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Nobel Prize in Chemistry 1935

Frédéric Joliot

Irène Joliot-Curie

The Nobel Prize in Chemistry 1935 was awarded jointly to Frédéric Joliot and Irène Joliot-Curie *"in recognition of their synthesis of new radioactive elements"*

RESEARCH INFORMATION:

On the 10th of December, 1911, Marie Sklodowska, a Polish chemist of world-wide reputation, wife of Professor Pierre Curie, was present at the solemn Swedish Nobel Prize ceremony to receive the Prize for Chemistry "in recognition of her services to the advancement of chemistry by the discovery of the elements radium and polonium, by the isolation of radium and the study of the nature and compounds of this remarkable element." Previously, in 1903, she had received, jointly with Professor Pierre Curie, half of the Nobel Prize in physics "in recognition of the extra ordinary services they have rendered by their joint researches on the radiation phenomena discovered by Professor Henri Becquerel", whilst the other half of the prize was simultaneously awarded to Professor Becquerel "in recognition of the extraordinary services he has rendered by his discovery of spontaneous radioactivity".

It is evident that in 1903 it was the importance to physics of the discoveries made which was the prime consideration. However, their extraordinary importance in chemistry became increasingly clear, in the main from the work of Marie Sklodowska-Curie, but also from that of Pierre Curie while he was alive, and it was considered fitting to award Madame Curie by an undivided Nobel Prize for Chemistry - her husband had died in the meantime so that his share in their work could no longer be rewarded. This prize was duly presented in 1911, and Marie Sklodowska-Curie thereby became the only person up to that time to have received more than one Nobel Prize.

The capital importance of these discoveries is generally recognized and two other Nobel Prizes in Chemistry have been awarded for discoveries in the field of radioactive substances, in 1908 to Lord Rutherford and in 1922 to Frederick Soddy. I need only recall the powerful remedy that radium has become in medicine in the struggle against the cancerous diseases, the fact that it has proved possible to calculate the minimum age of the earth through the transformation of radioactive substances, and that we have been able to form an idea of the internal energy of atoms, of the possibility of using radioactive substances as tracers, as they are called (a question to which I will return later), and so on. What is more interesting from the scientific point of view is that radium is spontaneously derived from uranium and that afterwards by its spontaneous and continuous disintegration it forms new elements, with lead as the final product. All these transformations are accompanied by radiations of different kinds and thus all the radioactive elements are unstable, although in different degrees. It is customary to define their stability by giving the time taken for them to become half-decomposed, a period which can be determined by observing how the intensity of the radiation diminishes. This time, which is generally known as the "halflife" can vary between thousands of millions of years (for uranium) down to fractions of a second, and the determination of this period thus forms a major means of defining the different radioactive elements. At first, three series of these were known, of which two originated from uranium, which is found as an oxide in the mineral pitchblende, and the remaining one from thorium, a metal belonging to the metals of the rare earths and whose oxide is used in the now almost obsolete incandescent mantle for gas lighting. The total number of these radioactive elements known in the early stages and formed spontaneously amounted to just over forty.

As we know, the alchemists strove to transform the elements one into another. Strictly speaking it was only one transformation of this kind which interested them, the transformation of base metals into gold and they were thus moved by purely venal motives. Yet it cannot be said that the formation of new elements in the way described above provides the solution to the alchemists' problem, for the radioactive elements known earlier appear and decompose spontaneously without it being possible in any way to interfere in the process, and a particular element cannot be transformed into another one by any artificial interference.

It is in this respect that something new has been given to science by the discoveries of Doctors Irène Joliot-Curie and Frédéric Joliot, today's Nobel Prize winners. Yet even this time it is not a question of the transformation of other metals into gold - unless it be indirectly in the form of a Nobel Prize! But it does concern the extremely interesting discovery that it is possible in certain other cases to transform one element into another by some external interference. I shall now try to give an outline of these discoveries.

