

JOGENDRA CHANDRA BARDHAN

(1896—1964)

Elected Fellow 1942

JOGENDRA CHANDRA BARDHAN was one of the foremost synthetic organic chemists of the country. He was a man of great simplicity, an erudite scholar, a critical thinker, a devoted teacher and a scientist of strong determination in achieving his goal in spite of the limitations and difficulties arising out of the environment. He made valuable contribution on synthesis in the fields of phenanthrenes, steroids and terpenoids. *Bardhan-Sengupta Synthesis* of phenanthrenes has become one of the classics in synthesis of polynuclear homocyclic organic compounds. His synthetic acumen was highlighted, in 1928, through his synthesis of Balbiano's acid, which resolved a serious problem in arriving at the structure of camphoric acid/camphor.

BIRTH, PARENTAGE AND CHILDHOOD

Bardhan was born on October 15, 1896 in the village, Swarnagram, in the district of Dacca (now in Bangladesh). His father was Annada Charan Bardhan, and his mother, Jnanada who loved him endearingly, died while he was a young boy. He felt very much mentally upset when his father married again, and this he could not forget during the rest of his life. Then onwards, he grew under the care of his grandmother.

EDUCATION

He had his early education at Jalpaiguri. He passed the Matriculation examination of the Calcutta University from the Jalpaiguri Zilla School in 1913 securing the highest position in order of merit amongst candidates from Jalpaiguri district. The same year he lost his grandmother. He passed the ISc examination of the University in 1915 from the City College, Calcutta and then he got admitted in the Presidency College, Calcutta for graduation. He passed the BSc examination with Honours in Chemistry in 1917 and the MSc examination in Chemistry of the Calcutta University in 1919 and stood second in order of merit at the latter, though he could not get a First Class. This proved to be a great stumbling block for achieving his aspirations in having an entry in the research team of Sir PC Ray, the then Sir Tarak Nath Palit Professor and Head of the Department of Chemistry of the newly started Calcutta University College of Science. In those days Sir PC Ray's laboratory was packed up with the cream of research students in inorganic, organic and physical chemistry.



Young Bardhan had another mental upset when he could not find a place in his laboratory. He could not even get a place in the laboratory of Professor PC Mitter, the then Sir Rash Behary Ghosh Professor of Organic Chemistry of the University and so he started working under Dr Rasik Lal Dutta, a noted synthetic organic chemist of his time and Lecturer at the Chemistry Department of Presidency College, under considerable financial strain for want of a supporting stipend.

SCIENTIFIC CONTRIBUTIONS AND TEACHING

Dr Dutta was one of the most practical type amongst Indian organic chemists of those days and took numerous useful patents relating to halogenation and nitration. After the first paper of Bardhan with Dr Dutta on the explosion temperatures of trinitrometacresolates was ready for publication in the *Journal of the American Chemical Society*, he could start working in the laboratory of Professor Mitter in 1920. Jointly with him he published a paper on condensation of amidines with ethoxymethylene derivatives of β -ketonic esters and β -diketones. He was awarded the DSc degree of Calcutta University in 1924 for his original work on *Synthesis of Heterocyclic Compounds*. This work was mostly concerned with cyanoacetamide condensation. His findings in this line was profitably utilised by SA Harris, ET Stiller and KJ Folkers in their useful synthesis of Pyridoxine (Vitamin B₆) in 1939.

In 1925 Bardhan received the Palit Foreign Scholarship of the Calcutta University, sailed for England, and joined the Imperial College of Science and Technology, London under Professor JF Thorpe. Here he carried out his famous work on the synthesis of Balbiano's acid, $C_8H_{10}O_5$, earlier obtained by Balbiano by oxidation of camphoric acid with potassium permanganate. It became extremely important to establish the structure of this product in the interest of establishing the structure of camphoric acid and of camphor. By a straight forward synthesis of the product he established it to be γ -keto- $\alpha\beta\beta$ -trimethylpropane- $\alpha\gamma$ -dicarboxylic acid, i.e. γ -keto- $\alpha\beta\beta$ -trimethylglutaric acid. This was carried out by a simple route by alkaline potassium permanganate oxidation of $\alpha\beta\beta$ -trimethylaevulic acid. This synthesis, proving Balbiano's acid to be a glutaric acid derivative and not a succinic acid derivative, established the glutaric acid structure of camphoric acid with reference to positions of the three methyl groups and the two carboxyl groups.

This work had immediate recognition amongst top-ranking organic chemists throughout the world when the two related papers were published in 1928. On the basis of this work he was awarded the DSc degree of London University in 1928, i.e. within four years of his having DSc degree of Calcutta University.

