also, no mention is made of lattice-based efforts. Otherwise, the coverage is good, I would say. The reader's imagination is tickled with brief mentions of GUTs and string theory.

The next two chapters (5 and 6) are somewhat technical in nature – dealing respectively, with neutrino experiments in general and the specific phenomenon of neutrino oscillations. First, different