MATA PRASAD

(1898—1979)

Foundation Fellow

BIRTH AND EDUCATION

MATA PRASAD was born on February 15, 1898 in Gursahaiganj in the district of Fatehgarh, UP, India. His father, Munshi Mathura Prasad, was in the UP Postal Service and was therefore transferred from one district to another in that state. Young Mata Prasad lived mostly with his mother, Smt Shibbo Devi, in their native place, Agra. He was the only son of his parents. He had one younger sister who was later married in Delhi.

He was educated at the Mufid-am and St John's High Schools in Agra and appeared for the Cambridge University Senior Examination in 1916 from the Allahabad Centre. He then joined the Agra College which at that time was considered to be the best college affiliated to the Allahabad University. He passed the BSc examination in 1920 with Physics, Chemistry and Mathematics with a high grade and was recipient of a merit scholarship to pursue his post-graduate education. In 1922, he passed MSc with Physics and was appointed a Junior Lecturer in a local college in Kanpur.

He had hardly been teaching for a couple of months when he met Professor SS Bhatnagar who was then on the faculty of the Banaras Hindu University and had come to Kanpur to give some lectures. Bhatnagar's lecture so influenced him that he approached him with a request that he might be taken as a research scholar so that he could work under his guidance. Bhatnagar readily agreed to take the bright young Mata Prasad as his first student for doing research for a doctorate of the BHU. Although no scholarship was available, Mata Prasad readily agreed to resign from his post in Kanpur and join the small research team of Bhatnagar. As he did not have a scholarship, Bhatnagar offered that young Mata Prasad might live with him in his house until a scholarship could be arranged for him. Thus started a very close relationship between the young Professor and his student, which had a considerable influence on Mata Prasad's future career. A few months later he was awarded a UP Government scholarship to enable him to do his doctorate.

Another person who had considerable influence on Mata Prasad was Professor Krishna Kumar Mathur who was then Professor of Geology in the Banaras University and who founded that Department. Professor Mathur's devotion to his subject, his interest in his students and his brilliance left a lasting impression on the young student who in his future life tried to emulate the two Professors, Mathur and Bhatnagar.

Joining the Banaras University in 1922, Mata Prasad worked very hard, sometimes spending entire night in the laboratory working on research problem entitled *Studies in Some Interesting Properties of Diphasic Systems*. The problems he worked on were some of the most varied and difficult colloid chemical problems. Because of his total devotion to his work he was able to complete his studies and submit his thesis for DSc in 1925. One of his examiners, Professor Wolfgang Ostwald of the Berlin University characterised his thesis as excellent and a very remarkable piece of scientific research. The other examiner, Professor FG Donnan, of the University College, London, reported that both in quality and quantity the work presented in the thesis entitled the candidate for the DSc. Mata Prasad was awarded the DSc of the Banaras University in 1925. He was the first to earn the DSc of this University.

In 1925, when Professor SS Bhatnagar moved to Lahore as the University Professor of Chemistry and Director of the University Chemical Research Laboratories, Mata Prasad accompanied him and was appointed to a junior position in his department in Lahore. He had at the same time applied for a post of Professor of Inorganic and Physical Chemistry at the Royal Institute of Science, Bombay. He was called for interview and the committee was so impressed that they unhesitatingly selected him for the post although the advertisement had mentioned that preference will be given to one who had a foreign degree. While recommending him for the post, the committee observed that after the probationary period he might be deputed abroad so that he could have research experience in some foreign laboratories. In 1926, therefore, he proceeded to England for one year where he worked in the laboratories of the Royal Institution, London, where Sir William Bragg was the Director. He also utilised this period to carry out some researches in the laboratories of Professor Donnan.

Positions Held

As already mentioned above, Mata Prasad was appointed to a junior teaching post which he held for about one year in the University Chemical Laboratories, Lahore. In 1925, he moved to Bombay as Professor of Inorganic and Physical Chemistry at the Royal Institute of Science where he continued until he retired as Principal of the college in 1953. Between 1925 to 1953, Mata Prasad established one of the very good schools in physicochemical research in the country and raised the status of the Institute from just an affiliated college of the Bombay University to that of an established research institute recognised internationally as a good school in chemistry.

On retirement from the Royal Institute of Science Bombay, he was appointed the first Founder-Director of the Central Salt Research Institute in Bhavnagar, the twelfth in the series of laboratories in the CSIR. Prior to this he was a member of the Salt Research Committee for many years. Leaving the Salt Research Institute in the latter half of 1955, he became the first Vice-Chancellor of the Vikram University, Ujjain (MP) where people still remember him as one who laid the foundations of good teaching and research. On his retirement as Vice-Chancellor he lived for sometime in his native city of Agra and worked as an Emeritus Professor in the local St John's College for six years. The last few years of his life were spent by him with his wife and children in India and USA in retirement, but he never lost interest in the areas of chemistry in which he had made significant contributions.