From London he went to Utrecht in Holland and worked with Professor Leopold Ruzicka. Here he worked on some degradations, of caryophyllenic acid. While his work at London established him as a scientist of very high standard, his work with



Ruzicka was of immense help to him and later to his school of research students with regard to acquiring a thorough training in microtechniques, e.g. bulb-tube fractional distillation in high vacuo, micro-filtration systems making use of thick-walled capillary tubes or micro-funnels with glass-beads having flat top provided with stem, etc. Later such techniques were introduced by some of his students and collaborators in many well known laboratories of the West.

He returned to India in 1930 and was appointed the first Sir PC Ray Fellow in the Department of Chemistry, Calcutta University College of Science and Technology. At this stage, jointly with his first student and collaborator, Suresh Chandra Sengupta, he carried out his memorable work on the general method for synthesis of phenanthrene and the various substituted phenanthrenes, which was soon recognised throughout the world as the '*Bardhan—Sengupta Synthesis*'. In those days, the synthesis of the various alkylated phenanthrenes, e.g. retene, pimanthrene, etc. was of fundamental importance for providing authentic specimens for comparison with such products obtained by sulphur or selenium dehydrogenation of naturally occurring products like resin acids and related terpenoids.

It may be noted in this connection that while Bardhan was Sir PC Ray Research Fellow at the University College of Science, he had very little working space there. In this respect Sengupta who was working in the Chemistry Department of Presidency College as a Laboratory Assistant, proved to be very useful as a collaborator not only for his devoted work but also for the working space and other facilities he could manage in their spacious laboratory.

In 1934-35, he made his second trip to England and worked in the Laboratories of Professor JF Thorpe and Professor O Rosenheim. During this period he made a very valuable contribution on the degradation of natural estrone to 7-methoxy-2-methyl-1, 2, 3, 4, 9, 10, 11, 12-octahydrophenanthrene-2-carboxylic-1- β -propionic acid. With acetic anhydride it gave the methyl ether of estrone. This may be regarded as the earliest partial synthesis of estrone methyl ether. He utilised this occasion in visiting most of the progressive centres for researches in organic chemistry in Europe. In 1955, he made a third trip to Europe and worked for about a year in various laboratories.

In 1937, he was appointed as a Lecturer in the Chemistry Department of Calcutta University College of Science, and thus he finally settled down to his task of training younger chemists. His laboratory soon became a favourite place for their training. Whether in the class room or in the laboratory he was regarded by all as an excellent teacher. Of course, he was a very competent teacher on alicyclic ring formation, steroids and terpenoids, the related resin acids and the like. But even in other diverse fields he proved his efficiency equally well. For instance, once he was required to teach chlorophyll in the MSc (Special—Organic) Class and he had only a short



notice for that. In a short time he went through all the related original papers and as a result his lucid exposition of the complex subject including the various degradation products was very much appreciated by the students. For creating interest in such subjects, whenever possible, he showed the related materials and even some simple experiments. For instance, in the case of chlorophyll, he showed the students in the class how the absorption bands differ in the cases of chlorophyll and blood when seen through a direct vision spectroscope.

Amongst his numerous students, particular mention may be made of Professor Suresh Chandra Sengupta, Professor Sudhir Kumar Banerjee, Professor Ram Gopal Chatterjee, Dr Nripendra Nath Chatterjee, Dr Mukul K Bose, Dr Narayan Chandra Ganguly, Dr Nirmal Kumar Brahmachari, Professor Ram Narayan Chakravarti, Mr R Swaminathan, Professor Debi Chakravarti (*née* Mukherji), Professor Kshitish Chandra Bhattacharya, Dr Bipin Behary Dutta, Professor Dhananjoy Nasipuri, Dr Rabindra Nath Adhya, Dr Usha Purakayastha (*née* Rakshit), Dr Manjuli Ray, Dr Ram C Banerjee, Dr Dwijendra Nath Mukherjee, Dr Paritosh Mohan Chakrabarty, Dr Alaka Rao (*née* Bhattacharya), Dr Amiya Kumar Sanyal, Dr Ramesh Chandra Dhar, Dr Biswanath Dasgupta, Dr Kamala R Tatta and Dr Gita Mukherjee (*née* Dutta). Amongst others who worked in his laboratory for shorter periods or were in close touch with him for their researches mention may be made of Professor Dilip Kumar Banerjee, Dr Satyesh Chandra Pakrashi, Dr Arun Kumar Bose, Dr Haragopal Biswas and Dr Satindra Jiban Dasgupta.

