Shanti Swarup Bhatnagar – A Visionary Extraordinary

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Shanti Swarup Bhatnagar holds a unique position in the annals of Indian Science. He was a man of many dimensions – an outstanding scientist, an able science manager, a visionary creator of institutions and a patriot who had an abiding faith in the scientific and technological prowess of India. Bhatnagar met his destiny in the year 1940, at the age of forty six, when he was called by the Government of India to become the Director of Board of Scientific and Industrial Research which was to become later the Council of Scientific and Industrial Research. This signaled the transition of Bhatnagar from a mere scientist to a science manager and a creator of institutions. By the time he died in 1955, Bhatnagar, had created one of the finest science and technology edifice of independent India, a chain of twelve discipline based laboratories ranging from physics and chemistry to leather and electrochemicals. He recognized the potential of science and technology to create wealth through business and established the National Research and Development Corporation of India, an organization dedicated to translate science and technology into business. As early as 1941, Bhatnagar persuaded the Government to set up an Industrial Research Utilization Committee (IRUC) for translating science and technology into applications. His singular devotion to the cause of building a scientific infrastructure in India, his pioneering ventures into making science useful to society and industry and his courage to shake the Indian scientific establishments out of the ivory towers it had ensconced itself make him, along with Homi Bhabha and Vikram Sarabhai, one of the most influential and visionary members of the scientific establishment in post independent India.

Bhatnagar was born on 21 February 1894, at Bhera, in the

district of Shahpur in Punjab. He was the second of three children. His father, Parameshwari Sahai Bhatnagar gained distinction as a teacher of history and English. His father was a puritan and joined the Brahmosamaj. Shanti Swarup Bhatnagar was only eight months old when his father died leaving the family in dire poverty. Shanti Swarup was brought up by his maternal grandfather who was an engineer by profession and one of the first graduates of the Roorkee College. Shanti Swarup developed his interest in applied sciences growing up with his grand father. Shanti Swarup studied till 1907 at the A V High School, Sikandarabad. He was later persuaded by a family friend to move to Lahore to attend the Dayal Singh High School In school he excelled in both science and Urdu grammar and poetry. In 1911, at the age of 17, he published his first paper in *Leader* of Allahabad on a method of making substitute carbon electrodes for a battery by heating molasses and carbonaceous matter under pressure.

Shanti Swarup joined the Forman Christian College, Lahore in 1913 for his BSc degree, which he completed in 1916 with honors in physics. He completed his MSc degree in chemistry in 1919. Presumably the system of education in those days provided the flexibility for a physics graduate to do MSc in chemistry, a feat that would not be easy today! Shanti Swarup wrote a thesis on 'effect of adsorbed gases on the surface tension of water'. Armed with a scholarship from Dayal Singh College Trust, Shanti Swarup left for America via England in 1919. However, the breaking of the First World War prevented him from going to America. So he decided to stay back in England. He joined the University College, London, under the mentorship of F G Donnan, a distinguished physical chemist known for his contributions to the area of surface and interface science. He was awarded a DSc degree in 1921 for his thesis 'solubility of bi- and trivalent salt of higher fatty acids in oils and their effects on the surface tension of oils'. While at London, his contemporaries were, J C Ghosh, later Sir J C Ghosh, member, planning commission, J N Mukherjee, later Director, Indian Agricultural

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Research Institute and M N Saha, later Palit Professor of Physics, Calcutta University.

On his return to India in 1921 he was appointed Professor of chemistry at the just established Benaras Hindu University. In 1924 he moved to Punjab University, Lahore as Director of the University Chemical Laboratories where he stayed on till 1940. He published over 100 papers, during this period, probably one of the most productive phase of his career.