Contributions to New Knowledge

Professor Mata Prasad has published over 150 original research papers in leading international scientific journals in India and abroad. His research contributions are mainly in the fields of colloidal chemistry, photochemistry, magnetochemistry, X-ray and crystal structure and various physico-chemical problems such as kinetics of reaction and preparation of oxides.

Colloidal Chemistry

The problems investigated by Mata Prasad deal with study of properties and mechanism of the formation of gels, kinetics of coagulation and adsorption and protection of colloidal systems. In his investigations Mata Prasad has classified gels as heterogeneous systems which may be transparent and opaque, elastic and rigid, and heat reversible and irreversible. Through extensive studies of various gels he showed that the above properties are not independent characteristics of a gel. In a series of papers he extensively studied the silicic acid gel system which had been known to be typically inelastic. Prasad showed that it possesses elasticity and obeyed Hooke's law within certain limits and the experimental values of elasticity could be reproduced from measurements of sonorous properties of these gels. From this investigation he concluded that silicic acid gels behaved more or less like isotropic solids.

Prasad and co-workers prepared a number of gels of inorganic substances in a translucent or opaque state or in a water-clear transparent condition by properly adjusting the hydrogen ion concentration. He established that the time of setting was the main property which characterises the gel. His group therefore measured the time of setting of several gels by various methods developed by him. In the case of sillicic acid he showed the dependence of the value of this constant upon the method employed for its measurement.

He showed that inorganic gels could be prepared by one of the following methods:

(a) By mixing the two constituents of the gel forming mixture. This resulted in some cases in the formation of a clear solution which went over to the colloidal state and in other cases formed a precipitate which disappeared on shaking.

(b) By addition of electrolytes to a fairly concentrated and suitably dialysed colloidal solution of the gel forming substance, or simply by prolonged dialysis of such a colloid.

(c) By dilution of a true solution of the gel forming substance which was sparingly soluble in the diluted solvent. Gels of thorium phosphate and thorium arsenate were prepared by this method.

(d) By mixing suitable amounts of appropriately dialysed, oppositely charged colloidal solutions. In this manner he prepared gels of aluminium hydroxide with (i) antimony sulphide, (ii) silicic acid, (iii) molybdic acid, (iv) manganese dioxide, and (v) chromium phosphate; of silicic acid with (i) ferric hydroxide, (ii) chromium hydroxide, (iii) molybdic acid, and (iv) nickel hydroxide; of copper hydroxide, stannic hydroxide and ferric phosphate with nickel hydroxide.

Gels prepared by the last method were obtained by him for the first time and by proper adjustment of hydrogen ion concentration he showed that these could be obtained in a transparent condition. He measured the time of setting of these transparent gels prepared by him under different conditions of pH and temperature and with the additions of electrolytes and non-electrolytes and in many cases measured the heats of activation of gels using Arrhenius' equation.

Since direct examination of gels revealed little regarding its structure, he studied the process of gelation by measuring viscosity and some optical properties which change continuously during setting. From such data he was able to draw conclusions regarding the mechanism of formation of gels and of their structure. In all cases he found that viscosity increased slowly during the earlier stages of gelation and rapidly during the later stages. The only exception to the above general observation was the behaviour of the gels of thorium molybdate which were found to be thixotropic. He further found that the course of gel formation as revealed by viscosity changes was considerably modified by changes in the concentrations of the constituents of the gel-forming substance, pH and temperature, and by addition of electrolytes, acids and non-electrolytes. In many cases the viscosity changes could be represented as

$$\eta - \eta_0 = at^c$$

Amongst the optical properties studied by him were the refractive index, extinction coefficient, opacity or transparency and light scattering; the last two of these were studied more extensively than the others. For this purpose he designed an apparatus employing condensate photo-cells for the measurements of relative values of opacity directly. He showed that the observed values of changes in opacity during gelation were due to changes in the size and shape and the state of aggregation of the gel particles. The extensive study of these properties in the gel systems on which he worked showed that there were two types of gels : (1) those which increased in opacity during gelation and (2) those which decreased. Further study of the process of gelation by changes in the intensity and depolarisation of transverse scattered light using plane vertically and horizontally polarised incident light showed that :

(a) the gel particles increased in size during gelation in both types of gels,

(b) the size of these particles was less than the wave length of light, and

(c) no great changes in the size of the gel particles occurred with changes in the amounts of gel forming substance. Thus the study of this optical property revealed that gels were formed by coagulation of the colloidal solution of the gelforming substance. In this process the gel particles got heavily sulphated, ultimately complete immobilisation of the fluid in the gel forming system took place. The final gel particles were found to be anisotropic, the greater the anisotropy of the gel particles the greater was the opacity of the gel. He found a similar behaviour in the case of a purely organic gel like agar-agar.