He started his research career with his work at the Presidency College, Calcutta with Dr RL Dutta on temperature of explosion of endothermic substances relating to explosion temperatures of trinitro-m-cresolates followed by his work with Professor PC Mitter on condensation of amidines with ethoxymethylene derivatives of β -ketonic esters and β -diketones carried out at the Calcutta University College of Science, and his work on heterocyclic compounds for his DSc of Calcutta University in 1924. The work for his DSc of London University was on establishment of structure of Balbiano's acid by its synthesis and synthesis of related products including a mechanism of formation of Balbiano's acid by permanganate oxidation of camphoric acid. At Utrecht under Ruzicka he had his experiences on newly developing micro techniques and the work on degradations of caryophyllenic acid.

These were followed by his publications on the chemistry of 1, 3-dicarbonyl compounds and the mechanism of cyanoacetamide and cyanoacetic ester condensations in 1929-30. This work was, in fact, carried out earlier by him at Calcutta. The '*Bardhan—Sengupta Synthesis*' was covered by his two well known papers on the resin acids published in 1932. At this stage he was naturally interested in synthetic work on the steroids as indicated by his note in the *Nature* in 1934 on synthesis in the estrin group and his work at London in 1935-36 on synthesis of 3'-keto-3, 4-dihydro-1, 2-cyclopentenophenanthrene and on a new synthesis of hydrophenanthrene derivatives,



as also his work a little earlier at Calcutta on synthesis of bicyclo-(0, 3, 3)-octane derivatives and in 1937 on experiments on synthesis of Wieland's tricarboxylic acid, $C_{13}H_{20}O_6$. However, he also showed his interest on the terpenes.

His series of papers on terpene compounds started with a preliminary synthetic investigation in the cadinene group in 1935. The same year he published Part II of this series on synthesis of homoapofenchocamphoric acid and in the next year Part III on isofenchocamphoric acid, and his work in the selinene group. Nevertheless, he tried his best to retain his interest in synthetic work on steroids as evident from his publications in 1940 on derivatives of 2-phenylcyclohexanones. However, these were his last publications of the series in sterol-estrone group and from this time onwards he started his new series of papers on synthesis of polycyclic compounds, the Part I of which on synthesis of alkylphenanthrenes appeared in 1956. This paper covers a very flexible new route which was used in the preparation of a number of alkylphenanthrenes. 2-Ethyl-1, 8-dimethylphenanthrene obtained in this way was found to be identical with the product of dehydrogenation, $C_{18}H_{18}$, of methyl vinylacrylate and other related diterpenoids.

Parts II to VI were published also in the same year. Part II includes ring closure of β -carboxy- γ -1-naphthylbutyric acid. The ring closure was carried out with 85% sulphuric acid. The same product was obtained by the action of anhydrous aluminium chloride on the corresponding anhydride. The structure of the keto-acid was proved by unambiguous synthesis. Part III of this series covers the synthesis of 3-phenylcyclohexanol which on cyclodehydration gave α -octahydrophenanthrene. A large number of mono-, di-, tri- and tetra-methyl phenanthrenes were prepared and published in Part IV. Part V of this series was on preparation of 4, 8-endomethylenebenzocyclooctane by phosphoric anhydride. On chromic acid oxidation it gave a ketone which on Clemmensen reduction gave the tricyclic hydrocarbon of Cook and Hewett thus confirming the structure of their product. Parts I-VI of this series came out in 1956, and the last Part, i.e. Part VII in 1962. It included synthesis of four polycyclic hydrocarbons by his general method in good yields.

Coming back to his work in the terpene series it may be pointed out that since 1937 he was much more interested in this line. Particular mention in this respect may be made of Part V of the terpene series on his synthesis of cis- and trans-(\pm)-isofenchocamphoric acid which was baffling attempts by earlier scientists. This synthesis established the correctness of the structure of Semmler-Wallach for this acid. Published in 1949, this paper also describes a direct synthesis of dehydroisofenchocamphoric acid. This valuable paper was followed by two other important papers in the same issue of the *Journal of the Chemical Society*, London, where he was regularly publishing practically all his papers, Part V on synthesis of (\pm)- β -Fenchocamphorone, and Part VI on synthesis of (\pm)-isofenchone. The synthetic isofenchone on potassium permanganate oxidation gave an excellent yield of (\pm)-cis-isofenchocam-



phoric acid, This synthesis established the correctness of Semmler's formula for isofenchone. Similarly the synthesis of (\pm) - β -fenchocamphorone established the correctness of the structures earlier accepted for β -fenchocamphorone and β -fenchone.

