Wilhelm Ostwald – The Scientist

Friedrich Wilhelm Ostwald was born on September 2, 1853 at Riga, Latvia, Russia to Gottfried Ostwald, a master cooper and Elisabeth Leuckel. He was the second son to his parents who both were descended from German immigrants. He had his early education at Riga. His subsequent education was at the University of Dorpat (now Tartu, Estonia) where he enrolled in 1872. At the university he studied chemistry under the tutelage of Carl ErnstHeinrich Schmidt (1822–1894) who again was a pupil of Justus von Liebig. Besides Schmidt, Johannes Lemberg (1842–1902) and Arthur von Oettingen (1836–1920) who were his teachers in physical chemistry were also principal influences. It was in 1877 that he defended his thesis 'Volumchemische Studien über Affinität'. Subsequently he taught as Privatdozent for a couple of years. During this period, his personal life saw some changes as well. He wedded Helene von Reyher (1854–1946) in 1880. With Helene, he had three sons, and two daughters. Amongst his children, Wolfgang went on to become a famous colloid chemist.

On the strength of recommendation from Dorpat, Ostwald was appointed as a Professor at Riga Polytechnicum in 1882. He worked on multiple applications of the law of mass action. He also conducted measurements in chemical reaction kinetics as well as conductivity of solutions. To this end, the pyknometer was developed which was used to determine the density of liquids. He also had a thermostat built and both of these were named after him. He was prolific in his teaching and research which helped establish a school of science at the university. This was attended by an increasing number of students and consequently necessitated the construction of a new building. He encouraged communication and he undertook 'laboratory travels' not infrequently to seek familiarity with laboratories at other institutes, principally in Germany. It was in 1884 that Ostwald became acquainted to Svante Arrhenius. who was studying the electrical conductivity of acids and their exchanges on this led to the dissociation theory of strong electrolytes which won the Nobel Prize for Arrhenius in 1903. Their collaborative efforts and exchanges at Riga brought about greater efficiency in instrumental and measurement techniques. Ostwald also strove to bring Arrhenius the recognition he deserved and which was denied him in his country, by promoting his ideas. It was in 1885 that Ostwald developed the viscometer which was named after him. During this period, physical chemistry as a subject failed to pique the interest of many who considered it formidable owing to the mathematics involved and also because organic chemistry was widely practised at the institutes. To improve this standing, Ostwald wrote two

volumes of *Lehrbuch der Allgemeinen Chemie* (*Textbook of General Chemistry*), the first of which came out in 1885 followed by the second in 1887. The volumes were quite successful in bringing together the various ideas in physical chemistry and led to an increased interest in physical chemistry.

The success of the books led Ostwald to consider the necessity of a physical chemistry journal which would help recognize important and unexplored ideas. Despite his colleagues' misgivings about the availability of material to publish, Ostwald urged the founding of *Zeitschrift fur Physikalische Chemie* (*Journal of Physical Chemistry*) in 1887, more so because there was the founding of a similar journal by one of his colleagues in Berlin around this time and he did not want to concede to someone else after pioneering the recognition of the subject. He successfully persuaded Jacobus Henricus van't Hoff (1852–1911), already reputed for his work on position of atoms in space as well the isomerism of hydrocarbons, to preside as the co-publisher. The journal rapidly scaled heights and became very important for newly recognized ideas and studies.

The following years saw an increased communication among Ostwald, Arrhenius and van't Hoff, the 'wild legion of ionists', famously proclaimed by Ostwald in his journal in an effort to publicize their theory. This theory claimed that the molecules dissociated into electropositive and electronegative ions in dilute solutions, resulting in their electrical conductivity. Their work in chemical kinetics helped establish physical chemistry as an important discipline, at par with organic and inorganic chemistry. van't Hoff worked on his theory of ideal solutions, Arrhenius studied electrolytic dissociation and dissociation constants more extensively and also developed the theory of reaction rates and activation energies. Ostwald investigated how chemical constitution affects dissociation constants and gave the dilution law for molar conductivity, which has been named after him. Ostwald's efforts were justly rewarded when he was appointed as the professor of physical chemistry at the university of Leipzig, 1887, after Gustave Wiedemann left. His years at the university were rewarding, both for him and his students who considered him a prolific teacher. As at Riga, the university saw a continual influx of students and later, in 1898 a new institute was founded which acquired well-deserved reputation in no time. He also wrote more volumes. *Grundri der Allgemeinen Chemie* (*Outline of General Chemistry*) came out in 1899, followed by the series Ostwalds Klassiker der Exakten Naturwissenschaften (*Ostwald's Classics of the Exact Natural Sciences*) in the same year. The methodology and techniques in physical chemistry were not systematically documented then and Ostwald filled the void by writing *Grundlagen der Analytischen Chemie* (*Fundamentals of Analytical Chemistry*) which contained a precise and lucid documentation of the techniques. This volume was published in several languages.

