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HISTORICAL NOTE

Contribution of Satyendra Nath Bose in chemical sciences and related disciplines

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Abstract
Professor Satyendra Nath Bose (S. N. Bose), the internationally recognized theoretical physicist, had equal interest in different branches of experimental chemistry. Both in Dhaka and Kolkata, he established sophisticated laboratories for chemistry research. In this present endeavor, the contributions of Bose in chemical sciences and related disciplines have been tried to be explored.

Keywords Satyendra Nath Bose · Analytical chemistry · Clay composition · Organic synthesis · Solution chemistry · Spectroscopy · X-ray research

1 Introduction

Satyendra Nath Bose (S. N. Bose), one of the architects of *Bose-Einstein statistics*, had his interest in chemistry and related disciplines equally with the theoretical physics. Being theoretical physicist of international repute, it is now wondered how did he get interested in organic, inorganic as well as physical aspects of experimental chemistry rather than some other theoretical parts of the subject like bonding calculations, different X-ray diffraction statistics, magneto-chemical calculations, etc. which could have been very close to the theoretical physics, his original passion. The reasons for Bose's interest in chemistry might be of many folds. He, like many other Indian scientists, had a very nationalistic feeling in then British ruled India (Choudhury, 1994a, 1994b) and tried to develop our own chemical and pharmaceutical sciences so that we could prepare several useful chemicals and drugs in our own country. Secondly, his interest in chemistry might be inherited from his father who being an East Indian Railway employee established a small chemical industry and thirdly, his close association with his teacher cum mentor Sir P. C. Rây who is considered as the father of modern chemistry education and research in India (Choudhury, 1994a, 1994b). During his first visit to Europe in 1921, Bose visited the laboratory of the famous German chemist Herman Mark. Mark wrote, "His (S. N. Bose) large and profound knowledge, which stretches over the whole of physics as well as wider territory of chemistry marks Mr Bose out prominently" (Mark 1926). This visit could have some influence on him for his interest in different chemical investigations in the following years (Chatterjee, 1975, p.72). Both in Dhaka (Dacca University, now University of Dhaka, Bangladesh) and Kolkata (Calcutta University), he established laboratories for organic synthesis and X-ray research. Regarding his interest in chemistry, one of his students in Dhaka, Gaganbehari Banerjee recalled, "While Professor Bose was in Dacca Dr Pratul Rakshit (later regarded as a noted physical chemist who worked under Sir J. C. Ghosh in Dhaka on ascorbic acid and others) and Dr Pulin Behari Sarkar (who later became renowned jute technologist and worked with Prof. J. K. Chowdhury in Dhaka) amongst many others often came to discuss chemistry with him. The discussions could have ranged from ascorbic acid to jute. Ashima Chatterjee (the famous organic chemist in later days), though always in Calcutta, was in touch with Bose even when he was in Dacca. Once Bose sent her from Dacca a compound, she was finding impossible to get in Calcutta" (Banerjee, 1974). Both in Dhaka and Kolkata chapters Bose worked in various fields like atomic spectroscopy, organic synthesis, X-ray characterization of soils and clay, extraction of metals from minerals, etc., and obviously theoretical physics. This wide range of his scientific activities is a surprise to the students and researchers of science even today.

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2 Chemistry activities: Dhaka and Kolkata

2.1 Organic synthesis and X-ray structures

The generous contribution of S. N. Bose in organic synthesis and clay analysis was reviewed by the esteemed organic chemist of our country Prof. Asima Chatterjee (Chatterjee, 1974). As discussed earlier Bose started working on organic synthesis while he was in Dhaka. His one publication (Bose, 1943) with Paritosh Kumar Dutta on sulphonazide chemistry was found from Dhaka. At Dhaka, he also synthesized several sulfa drugs, γ-pyrone derivatives, etc. Later, he moved to Calcutta University in 1945. There, he worked on synthesizing different bioactive organic molecules. Several students who established themselves as famous organic chemists in later years, like Asima Chatterjee (who later became professor at Calcutta University) and Jadu Gopal Dutta (who later became professor at Burdwan University) worked with him.

The expertise and interest of Bose in X-ray might have come from his working experience in the laboratory of Maurice de Broglie (in Paris) who was then doing original research in X-ray crystallography. In a correspondence from Paris to the then Dacca University Vice-Chancellor P. J. Hartog, Bose wrote, "I am at present working at the X-ray laboratory of M. de Broglie." (Majumdar, 1994, p. 50). Along with synthesizing organic molecules, Bose was interested to solve their structures from single crystal X-ray diffraction data. He encouraged and insisted many of his students in this kind of work. The X-ray structure of anthraquinone was solved by (Sen (1948) and it was established that Anthraquinone belongs to monoclinic crystal system, but it was known to have orthorhombic system earlier. In this publication, the author acknowledged the interest and encouragement he received from Bose in that investigation. The X-ray structures of nor-harman and rauwolscine were solved in his (S. N. Bose) laboratory in Calcutta University in two separate publications (Ray, 1956 and 1957). But Bose was not an author in either of the papers. L. Ray, the single author of both the publications, unhesitatingly expressed her indebtedness to Bose under whose guidance and direction the project was completed.