The spontaneous decomposition of a radioactive element can be compared to an explosion, the radiation which is involved in it consisting of the projection at high speed of particles charged with electricity. One type of these particles, the so-called alpha particles, consists of helium atoms with positive electrical charges. I must also recall that according to the now generally accepted view an atom is composed of a nucleus with a positive electrical charge surrounded by a group of units of negative electricity, the electrons, which can be compared to a kind of planetary system round the nucleus. If an alpha particle thus thrown out happens to strike such a nucleus, which is now thought to be composed of a definite number of hydrogen nuclei with positive charges, the so-called protons, and of an equally definite number of neutrons (already mentioned this evening) - that is to say, composed of the two kinds of matter which, with the electrons, are at present considered to be the smallest stones with which the universe is built - then it may happen that the nucleus is shattered, a process by which atoms of other elements are formed.

However, the nucleus is extremely small, so small that the surface area of its cross-section forms only about one hundred-thousandth part of the whole atom with its envelope of electrons. This means that the number of effective collisions during a bombardment is minute - it is calculated that one hit occurs in ten million shots, that is out of ten million alpha particles.

So the scientific couple Curie-Joliot bombarded aluminium with alpha particles derived from polonium. Polonium, which is somewhat akin to sulphur, is a radioactive element less stable than radium and therefore it projects alpha particles in greater numbers and at higher speeds than the same amount of radium, that is, it yields a more effective radiation for atomic bombardment. As it is also among the few radioactive elements obtainable in reasonable quantity, it represents a good choice for this purpose.

Having thus exposed aluminium to bombardment, today's prize-winners found that after some minutes had elapsed the metal began to emit rays to a noticeable degree - in this case units of positive electricity, called positrons, discovered in the autumn of 1932 by Carl Anderson at Pasadena. This was an indication of the formation of a new radioactive element. And after ceasing the bombardment, the emission of rays from the aluminium did not stop immediately but continued for a while to a noticeable degree until the radioactive element created was once more for the most part decomposed in the usual manner. This was again an indication of the formation of a new radioactive element.

More extensive investigation has shown that the newly formed element is phosphorus in a new radioactive state, radio-phosphorus. This is an isotope of ordinary phosphorus, that is, its nucleus contains as many positive charges as normal phosphorus, but its weight is different.

We have earlier indicated that, on account of their instability, it has been impossible to obtain the unstable radioactive elements, which form the majority, in reasonable quantities, so that it has been impossible to examine them or even to demonstrate their existence by chemical tests. In order to show that they exist and determine their characteristics, it is necessary to have recourse to the radiation emitted as I have previously stated. In this particular case recognition by a chemical method was successful in that it was possible to show that following the decomposition of irradiated aluminium in an acid, all the radioactivity was attached to the gas generated, which is as would be expected if an isotope of phosphorus had been formed, since gaseous phosphorus hydride would be produced. Another chemical treatment of irradiated aluminium confirmed this hypothesis.

In a similar way a new radio-nitrogen has been obtained from boron, a constituent of boric acid, and radio-silicon and radio-aluminium derived from two isotopes of the metal magnesium.

In fact it is not the first time that the transformation of one element into another by alpha-ray bombardment has been achieved, for Lord Rutherford and others had by this means succeeded in smashing the atoms of several elements, a process by which, however, the elements formed were not *new*. One can thus characterize the discovery of the couple Curie-Joliot as the *synthesis* of new radioactive elements, even though the term "synthesis" properly signifies the associating or combining into a unity, and that previously the word was only used to indicate the preparation of complex chemical compounds using simpler ones or elements as the starting-point.

The field of investigation with which we are concerned today is the object of intense activity and so the discovery of the Curie-Joliot's, communicated to the French Academy of Sciences on the 15th of January, 1934, was not long in stimulating other scientists to take up this research. It must here be emphasized that in the early stages, that is in April, 1934, the Curie-Joliot's had suggested that projectiles suitable for the disintegration of atoms were protons, deuterons (equivalent to protons but coming from heavy hydrogen, the discovery of which was rewarded last year by a Nobel Prize in Chemistry), and neutrons. With Preiswerk they themselves used neutrons but it is above all the Italian Fermi, who had already used them with great success a little before the suggestion of the Curie-Joliot's, and had arrived at a large number of extremely interesting results

But it is the first step which counts, as an eminent scientist has rightly said in the letter in which he proposes the Curie-Joliot's for the award of this year's Nobel Prize for Chemistry.