Inorganic-organic gels

As the name implies these are gels obtained from substances which are neither entirely inorganic nor organic. In this class, Prasad and his co-workers carried out extensive studies on the gels of certain soaps in non-aqueous solvents. He observed that sodium and potassium salts of oleic, stearic and palmitic acids dissolved easily in pinene at about 140°C and the resulting solutions set to a transparent colourless gel when cooled to temperature below 90°. He found these gels to be heat reversible. He prepared the gels of these soaps in xylene, toluene and nujol. He found that the time of setting at any temperature decreased rapidly at first and then slowly as the amount of soap in the mixture was increased and that gels containing the same amount of soap set earlier the lower the temperature of setting. He further found that these gels also obey the Arrhenius' equation from which he calculated the heat of activation.

The cooling curves of these gel forming systems were found to be regular and smooth and showed no change of direction during setting. The viscosity changes during the setting of these gels were also found to be regular and took place in the same manner as in inorganic gels and obeyed the empirical relation

$$\eta - \eta_0 = a_e^{kt}$$

Sodium oleate gels in pinine were found to be peculiar in exhibiting the phenomenon of syneresis. Prasad carried out detailed study of this phenomenon and brought out the following interesting results :

1. The total amount of liquid exuded at a certain interval after syneresis had started was greater the smaller the soap content of the gel and the lower the temperature at which the gel was allowed to synerese and

2. The mathematical interpretation of results led to an expression which held for the imbibation of liquids for non-swelling gels and indicated that the phenomenon of syneresis was an inhibited first-order reaction.

Photochemistry

During the thirties photochemistry was considered to be an important branch of physical chemistry and, as in many other countries, the then senior chemists in India also carried out researches in this area inspite of the very meagre facilities available to them at that time. Mata Prasad therefore trained a few of his students in this branch but could not continue after the second world war started because of non-availability of simple components like suitable light source. Prasad attempted mainly the study of photoreduction of ferric chloride in the presence of certain organic substances. Earlier work on this system had been more or less qualitative the difficulty mainly being the absence of an accurate and unambiguous method for estimation of the amount of reaction. The analytical methods used by previous workers had been found to be defective when used in presence of organic substances. Prasad found that ceric sulphate, a titrating agent never before used in photochemical work, gave accurate and satisfactory results. Using this technique Prasad exhaustively studied the photoreduction of ferric chloride in the presence of organic acids, sugars, acetone, acetaldehyde, alcohols and ethers in aqueous and non-aqueous media. He showed that the photoreduction was zero-molecular in presence of organic acids and sugars, unimolecular in presence of ether and aqueous acetone; in presence of alcohols, anhydrous acetone and aqueous acetaldehyde the photoreduction was found to be neither zeromolecular nor uni-molecular but was of an inhibited type. Further, in all cases the velocity constant increased with the frequency of the exciting radiation and was directly proportional to the intensity of the incident light. The values of the temperature coefficient for a ten-degree rise were very nearly unity for the zero and uni-molecular reactions while they were between 2 and 3 for the reduction of the inhibited type. He explained the mechanism of the photoreaction on the basis of formation of an activated ferric chloride molecule which then reacted with an inactivated molecule but gave ferrous chloride and chlorine. This mechanism would require a quantum efficiency of two which was not always experimentally obtained. The quantum yield increased regularly with the frequency of the incident radiation, temperature and dilution of the solution up to a certain stage. He found that at this concentration the number of effective collisions between the activated and inactivated molecules of ferric chloride reached a maximum value because he found that at this dilution the quantum yield very nearly approached the expected theoretical value, thus supporting the mechanism suggested by him.

Magnetochemistry

As is well known, Professor SS Bhatnagar had set up in his laboratory a number of magnetic balances some of which suitably modified to give values of magnetic susceptibility with greater accuracy than any of the then existing balances. This gave a great fillip to magnetochemical work in the country. Mata Prasad being his first doctorate promptly took advantage of this and set up in his laboratory in Bombay a modified Gouy balance capable of giving very accurate values of susceptibilities. With his students, notably SS Dharmatti, CR Kanekar and DD Khanolkar, he carried out extensive work on determination of ionic susceptibilities of many cations and anions and on molecular structure of certain compounds using susceptibility measurements, and on the effect of colloidalisation on magnetic susceptibilities of substances.