Ostwald gained rapid recognition and his rise was inevitable. However, quite frequently he put across his ideas very brusquely and considered himself a principal critic for physical chemistry. This attitude did not prove to be very fetching and often led to disputes. In 1894 he co-founded Deutsche Elektrochemische Gesellschaft (German Electrochemical Society) which was re-named Deutsche Bunsen-Gesellschaft fur Angewandte Physikalische Chemie (German Bunsen Society for Applied Physical Chemistry) in 1902, and *Zeitschrift fur Elektrotechnik und Elektrochemie* (*Journal of Electrical Engineering and Electrochemistry*) which came to be known since 1985 as *Zeitschrift fur Elektrochemie* (*Journal of Electrochemistry*). He also wrote a second edition of his book, *Lehrbuch der Allgemeinen Chemie and Die Wissenschaftlichen Grundlagen der Analytischen Chemie* (*The Scientific Basis of Analytical Chemistry*) in 1894 to facilitate a more comprehensive understanding of the developing aspects of physical chemistry. *Elektrochemie, Ihre Geschichte und Lehre* (*Electrochemistry, History and Education*), another of his volumes, appeared in the year 1896.

From 1890 Ostwald was increasingly taken up with philosophy. His ideas were at conflict with the atomic theory which he once patronized. Cconsequently, like contemporary scholars Ernst Mach (1838–1916), Franz Wild (1861–1930) and several others, he sought an approach different from atomic theory. He discarded this line of thought and justified ideas using the concept of energism. In 1895, he delivered the lecture 'Die Uberwindung des Wissenchaftlichen Materialismus' (Overcoming Scientific Materialism) at the meeting of the Gesellschaft Deutscher Naturforscher und Arzte (German Society of Scientists and Physicians). It was here that he introduced the energism concept. However it was not very well-received by many, Ludwig Boltzmann (1844–1906) being one among the unhappy audience. However, later, Planck's quantum theory and Einstein's relativistic theory as well as the radioactivity studies and Brownian motion studies found Ostwald re-considering the concept of atomism and he called it 'well-founded' around 1908. But interestingly, he didn't revise his volumes accordingly.

The following years saw him working on the theory of catalysis. He established that a catalyst essentially accelerates the reaction without itself appearing in the product. He also worked out a catalytic process of ammonia production from free hydrogen and nitrogen. He obtained a patent for this but the method did not prove to be economically facile. He worked as well on the oxidation of ammonia which showed better prospects.

It was around 1897 that Ostwald became increasingly involved in policy disputes centering around the idea of introduction of examination for chemists. This proposition was from the industry. They emphasized on an examination system to gauge the students' capacity and capability. Ostwald was opposed to it. He and many others (namely, Adolf von Baeyer (1835–1917) and Victor Meyer (1848–1897)) exercised the belief that it was solely under the aegis of

the universities to grant doctorates and decide on the course content. The universities also apprehended similar demands by the technical high schools. And though the proposition was eventually discarded, there was the Verband der Laboratorium Verstande being founded which laid down unified examination regulations; the technical high schools in Berlin were given the right to grant doctorates in 1899. von Baeyer, in one of his written communications to Ostwald, said: "... The transfer of a specific right of universities (can) perhaps become dangerous. Does this strike at the heart of the university? Perhaps! But can we prevent it?...".

Due to several years of lectures and research and his involved participation in the journals and university administrations and the establishment of new institutes and myriad other businesses, Ostwald suffered from repeated bonts of fatigue. For the betterment of his health, he undertook extended vacations. Interestingly, during this period, after 1900, he formulated a theory for the proper administration of one's energy and developed a formula for happiness.

In the years after 1900 he developed the concept of 'energetic monism' encompassing his ideas on energism. Subsequently he wrote the volume *Annalen der Naturphilosophie* (*Annals of Natural Philosophy*) which contained his ideas on natural philosophy. The basis of this was that mankind concentrates it's energy on a plethora of disdainful activities arising from false faith and beliefs, disagreements and destruction of cultural values. He preached against mysticism and religion, and propagated that science is the sole discipline which could direct one's energy into altruistic and beneficial activities. 'Do not squander energy, ennoble it!' He also presided over the Monist League founded by Ernst Haeckel (1834–1919) for several years and promoted Social Darwinism, eugenics and euthanasia. His interest in the International Language movement was considerable, learning Esperanto and later supporting Ido (Esperanto and Ido were international languages for the sake of international communication among men). However with the advent of the First World War, he retracted his pacifist views which claimed military power to be a waste and maintained that war was necessary for defending the German culture. His changed views were attacked and he withdrew from the Monist League.