Apart from his many original scientific contributions to colloid and magneto-chemistry, he did considerable work in industrial and practical chemistry. One of his major achievements of this period was the work he performed for Messrs Steel Brothers and Co., London. In the process of drilling for oil, the Attock Oil Company at Rawalpindi was using a drilling mud, which solidified upon contact with saline water. Shanti Swarup Bhatnagar solved the problem by the addition of an Indian gum, which had the remarkable property of lowering the viscosity of the mud suspension and at the same time increasing its stability against flocculation action of electrolytes. The company was so pleased that they offered Bhatnagar a sum of one hundred and fifty thousand rupees – a princely sum for R&D in 1925! Bhatnagar insisted that the money should be paid to the University. The proceeds from the donation were used to set up a Department of Petroleum Research at Punjab University. During the next ten years, Bhatnagar and his students carried out pioneering researches on deodorization of waxes, increasing the flame height of kerosene, lubrication, corrosion prevention, etc. Several patents were granted and licensed. Bhatnagar offered 50% of the income from licensing to the University with a proviso that they should be used solely for scientific research. Bhatnagar combined pioneering basic research with purposeful applied research, proving that they are but two sides of the same coin and cannot be mutually exclusive. He created wealth out of knowledge by recognizing the value of intellectual property, long before this term became a part of the lexicon of the scientific community in India.

Bhatnagar, nevertheless, refused to accept any financial reward for himself. He believed that scientific work loses its altruistic character, if the worker begins to secure financial benefit for himself. He felt that the public begins to doubt the credibility of a scientist if he only works hard to make himself rich. Noble thoughts indeed and a far cry from the late twentieth century scientific endeavors, where creation of personal wealth through science and scientific entrepreneurship has come to stay as being perfectly moral and, even, desirable.

Right honourable Sir Tej Bahadur Sapru, in his convocation address to Punjab University in 1936 remarked 'I feel that your University is lucky in possessing a professor who out of a singular sense of patriotism and self denial, contributed a considerable part of his gift to the university, who was alive to his duty to the country and was not afraid of being accused of doing something practical for the good of the country'. M N Saha wrote to Bhatnagar 'please accept my heartiest congratulations on your noble gift to the Punjab University. You have thereby raised the status of the university teachers in the estimation of the public. India does not lack men earning in millions, but if a few of these millionaires were guided by the fine example set by a comparatively poor teacher like yourself, I think her scientific and moral progress would have been rapid'.

Two areas where Bhatnagar contributed extensively were magneto-chemistry and physical chemistry of emulsions. Early in his career Bhatnagar realized that the application of magnetism to chemistry had great possibilities. He used magnetic susceptibility measurements to study the properties of organic compounds, solutions, films and colloids. At the beginning of his study Bhatnagar realized the lack of suitable equipment for the study of small changes in magnetic susceptibilities. He and his student K N Mathur (who later went on to become Director, Central Scientific Instruments Organization, Chandigarh) designed an equipment (called Bhatnagar–Mathur light interference balance), patented it and licensed the patent to Adam Hilger and Company, London for production (*Philos. Mag.*, Vol.

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8, p.1041, 1929). He examined the scope of Pascal's law of additivity and reported dependable values of atomic and constitutive constants. He showed that for inorganic compounds, the sum of ionic susceptibilities gave the molecular susceptibility. He showed that the temperature dependence of magnetic susceptibilities are different for symmetric molecules (CCl_4), associative liquids (water, alcohols) and aromatic compounds (benzene, toluene). Bhatnagar and his colleagues studied complex problems connected with colloids, solid solutions, allotropy and photochemistry using the method of magnetic susceptibility. A clever application of this method was the investigation of the nature of oxide films formed on strips of heated copper. From the paramagnetic nature of this film, it was deduced that they contained higher oxides of copper, i.e., CuO. He provided definitive evidence for the existence of ionic micelles by the study of magnetic rotation of solutions of salts of higher fatty acids in water and alcohol (*J. Indian Chem. Soc.*, Vol. 11, p. 767, 1934). Bhatnagar made a study of large number of reactions of various types in and outside the magnetic field and concluded that the difference between the sum of the molecular susceptibilities of the initial reactants and the final products was critical in determining whether the magnetic field had an effect or not on a given reaction.

The contributions of Bhatnagar and his students to the area of magneto-chemistry has been reviewed in a book titled *Physical Principles and Application of Magneto-chemistry* by Bhatnagar and Mathur, published by Macmillan and Co., Ltd., in 1935.