Investigations of selenium and tellurium showed that the process of powdering (colloidalisation) introduced impurities from the air which influenced the values of magnetic susceptibilities. If these impurities were removed by any chemical process or if the powdering was done in vacuum or if the substances were brought in to colloidal state in an atmosphere free from air then the values of magnetic susceptibilities in the powder or colloidal condition were the same as those in the "en masse" state. He thus proved that the earlier published results suggesting a change of susceptibility on powdering selenuim and tellurium as due to colloidalisation were really due to impurities adsorbed on the fine particles.

The then existing literature had given several values of magnetic susceptibilities to many ions. Prasad and his collaborators therefore embarked on a systematic study of ionic susceptibilities with a view to obtaining standard values. Using the modified Guoy balance, they measured magnetics usceptibility of a large number of salts of calcium, strontium and barium and from these deduced the values for the ions of these metals. He also calculated the ionic radii of these three ions. A similar systematic study of the magnetic susceptibilities of a large number of salts of sodium and potassium containing the anions, carbonate, nitrate, phosphate, chlorate, bromate, iodate, perchlorate, periodate, sulphate, thiosulphate, persulphate, sulphite and borate was made. He found that the magnetic susceptibilities of these salts were not the sum of the susceptibilities of the constituent ions as had been assumed by previous authors, but that certain constitutional factors were also involved. He used these studies for the elucidation of the molecular structures of some compounds of sulphur, selenium and tellurium whose structures were not unequivocally known before. For some of these measurements he used a special type of magnet which gave a fairly large field with extremely small electric current thus avoiding heating effects.

He extended these investigations to some boron compounds, their hydrates and to many cations such as Mg, Zn, Hg (both 'ous' and 'ic') and Pb. He made the observation that the mean susceptibilities for ions obtained from salts of organic acids were higher than those obtained from salts of inorganic acids and attributed this to differences in the type of bonding. He also studied certain double salts in solution.

X-ray and Crystal Structure

As stated earlier, Mata Prasad went on study leave for one year in 1926 to UK and worked for some time in the Davy-Faraday laboratories of the Royal Institution, London on X-ray and Crystal Structure of azobenzene. On his return he started to assemble facilities for starting similar work in the Royal Institute of Science, Bombay. It may be remembered that at time the only crystal which had been completely analysed was that of hexamethylbenzene carried out by kathelene Lonsdale. In the absence of appropriate X-ray generator set and an appropriate goniometer, Mata Prasad with the help of his students, notably Jagdish Shankar, assembled an X-ray generator using a large induction coil together with an interruptor as high voltage source all built in the laboratory. He used a Debye Sherrer X-ray tube evacuated by a rotary oil pump and a Warren mercury diffusion pump for creating the necessary high vacuum. A simple imported X-ray goniometer was used to take Lave photographs or rotation/oscillation photographs either on a plate camera or a small 3.5″ dia. cylindrical camera. A large number of simple organic compounds were studied with these facilities essentially for determining their space groups. In a few cases approximate structures were also assigned on the basis of packing characteristics of molecules in the unit cell.

In 1935, after a brief training at the Indian Association for Cultivation of Science, Calcutta, Jagdish Shankar built in Bombay the necessary apparatus for measurement of magnetic anisotropy of single crystals and using this data assigned molecular structures of a number of compounds, mostly aromatic and some belonging to the cyanuric group of which space groups had earlier been determined by X-rays. An attempt was also made to study the complete structure of di-azotoluence by measuring the intensity of X-ray reflections from the crystals and the magnetic anisotropy and thus arriving at the electron density in different planes. In the absence of more sophisticated techniques Mata Prasad gave up this work from 1940 after the departure of some of his senior students.

Other Physico-Chemical Research

For some time Professor Mata Prasad and his students carried out work on kinetics of reactions. This work can be divided into two groups :

(a) Kinetics of some reactions were studied in solutions containing the mixture of alcohols and water with a view to examine the influence of several alcohols on the velocity of reaction in water. He found that an increase in the number of CH_2 groups in the alcohol produce a regular increase or decrease in the rate of reactions.