Gradually Ostwald's passion for teaching abated. He yearned to devote greater periods of time to his ideas on natural philosophy and scientific theory and desired to leave Leipzig. In 1905–06 he was invited to work as the first German exchange professor in USA. After his return from USA, he abruptly ended his activities at the Leipzig university, intending to work as a private scholar. He retired on 30th September 1906 and continued working on issues of scientific research and the history of science at his country house 'Energy' in Grossbothen. It was in 1909 that his work on catalysis as well as other studies on chemical equilibria and reaction rates won him the Nobel Prize.

The Nobel Prize was initiated in 1901. Ostwald did not receive the Nobel along with Arrhenius because he was nominated only from 1904 and was repeatedly nominated for the subsequent years. However, in those years, there were other eligible candidates in physical chemistry as well as in the other chemistry disciplines. The statutes at that time stated that the Nobel Prize had to be awarded atmost in a year following the achievement whereas Ostwald's work on catalysis and reaction rates were done much before. Besides, Ostwald had already retired and was no longer involved in active research. His abrupt retirement affected his chances as well. In 1906, Beckmann had written to Arrhenius : "Unfortunately the general situation and opinion would appear to suggest that Ostwald's nomination be postponed. He is increasingly distancing himself from chemistry, and even his closest friends here and in wider circles do not support the nomination at the present time. In America Ostwald had chosen philosophy, world language, and painting as a hobby horse, and in the Fall he intends to relinquish his chemistry professorship totally. Under these circumstances and in the present climate it is really for the better not to subject Ostwald to further chemical criticism. Since I hear from you that merits lying further back are to be assessed fully, waiting brings with it no great risk". Eventually it was in 1907 that Landolt wrote in his communication to Arrhenius that consultation with van't Hoff and Nernst concerning Ostwald's receiving the Nobel yielded an affirmative response but he also had to speak to E. Fischer. Before the Nobel Committee of 1908, Landolt asserted that Ostwald's brilliant career at Riga and then Leipzig and his groundbreaking research on catalysis, chemical equilibrium and reaction rates deserved the honour. He also maintained that the journals Ostwald had founded and the volumes he had written were important achievements and his views on natural philosophy were also highlighted. Finally, in 1909, Landolt wrote to Arrhenius "that Ostwald is being considered for the next Nobel Prize. He would certainly be deserving of it for he is truly the 'grandfather' of modern physical chemistry, whereas the title 'father' befits you yourself." However the award came late, almost three years after his retirement, despite his highly successful career at Riga and Leipzig and his efforts at institutionalization of physical chemistry as a discipline.

The International Committee on Atomic Weights featured Ostwald as a member. The World War I happened from 1914–1918. His membership ended in 1917 and as a consequence of the war, was not resumed after the war. The 1917 Annual report of the committee featured the unusual note: 'Because of the European war the Committee has had much difficulty in the way of correspondence. The German member, Professor Ostwald, has not been heard from in connection with this report. Possibly the censorship of letters, either in Germany or en route, has led to a miscarriage'.

Ostwald exercised a great passion for painting as well. Besides, he was considerably interested

in colour theory and wrote several articles including Malerbriefe (Letters to a Painter, 1904) and Die Farbenfibel (The Color Primer, 1916). His work was principally inspired by that of Albert Henry Munsell, and in turn influenced Paul Klee and members of De Stijl, including Piet Mondrian. Ostwald felt that his work on colour theory was not very well recognized because of the war. He submitted his studies on colour theory for the Nobel Prize in Physics repeatedly from 1919 despite the statutes forbidding self-nomination. Ostwald also patronized music and played the viola. In 1926–1927, his autobiography '*Lebenslinien*' (*Lifeline*) was published in three volumes.

After a life replete with accomplishments and honours, Ostwald finally breathed his last on 4th April 1932.

Paul Walden (1863–1957), his bibliographer and biographer and also a former pupil and later successor at Riga Polytechnic, paid him a worthy tribute: "Dem lieben, verehrten Meister, Dem Jungen trotz Taufschein und Alter: Noch lange wecke als Weiser die Geister Und wirke als farbreichen Weltbilds Gestalter!"

(Beloved and Revered Master, Youthful despite his age and birth: Long live his sagacious spirits and his work, for he was the image designer of a colourful world!)

Suggested Reading

[1] **Wilder D Bancroft, 'Wilhelm Ostwald, the great protagonist' (Part I), *Journal of Chemical Education*, Vol.10, No.9, p.539, 1933.**

[2] **Wilder D Bancroft, 'Wilhelm Ostwald, the great protagonist' (Part II), *Journal of Chemical Education*, Vol.10, No.10, p.609, 1933.**

[3] **Micheal Sutton, The Father of Physical Chemistry, *Chemistry in Britain*, Vol.39, No.5, pp.32–34, 2003.**

[4] **Shridhar R Gadre, Century of Nobel Prizes: 1909 Chemistry Laureate, *Resonance*, Vol.8, No.1, p.77, 2003.**

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