2.2 Composition of clay, shale and soil

S. N. Bose made very important contribution in determination of structure and composition of clays, shales and soils of different parts of India using thermal analysis and X-ray diffraction. During that post-independence period those investigations were of much importance for the development of agriculture and pottery in our country. Surprisingly, here also no authorship is found in the publications coming out of these investigations from the laboratory (Khaira laboratory) of Bose. Samples from different parts of India were investigated and then divided into four categories: (i) Montmorillonite, (ii) Vermiculite and chlorite, (iii) Illite and (iv) Kaolinite (Chatterjee, 1974). Purnima Sinha (neé Sengupta), student of Bose and the first woman PhD of Calcutta University, made very pertinent contribution in this field. In two of her important publications in *Nature* (Bose, 1954 and Sinha, 1962), she expressed thanks to Bose for his important advice and suggestions. Sinha records, "Few will realize that it was S. N. Bose, one of India's finest theoretical physicists, who first initiated research in X-ray based structural analysis of clay samples from different parts of this country!" (Sinha, 2008, p. 307). Prof. J. N. Mukherjee, the noted colloid chemist and classmate of Bose, after investigating the characters of clays from different parts of India, prepared a map (of clays). The structural investigations of these clays were performed in Bose's laboratory (Choudhury, 1994a, 1994b).

2.3 Spectroscopy

After returning from Europe, Bose established a spectroscopy laboratory at Dhaka. From there a scientific paper on atomic emission spectroscopy of beryllium jointly authored by Prof. Bose and Surya Kumar Mukherjee (then lecturer in Physics, Dacca University) has been found (Bose, 1929). As valence shell electronic configuration of beryllium ($[He]2s^2$) is similar to helium ($1s^2$), the atomic emission spectra of these two atoms are, expectedly, similar. Bose (1929) tackled the problem of few previous controversies on the beryllium spectra. In 1955, Bose reported a thermo-luminescence behavior of some alkali halides and organic molecules at Calcutta University (Bose, 1955). In that paper, thermoluminescence behaviors of some sand samples from different parts of the country were investigated.

2.4 Germanium extraction

The element Germanium, discovered by C. Winkler in 1886 attracted the attention of physicists and chemists after the invention of transistor in the middle of the last century. The noted Indian Physicist S. K. Mitra in his 1955 Indian Science Congress Presidential address told that, "The future stage, if one may venture to make a prophecy, will be the era of the uses and applications of the element germanium" (Mitra, 1955). The source of germanium in early twentieth century was mainly the chimneys of several industries in USA and UK, where the coals used had good amount of germanium content (Nag, 1994, p. 13). Bose identified the very important problem in those days and started to search suitable ore in and around our country. He found sphalerite as the suitable ore of germanium in Nepal and published three original scientific publications in extraction of the metal

from the ore (Bose, 1950, pp. 52, 251, 271; Datta, 1950a, b). In case of detection and extraction of germanium, Bose used analytical, spectroscopic and X-ray methods. In each of the publications, the help rendered by Pulin Bihari Sarkar (the renowned analytical chemist of Calcutta University as well as college-day associate of Bose) was duly acknowledged.

2.5 Solution chemistry

In Dhaka, another important publication of Bose along with Susil Chandra Biswas (then lecturer at Department of Physics, Dacca University) was on the measurement of polarization and decomposition voltages of some electrolytes in non-aqueous solvents (Biswas, 1927). The instrument used was completely designed and developed by Prof. Bose.

3 Conclusion

We find that scientific interest of S. N. Bose, once he returned from his first visit from Europe became diversified. With basic interest in theoretical physics, he worked in several aspects of experimental physical and chemical sciences. Apart from this, he also wished to crack the several then relevant problems of science so that industrial development in pharmaceutics, electronics, etc. can grow in our country after having independence from about two-century long British rule. At very matured age, he pursued to explore the rare gas helium, which could generate loss-free electrical power, from the natural thermal spring in Bakreswar in West Bengal.

Pratul Chandra Rakshit in his Bengali autobiography *Periye Elem* (*Have Crossed Through*) quoted K. S. Krishnan (who was reader in Physics in Dacca University) as: "Dr Bose finds his pleasure in complex problems. His enthusiasm dies once he solves them. He throws the proofs in the waste-paper basket, never bothering to send them to any journal" (Rakshit, 1992). This may be the reason that many of his findings with Pranabandhu Dutta and Jadu Gopal Dutta remained unpublished (Chatterjee, 1974). Moreover, for this very reason, the saint-like personality Bose did not have his authorship in many of the publications which came out from his laboratory. However, investigations of S. N. Bose, the scientist with multi-dimension and encyclopedic knowledge, beyond *Bose Statistics* should be explored and respectfully regarded. Undoubtedly, Indian science will owe to him forever.

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