Conversion of (\pm) -benzylidenepiperitone into 3-isopropylphenanthrene as in Part VIII of this series of papers proved Earl and Read's structure of (\pm) -benzylidenepiperitone, the structure of 3-isopropylphenanthrene being established by an unambiguous synthesis of the product as described in the same paper. In Part IX is covered his work on method of formation of homoapocamphoric acid, while Part X covers a synthesis of (\pm) -anguistinone. Parts VII-X were published in 1956.

The synthesis of Samuel and Manasse's keto-acid, $C_{10}H_{16}O_3$, originally obtained by rearrangement of camphorquinone by dissolution in concentrated sulphuric acid, is covered in Part XI of this series of papers. This synthesis has finally established the structure of the rearranged keto-acid beyond doubt. Synthesis of (\pm) -cryptone and related compounds are covered in Part XII, and synthesis of 1, 5-dimethylhexylcyclohexanones in Part XIII. These three papers appeared in the *Journal of the Chemical Society*, London in 1963 and were his last publications.

POSITIONS HELD AND HONOURS

In 1923 he became the first recipient of the Nagarjuna Prize of Calcutta University (donated by Sir PC Ray) for meritorius research in chemistry and also awarded the coveted Premchand Roychand Studentship (PRS) of Calcutta University. On satisfactory completion of the research period of the latter he was awarded the Mouat Medal of Calcutta University in 1924. In 1925, he was awarded the well known Sir Taraknath Palit Scholarship for research abroad of the Calcutta University and worked at the Imperial College of Science and Technology, London as mentioned earlier. On his return to Calcutta, during 1930-33, he worked as the first Sir Prafulla Chandra Ray Research Fellow of Calcutta University, value Rs 200/- per month and annual research grant of Rs 1,000/-. In 1934-35, he was awarded the Ghose Travelling Fellowship of Calcutta University for continuing his researches in England. On his return after his second foreign sojourn, he rejoined Pure Chemistry Department of Calcutta University College of Science at 92, Acharya Prafulla Chandra Road as Sir Prafulla Chandra Ray Research Fellow for 1937-38 and from this position he was directly absorbed as Lecturer of the Department. In 1946, he was appointed Khaira Professor of Chemistry of Calcutta University, which post he retained up to the date of his retirement. During 1960-62, he was Head of Pure Chemistry Department and retired on superannuation in 1962. After his retirement, he moved to Delhi and joined the Ministry of Education of the Government of India as a Member of the Scientific and Technical Terminological Commission. He retained this post up to the last day of his life.



PERSONAL LIFE AND LOVE FOR SCIENCE

His was a life of great struggle and the pity was that few could appreciate this. At a tender age he lost his mother and his father married again. He could not stand this change in the family and, as it appears, he missed the proper touch to bear this change more easily. It had a standing reflection in his mind, due to which he never saw his father afterwards. He had some solace through the love and care of his maternal grandmother who reared him up till he came to Calcutta from Jalpaiguri. At Calcutta, he had to maintain himself mostly through private coaching of younger students.

The second time when he felt seriously hurt was when, after his MSc, he was refused by Sir PC Ray to have him in his research group. As it appeared, Sir PC Ray was a man of strong likes and dislikes and young Bardhan could not understand why he did not agree to accept him. Though he did not get a First Class in MSc, he was second in order of merit and in that year only one had a First Class. He felt very much frustrated and wept as he came out of the laboratory. In this case also he had some solace when, one day while he was working with full attention in the laboratory in his characteristic way, to his utter surprise he suddenly found Sir Asutosh Mookerjee standing at his back and patting him in appreciation of the excellent reports on his DSc Thesis received from his foreign examiners. Nevertheless, he could not forget throughout his life that he was not accepted as a research student by Sir PC Ray. His sense of frustration in this respect was mostly because he thought he did not have proper consideration from him. This feelings left a more or less permanent mark in him due to which he appeared to be quite alone in the Pure Chemistry Department except for the friendly relation with Professor PB Sarkar who was also not happy with Sir PC Ray.

The writer started his research career under him in 1938 just after he became a Lecturer. One may have a glimpse of the prevailing atmosphere from the fact that just before joining under Bardhan he had to hear from his elder brother, who was at that time studying in the Calcutta Medical College, that Dr Bardhan did not behave properly with his students. In the early fifties, Sir SS Bhatnagar speaking before a gathering of scientists at the Bengal Immunity Research Institute, Calcutta remarked that he heard many things against Bardhan in Calcutta, but while abroad he acquired the impression that Bardhan was most widely appreciated as an organic chemist of a very high standard of this country.