The other area to which Bhatnagar made seminal contributions was to the study of emulsions. His extensive studies on inversion of emulsions by electrolytes had a profound impact on both the practical and theoretical understanding of the behaviour of emulsions. He established a method to detect the inversion points and the exact amount of electrolytes needed for inversion. Based on his extensive studies, he formulated the following two empirical rules: (1) A water-in-oil emulsion can be transformed into oil-in-water emulsion by electrolytes having

anions like OH^- and PO_4^{3-} and (2) an emulsion of oil in water can be reversed by electrolytes having cation like H^+, Al^{3+} and Fe^{3+}. He established that emulsification is influenced by the mass of the emulsifying agent, the ease with which it can be absorbed at the interface and the nature of ions adsorbed by the resulting film. He proposed the following generalization: All emulsifying agents with an excess of negative ions on them and wetted by water will yield oil-in-water emulsions while those having excess of adsorbed positive ions and wetted by oil will give water-in-oil emulsions. This simple rule is till today true! It must be recognized that the thirties was the most exciting decade for the science of colloids, with the maturing of several analytical techniques to probe the properties of colloids, namely, ultracentrifuge, electrophoretic techniques, light scattering and osmometry to cite just a few. The Nobel Prize in Chemistry in two years in succession went to chemists who made pioneering contributions to colloid chemistry, namely, to Richard Zsigmondy in 1925 and to the Swedberg and Jean Perrin in 1926. Bhatnagar was in the mainstream of colloid research at that time. It, therefore, comes as no surprise that when he had to make a choice for the first Director of the National Chemical Laboratory in 1949, he selected J W McBain, a fellow physical chemist with profound contributions to colloid science (J W McBain, *Colloid Science,* D C Heath & Co., Boston, 1950). Colloid science, both in terms of properties and techniques, shared many common features with synthetic macromolecules, so much so that many believed that a polymer or a macromolecule was a micellar aggregate of many small molecules. It was Staudinger who through his pioneering researches in the early thirties, established that polymers were covalently linked organic molecules made up of repeat units of several monomers. Bhatnagar, with his deep interests in colloid science, must have been a witness to this fascinating development and the birth of a new discipline called polymer science. It is, therefore, not surprising that he turned his attention to this new field in the late thirties. He examined the influence of polymerization on magnetic susceptibilities (*Z. Phy.* Vol. 100, p.141, 1936) and the adsorptive

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properties of synthetic resins (*J. Indian. Chem. Soc.*, ,Vol. 13, p. 489, 1936). Later, he extensively researched on the development of plastics from Indian waste materials. It was, therefore, only natural that in 1950, when the National Chemical Laboratory was established at Pune. Bhatnagar created a Division of Plastics and Resins which later was renamed as Division of Polymer Chemistry.

The year 1940 saw a big change in the career of Bhatnagar. At the break of the Second World War, the Government of India established the Board of Scientific and Industrial Research. In December 1939, the Viceroy of India, on the advice of the Commerce Member of his Council, A Ramaswamy Mudaliar asked Punjab to transfer Bhatnagar to the Government of India as Adviser in Scientific and Industrial Research. Thus began his fifteen years association with the Council of Scientific and Industrial Research (CSIR), which came into existence on 26 September 1942 as an autonomous body approved by the Central Assembly in Delhi at its session on 14 November 1941.

Bhatnagar, through his boundless energy and clear vision created the blue print of the CSIR. At the time of his demise twelve laboratories were fully functional. Apart from his role in establishing CSIR, Bhatnagar played a key role in the establishment of Indian Rare Earths Ltd., to process the monazite sands of Kerala and was instrumental in the establishment of private sector oil refineries in India. He held many high offices, such as, Secretary of the Atomic Energy Commission, Director, Scientific and Industrial Research and Chairman, University Grants Commission. Many honours came his way, the significant being OBE in 1936, Knighthood in 1941, Fellowship of the Royal Society in 1943, Foundation Fellow of the Indian National Science Academy and several honorary degrees.

Bhatnagar's demise came suddenly on 1 January 1955. After an evening meeting with scientists, he returned home to bed, suffered a heart attack and passed away silently.

Bhatnagar in his eventful sixty years achieved more than what generation of men could not accomplish. He left his indelible imprint on pure science. He demonstrated that science becomes relevant to society only when its practioners are willing to descend down from their ivory towers and translate science into applications. He was a visionary extraordinary who saw the need for a strong scientific infrastructure for an independent India. He pioneered the concept of 'organized' science at a time when the scientific establishment of the day scorned him for this effort. He created institutions which became the 'cradle' for science in India and which have stood the test of time in terms of both relevance and need. He was an eloquent speaker, an effective communicator, a talented poet in Urdu, and above all, a leader of men.

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