(b) Kinetics of certain heterageneous reactions, for example, of manganese dioxide and chromium sulphate, and chromium oxide and potassium permanganate, and the influence of factors such as concentrations of the reacting solutions, size of particles of the solid, temperature, pH of the reacting solution and the rate of stirring were studied. He explained the results obtained on the basis of Nernst's diffusion theory. He also found that the results were in fairly good agreement with the expressions developed on Langmuir's adsorption theory.

Study of nickel and cobalt oxides

A systematic study of the preparation of nickelous oxide showed that this oxide could be obtained in various colours, from black to greenish yellow, according to the temperature of preparation ranging from 400 to 1000°C. The density, electrical resistance, solubility in sulphuric acid, and the catalytic action for the decomposition of hydrogen peroxide of the black and greenish yellow varieties of the oxide were found to be very different from each other. These studies also explained the mechanism of the separation of nickel and copper from the nickel-copper matter by the action of sulphuric acid. Similar studies were also carried out on cobaltous oxide.

Work on salt and other industrial processes

Before the Salt Research Institute was set up in Bhavnagar, Mata Prasad had worked on the Salt Research Committee of the CSIR, of which he later became the Chairman. During this period, applying the phase rule he attempted to recover by-products from the bitterns obtained at the Pritchard Salt Works at Kharaghoda. On the basis of this study, about 100 tonnes of potassium chloride were recovered from this source in 1941-42 for the first time in India, as these were greatly in need as part of the second world war requirements. He also worked out a method for the recovery of bromine from the same source and established that by the method worked out by him 60 tonnes of bromine could be recovered annually. Other products obtained from this source were magnesium sulphate and magnesium chloride.

During the period after the end of the War and shortly before retirement from the Institute of Science, he and his students worked on a wide variety of problems as for example, those relating to the manufacture of gelatine, high purity potassium chloride and potassium salts from wood ashes, light magnesium carbonate, many extra pure and AR quality inorganic chemicals, hydrogen peroxide, strontium carbonate from calestite ore, recovery of potassium and magnesium salts from deposits in the Radhampur State and investigations on efflorescent salt deposits of Kathiawar.

During the period when he was Director of the Salt Research Institute, Mata Prasad guided investigations on a variety of problems with a view to recovering various important constituents from sea water to increase the yield of salt and on marine algae.

On retirement from government service in Bombay, the Salt Research Institute and as Vice-Chancellor of the Vikram University, Mata Prasad involved himself mostly in the subject of science education. He gave a number of thought-provoking lectures and wrote articles on 'teaching of science in schools' and 'the role of science in education'. He continued interest in chemical research by agreeing to become Emeritus Professor (in an honorary capacity) in the St. John's College Agra where he guided a number of students for their PhD.

AWARDS & HONOURS

Dr Mata Prasad was elected a Fellow of the Royal Institute of Chemistry in 1934, a Foundation Fellow of the National Institute of Science (now called the Indian National Science Academy), a Fellow of the Indian Academy of Science, Bangalore and of the National Academy of Science, Allahabad. He was President of the Chemistry Section of the Indian Science Congress in 1941 and President of the Indian Chemical Society in 1953-54, and was the President of the Institution of Chemists (India) in 1954-55.

He was a member of the Central Advisory Board of Education of the Government of India, All India Council of Technical Education, Board of the CSIR and numerous other committees and advisory boards in various Universities in India. He was awarded the honorary degree of DSc by the Vikram University, Ujjain and was given the distinction of delivering the Acharya PC Ray, Acharya JC Ghosh and Acharya HK Sen Memorial Lectures of the Indian Chemical Society. In 1951, he was invited by the United States Government to visit various centres of research in USA and to deliver lectures. He was also an advisor for some time to the Government of Afghanistan on scientific education and research.

PERSONAL LIFE AND LAST DAYS

Mata Prasad was married soon after graduation and had a daughter and a son from this marriage. His wife passed away in 1930 and he married again a year later Sheila Mathur from Allahabad. From this marriage he had two sons and a daughter. The eldest son from his first marriage distinguished himself in chemistry, getting his doctorate at the early age of 25 and is now holding a senior position in the Research Laboratories of the Oil and Natural Gas Commission. The second son is a senior engineer while the third is a physicist, both having settled down in the United States. His two daughters are both happily married in India, the youngest one to a distinguished chemist now working in the Bhabha Atomic Research Centre, in the Water and Steam Chemistry Division.

Dr Mata Prasad continued to take interest in academic matters till the end, Early in 1979, he fell down accidentally in his home in Agra sustaining severe head injuries resulting in cerebral haemorrhage. This proved fatal and he passed away on January 28, 1979.

JAGDISH SHANKAR

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