There is hardly any need for me to add more on the importance of their discovery to science. I simply want to recall that the English scientist Boyle, to whom chemistry as much as physics owes fundamental laws, in defining the notion of a chemical element 250 years ago and in adopting for it the idea of the Greek philosopher Democritus on the indivisible atom, taught in 500 B.C., nevertheless made a wise reservation. In fact he said that perhaps someday it would be possible to find an *agens subtile et potens*, that is a subtle and powerful means, by whose aid elements might be decomposed. That vision into the future is now realized by the discoveries of this year's Nobel Prize winners for Chemistry and by those of other scientists.

Have we by this reached the end of what might be called the world of the infinitely small? Who knows, it is hardly likely. In fact, it makes us, as we think about it, as dizzy in seeking to penetrate to the bottom of what is infinitely small as it does to make out the summit of that which is infinitely large.

But it is also possible even now to get a glimpse of practical uses. Some of these artificial radioactive elements - for whose production the raw materials, the ordinary elements, that is, are available in large quantities compared with the minerals which in the earlier stages were the sources of the radioactive elements - emit a radiation known as gamma, a kind of X-rays, with a definite wavelength, which is valuable for many purposes. Again, in general the radioactive elements can only be obtained in small quantities; but on the other hand the method of determining their characteristics and their amount by observing their capacity for making, by virtue of their radiation, air or other gases into conductors of electricity, is so sensitive that it surpasses all chemical methods. On this property is based the use of radioactive elements as tracers - a method first described by de Hevesy and Paneth. The Curie-Joliot's have expressed the hope of being able very soon to supply the physiologists with radioactive preparations, containing, for example, radioactive carbon which after being introduced into the body of an animal or plant makes it possible to discover the movement and distribution of certain of the substances in the organism. And referring to radio-sodium in particular, obtained by Lawrence by bombarding sodium with deuterons, which has a sufficiently long life, it is to be hoped that it can be used in the same way as radium salts in medical applications. Here also new effects can be expected because of the difference of radium from the chemical point of view and because no radioactive residue is formed on the decay of the new radioactive elements.

Therefore the Royal Academy of Sciences has had no hesitation in rewarding with the Nobel Prize for Chemistry the discovery which I have sought to summarize; and in doing so the Academy has also had the pleasure of being able to reward a discovery made at a quite recent date, in complete accordance with the words of Nobel's will - something which does not happen very often.

The Royal Academy of Sciences has therefore decided that the Nobel Prize for Chemistry for this year should be shared equally by the Doctors Irène Joliot-Curie and Frédéric Joliot of Paris for their synthesis of new radioactive elements carried out in partnership

Madame, Sir. In awarding to both of you in equal shares the Nobel Prize in Chemistry for this year, the Royal Academy of Sciences has been pleased to be able to reward, in a brilliant way, the synthesis, achieved by your united efforts, of new radioactive elements.

Thanks to your discoveries, it has become possible, for the first time, to transform artificially one element into another hitherto unknown. At last the old dream of the alchemists has become reality. Their main object, the production of gold, has been attained, though by a path, it is true, less direct than they thought would lead them there. The results of your researches are of capital importance for pure science, but in addition, physiologists, doctors, and the whole of suffering humanity hope to gain from your discoveries, remedies of inestimable value.

Madame, 24 years ago, your mother, Madame Marie Sklodowska-Curie, was present at the Nobel festival in order to receive the Chemistry Prize, as a reward for her discovery of radium in the first place; and you, Madame, were also present on that occasion, as a little girl.

Her husband, your father Pierre Curie, was already dead; but earlier on, in 1903, he had shared with her, half the Physics Prize, an award well deserved for their work on the phenomena of radiation. In collaboration with your husband, you have worthily maintained those brilliant traditions. The work of both of you, Madame and Sir, has quickly attracted the attention of the scientific world, and its importance has been amply and universally recognized.

For more details please visit:

http://www.nobelprize.org/nobel_prizes/chemistry/laureates/1935/press.html