Alfred Werner

1913 was a memorable year, Rabindranath Tagore became the first Indian to receive the Nobel Prize for creating "sensitive, fresh and beautiful verse". And Alfred Werner became the first Swiss chemist to win it for throwing "new light … on the linkage of atoms in molecules". The poet eulogized the mind that is without fear. Such was the mind of Werner who "shook chemistry to its innermost foundations" at the turn of the century.

Werner was born in Mulhouse, France on December 12, 1866 as the youngest of four children of Jean (a foundry foreman) and Salomé. A romantic enthusiasm for chemistry became apparent in young Werner and so did an aura of self-confidence and independent thinking. The latter traits sometimes found expression in pompous claims. A mentor advised the 18-year old lad, "a little modesty would be proper" and "be patient for 7 or 8 years". Today Mulhouse has a street named after Werner.

Werner studied organic chemistry at Karlsruhe and Zürich which became his permanent home from 1886. After completing a diploma course he started his doctoral research under the distinguished organic chemist Arthur Hantzsch in 1889. Young Werner finally found a place to stand and he would soon begin to move the earth.

August Kekulé, the supremo of structural organic chemistry, had shown that carbon usually forms four bonds. Then in 1874 two young men, van't Hoff and Le Bel, proposed that these bonds are tetrahedrally disposed in space. And organic chemistry was witnessing great triumphs in the latter half of the 19th century. It is in this setting that Werner started his research work.

An inherent "lack of belief in authority… and an urge towards the truth" drove him. The edict of spatial orientation of bonds (stereochemistry) as a special feature of carbon alone did not sound logical to him. And he took to the mission of liberating stereochemistry from a mere speciality to an all-pervading generality. Werner was inventing a new paradigm in chemical science.

The first fruit was his doctoral thesis (1890), "On the spatial arrangement of atoms in nitrogen compounds". He cleverly extended the tetrahedral carbon concept to nitrogen which clarified a number of vexed problems in nitrogen chemistry. Formally, the work was done under Hantzsch but the generous teacher acknowledged that the idea was all his pupil's. Later Werner dedicated his book on stereochemistry (1904) to his beloved teacher.

After his doctoral work, Werner decided to pursue an academic career. It took some time to complete the formalities and inbetween he spent a semester in Paris with the celebrated chemist Berthelot. He was appointed extraordinary professor (associate professor) of organic chemistry at the University of Zürich in August 1893. He soon met young Emma Giesker and after a brief courtship the couple got married in 1894. In the same year Werner became a Swiss citizen.

Werner had already created his masterpiece, 'A contribution to the constitution of inorganic compounds' in the autumn of 1892. At that time the many known inorganic compounds made a bizarre catalogue, there being no unifying structural principles to rationalize their nature and composition. This confusion did not make inorganic chemistry an attractive subject but for Werner it was a rare opportunity: "... So many problems whose solution attract me". Effortlessly he metamorphosed himself into an inorganic chemist.

Werner taught only organic chemistry till 1902 and since then both inorganic and organic chemistry.

In the paper noted above, Werner scrutinized the puzzle of inorganic 'molecular compounds – a large group of substances formed by the combination of apparently saturated molecules. He solved the puzzle by inventing the coordination theory – a theory that truly liberated stereochemistry from all prevalent shackles into a flexible atom-dependent form both in terms of number of bonds (coordination number) and the associated spatial arrangement (coordination geometry).

A historically important molecular compound, also called coordination compound or complex, is yellow-coloured $CoCl_3.6NH_3$. Werner formulated it as the salt $[Co(NH_3)_6]Cl_3$, where the six NH_3 molecules are bonded (coordinated) to the central cobalt ion forming the complex cation $[Co(NH_3)_6]^{3+}$, its ionic charge being balanced by $3Cl^-$. Here the coordination number is 6 and the geometry is octahedral. Coordination theory was being praised and rebuked right from its publication. In effect Werner was becoming famous. In 1895, he was made ordinary professor (full professor). Later major universities of Europe became keen to hire him, but in vain.

Werner galvanized his stereochemical thoughts within a short span of two to three years. It is said that coordination theory crystallized in an early morning dream. Experimental verification and silencing critics took much longer. He and his many students worked for 21 years with an "intensity that has hardly ever been equalled". They made many new series of coordination compounds and examined their configurations in terms of isomerism and other properties. All the chemistry was falling into a harmonious pattern and finally in 1911, an asymmetric inorganic complex was resolved into optical isomers (so far a monopoly of carbon compounds) signifying the ultimate triumph of his ideas. On hearing the news Werner 'leaned back in his chair, smiled and said not a single word'. Chemistry would never be the same again.

Today coordination theory can be seen in action all over molecular compounds, organometallics, biomolecules, inorganic solids, minerals, catalysts and so on. This is so because polyhedral arrangement of valence is ingrained in the electronic structure of atoms as was shown by Linus Pauling and others years later. But, for Werner the invention of the coordination theory was an act of supreme intuition.

Werner was a plain and simple person who lived for his science and this made him a taskmaster to those working with him. Owing to chronic overwork year after year, and increasing dependence on alcohol as the years passed by, his health started deteriorating quite early. He died on November 15, 1919. He was not yet 53 years of age. Dmitri Ivanovich Mendeleev who invented the bedrock of elemental order, the periodic table (1869), once said that a true mover of inorganic chemistry has to be "a thinking creative artist". Alfred Werner remains the most celebrated example.

Sources

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[3] G B Kauffman, Inorganic Coordination Compounds, *Nobel Prize Topics in Chemistry*, Heyden, 1981.

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