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Nobel Prize in Chemistry 1943

George de Hevesy

The Nobel Prize in Chemistry 1943 was awarded to George de Hevesy *"for his work on the use of isotopes as tracers in the study of chemical processes"*.

RESEARCH INFORMATION:

When, in 1913, de Hevesy was working with Rutherford in Manchester, this young scientist had been commissioned to isolate radium D from radioactive lead. His efforts were unsuccessful. It had in fact become apparent that radioactive radium D differed so little from inactive radium G, the last of the series of descendants of radium, that all attempts to isolate them from each other seemed destined to failure. The reason for this was at the same time discovered. Radium D and radium G are isotopes and constitute different species of lead. They differ in their atomic weight whilst their atoms have the same nuclear charge. The shells of their electrons, shells which determine their chemical properties, are therefore more or less identical.

Although unsuccessful, de Hevesy's efforts were not wasted. They gave him the idea for a new method of chemical research. If it is impossible to isolate chemically a radioactive isotope from an element of which it is part, it must be possible to use this peculiarity to follow in its details the behaviour of this element during chemical reactions and physical processes of different kinds. The active atoms are recognized by their radiation and, being faithful companions of the inactive atoms of an element, they serve as markers for them. Since the intensity of radiation can be determined with such precision that imponderable quantities can be measured in this way, extremely small quantities of a marker of this kind are sufficient.

By using radium D as a marker, de Hevesy determined the solubility of highly insoluble lead compounds. He succeeded in determining exactly the quantity of lead sulphide or of lead chromate taken up under different conditions from solvents of different types. He studied the exchangeability of lead atoms into the dissolved substances and was able to confirm that it corresponded to the behaviour of the lead atoms as ions. The movements of the atoms in solid lead, i.e. the self-diffusion which occurs in this metal, would be determined; it had previously been impossible to measure this process. By precipitating thorium B, a very active isotope of lead, on the surface of a lead crystal and by following the reduction in radiation intensity brought about by the changes in place of the active atoms with the inactive lead atoms of the lower layer, and hence with the penetrations which took place in the crystal, he was able to measure the energy needed to liberate an atom from the crystallised part of the lead, in other words the dissociation energy of the crystal lattice. This energy was found to be of the same order of magnitude as the heat of vaporisation of lead. This latter research is particularly interesting from the physico-chemical point of view.

The new method has also enabled biological processes to be studied. Beans placed in solutions containing lead salts with a mixture of active lead atoms absorbed a part of these salts but the distribution of the metal was not the same in the root, the stem and the leaves. Most of the lead, which does not favour natural biological development but on the contrary acts as a poison, stays in the root. Relatively more lead was extracted from dilute than from more concentrated solutions. Absorption and elimination of lead, bismuth and thallium salts by animal organisms was studied in this way. A knowledge of the distribution of bismuth compounds introduced into an animal organism is valuable from the medical point of view, since some of these compounds, as we know, are used therapeutically.

So long as natural radioactive elements only were used as markers, use of the new method was inevitably very limited. In fact the method could be applied only in the case of heavy metals - lead, thorium, bismuth and thallium - and their compounds. The situation was to be very different when Frédéric and Irène Joliot-Curie, and Fermi succeeded in producing radioactive isotopes from any element by bombarding it with particles. This discovery was made some ten years ago and the study of chemical processes by means of radioactive markers has since then been carried to such a point that it is now widely used in laboratories throughout the world. De Hevesy has remained the prime mover in this new field of activity and much first-class and important research has been carried out by him and his co-workers.

Exceptionally valuable results have thus been obtained in biology. An isotope of radioactive phosphorus, which can be obtained by exposing sulphur to neutron radiation or ordinary phosphorus to radiation from nuclei of heavy hydrogen, has mostly been used. This radioactive phosphorus is sufficiently long-lasting for tests of this nature. It has a half-life of approximately 14.8 days. De Hevesy produced physiological solutions of sodium phosphate containing this marker and injected them into animals and humans. The distribution of the phosphorus was determined at certain intervals. A study of blood samples showed that the phosphorus thus introduced quickly left the blood. In human blood the radio-phosphorus content had fallen after only 2 hours to a mere 2% of its initial value. It diffuses into the extra-cellular body fluid and gradually changes places with the phosphorus atoms of the tissues, organs and skeleton. After some time it can even be found, though in very small quantities, in the enamel of the teeth. Exchanges small and slow as they may be, therefore occur between the outer hard parts of the teeth and the inner tissues of the bones and the lymph. Most of the phosphorus introduced, finds its way into the skeleton, muscles, liver and gastro-intestinal organs. Elimination of phosphorus from living organisms has also been studied by this method.

Phosphorus is an extremely important element in biological processes. The knowledge of its functions in living organisms which has been acquired thanks to the use of radioactive markers is therefore of the very greatest interest. De Hevesy succeeded in detecting where and at what speed the various organic compounds of phosphorus are able to form and the paths which they take in the animal organism. In order to form from a phosphate which has been injected into the blood they must first penetrate into the cells. Acid-soluble compounds of phosphorus form rapidly, whereas phosphatides closely related to fatty substances are slower-forming. These latter form mainly in the liver, whence they are carried by the blood plasma to the places where they will be consumed. De Hevesy showed that the phosphatides of the chicken embryo are produced in the embryo itself and that they cannot be extracted from the egg yolk.

For more details please visit:

http://www.nobelprize.org/nobel_prizes/chemistry/laureates/1943/press.html