Though Bardhan felt very sorry with regard to Sir PC Ray, at heart he was all the time admiring his good qualities and trying to copy those, much better than any of his favourities. Like Sir PC Ray, he practised very plain living and high thinking, and remained a bachelor throughout his life. Every now and then he used to tell his students the valuable remarks of Sir PC Ray such as *hand is the best spatula; a chemist should have the patience of an ass*, etc. He never drank tea as Sir PC Ray was



very much against drinking of tea and his slogan was *drinking of tea is drinking of poison*.

Bardhan was happier with his substantial research grant while earlier he was working as Sir Prafulla Chandra Ray Research Fellow, but when he became a Lecturer he had a meagre research grant of Rs 250/- annually from the University. However, as an adviser to the then Lister Antiseptics & Dressings Co. (1928) Ltd. he used to get a substantial sum which was kept in the care of the writer and the full amount used in purchases of chemicals, etc. required for his laboratory. Besides this, he used to maintain a laboratory bearer and a laboratory assistant, by paying them from his own income, for help in laboratory work. From time to time, he also maintained a research assistant like that, especially when such a person came to work under him without other means of support.

Whether at home or in his laboratory, he was a very thrifty person and that is why, while the War was going on during 1939-45, he had good stock of rare organic chemicals. All the time he had an eye for avoiding wastage and recovery of chemicals and solvents. Even there was regular system of recovery of metallic sodium from scrapings and recovery of platinum oxide from waste platinum catalyst. In view of the very sound training in synthetic organic chemistry, his laboratory was always packed up with research students. Though there was no dearth of chemicals, solvents and glass-wares, simple items like good velvet corks, glass rods, glass tubes, etc. were not much in stock and the students had to understand the principle of 'beg, borrow or steal' for having such requirements from other laboratories.

He was a man of regular habits and observed strictest punctuality. He hated luxury like anything. He was very fond of walking fast with his umbrella in hand, and it was quite difficult even for young students to accompany him during walking. A run or at least a fast walk from the Octorloney Monument (presently known as Sahid Minar) to the Victoria Memorial on the Calcutta Maidan very early in the morning was a must throughout his life at Calcutta. As a result, he maintained sturdy health all through, while at Calcutta. He took class lectures very seriously and was always well prepared. In the class, he wrote very clearly all the details on the black-board. This was very much appreciated by the students. Often the students used to come to his laboratory for further discussion and clarifications.

At his residence, in a rented flat not far from the laboratory, he maintained a library where he used to spend most of his available time at home in reading. This place was more or less midway between the main building of the University at College Square and the laboratory of the University College of Science and Technology at 92, Acharya Prafulla Chandra Road and thus he had very little need for any conveyance as he loved to walk these distances. Of course, for his early morning run on the maidan he



used to go from his residence to the maidan by the first tram car on the College Street line at about 4 am everyday and used to come back while the city was still practically sleeping.

He had great love for the laboratory. Everyday he used to work there with his own hands, and thus he inspired working habits amongst his research team. The writer started his research career under him on May 1, 1938, a Sunday. When he reached his laboratory, he found Dr Bardhan in his lab-coat deeply engaged in a vacuum distillation. Again, about a month prior to retirement of Professor Bardhan, the writer met him in the same laboratory on a holiday and found him busy with a filtration at the water-pump with a glass stopper in one hand for pressing the product on the filter. During discussion with him he expressed his keen desire for continuing work after retirement and wished very much that the University would grant him the permission required for using one of the rooms for continuing his researches. As the University could not offer him the facility, after his retirement he had nothing but to agree to join as a Member of the Scientific and Technical Terminological Commission of the Government of India, Ministry of Education, New Delhi. For this he had to move to Delhi. In recent years, the writer has often heard a common remark from many visiting foreign scientists during their visits to Indian laboratories that they found the Heads of laboratories mostly in their office room and not in the laboratory in working condition. Bardhan, on the other hand, used to spend most of his time in the laboratory on foot and not so much in his chair. When he had no work to do, he would go round and round the working tables in a pensive mood.

LAST DAYS

After his normal, regular routine life at Calcutta, his stay at Delhi proved to be a great change. Added to this was his great sense of frustration for his inability to continue his researches in the laboratory. The end came rather fast from a stroke while at Delhi, where he died on December 23, 1964, a little over two years after his retirement. He was survived by his elder brother, Upendra Chandra Bardhan, also a bachelor and intimately connected with the Ramakrishna Mission. He was a demonstrator in biology at the Vidyasager College, Calcutta and stayed with Professor Bardhan for a long period. Thus ended the life of a great scientist, and one of the foremost amongst organic chemists of the country.

RN CHAKRAVARTI

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