ISSN:2249-5347
IJSID
International Journal of Science Innovations and Discoveries
An International peer Review Journal for Science

Nobel Prize in Chemistry 1950

Otto Paul Hermann Diels

Kurt Alder

The Nobel Prize in Chemistry 1950 was awarded jointly to Otto Paul Hermann Diels and Kurt Alder *"for their discovery and development of the diene synthesis"*

RESEARCH INFORMATION:

With this year's Nobel Prize for Chemistry, the Academy of Sciences wished to signalize the discovery and development of diene synthesis. This achievement falls within the domain of classical organic chemistry- the chemistry of carbon compounds. The field in question is somewhat recondite and not easy to describe in words "that everyone can understand" - a fact to which the scientists whose task it has been to explain the Nobel Prize in the press can testify. The chemistry of carbon compounds is rather like a Chinese puzzle in which the pieces consist of atoms - a puzzle with simple fixed rules and a great many possible combinations. The task of the research scientist is twofold: on the one hand he has to discover how Nature has arranged the puzzle in the thousands of compounds which we meet in the animal and vegetable kingdoms, whilst on the other he has to imitate, modify, and supplement the work of Nature. A fascinating game for anyone who knows the rules!

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Diene synthesis occurs between two different molecules of more or less complex structure. One of them, the diene, contains a chain of four carbon atoms, linked by two double bonds and - in the centre of the chain - a single bond. The first syllable of *diene* is the Greek word for "two", and refers to the two double bonds. The other molecule must contain two carbon atoms linked by a double bond, and must also satisfy certain other structural requirements. This component is usually called the dienophil or philodiene, i.e. the diene-loving, partner. In diene synthesis the two chains attach themselves to four or two carbon atoms to form a ring, which thus contains six atoms; this number is particularly favourable to cyclization. At the same time the double bonds are broken, so that only *one* remains in the new system.

It has long been known that molecules with double bonds readily become attached to one another; today we also know that this process usually results in very long atom chains, known as giant molecules. Diene synthesis is a special case, where, owing to certain geometrical and arithmetical relations, growth of the atom chain by attachment of new molecules ceases. lnstead, the chain catches its own tail, so to speak, and forms itself into a ring which can grow no further.

The reaction occurs with astonishing facility, often quite spontaneously, without external heating, addition of condensing agents or the like. It is perhaps surprising that this reaction, which is extremely elegant from the chemical point of view, should not have been discovered earlier, for cyclic structures had in fact been known since the sixties of last century. Individual observations had been made but they had been misunderstood or overlooked. The correct interpretation was so simple and yet - a mere twenty years ago - so bold, so like a chemist's utopian dream, that it was beyond reach.

Diels and Alder were interested in a particular, not entirely simple, form of this reaction, which had formerly been misunderstood, and they gave the correct interpretation of it. They also suspected that they had found a general method of synthesis of great fundamental significance, and their conjectures were confirmed by many investigations in

various directions. This achievement was described by a famous French scientist as "profondément intuitive et géniale".

This was more than twenty years ago, and diene synthesis has now developed into one of the most important working methods in organic chemistry. By means of this method a large number of compounds of complex structure can easily be produced - compounds which it would be quite impossible or very difficult to produce in any other way. An example is the peculiar carbon framework of the camphor molecule. The method has also proved valuable in a great many ways in research into the constitution of complex natural products; these include the resinic acids and cantharidin, the active substance - with very peculiar chemical properties - of the "Spanish fly" (which is actually a beetle).

The compounds present in essential oils and natural resins often possess a diene structure. Reaction with suitable philodienes produces substances with properties valuable to industry, e.g. as raw materials for plastics. Numerous applications for patents testify to this. Among the many industrial applications of diene synthesis one might also mention analysis and refining of synthetic motor fuels.

The products formed by diene synthesis are usually stable, although sometimes they break down into their components at high temperatures. In a few cases, however, disintegration takes a different form - here, a part of the molecule is said to be "expelled". This results in new substances - in some cases substances which cannot be obtained in any other way.

The many theoretical problems which diene synthesis has created or brought into prominence cannot be discussed here Professor Diels, Professor Alder. More than two decades have passed since the day when you sent in the first paper on "Syntheses in the Hydroaromatic Series" to the Editor of the *Annals*. Much has happened since then - in Science, as well as in the world. The reciprocal addition of the unsaturated compounds was at that time still somewhat mysterious. The chemistry of the high polymer compounds belonged for the most part to the future. You found it necessary to stress that the new substances which you obtained so easily were not molecular compounds but were really

new molecules, stable and firmly bonded. New simple bonds had come into being of the old, well-known kind. This identification has paved the way to a right understanding of the polymerization phenomena of the unsaturated compounds, and through it you have very greatly advanced the development of high polymer chemistry and technics.

In this treatise you have even indicated how highly promising the consequences of the low molecular compounds were for the future of chemistry. In the past years the synthesis of dienes has, to be sure, achieved more than you could either foresee or predict when you wrote your paper. But the general trend, the prophetic leading ideas are already to be found in it.

You mention there the possibilities for discussion of several theoretically interesting questions concerning the forces of attraction in polycyclic systems. You also mention the practical consequences. The possibility of the synthetic production of complicated natural substances or of compounds similar to them is, in your view, immediately in prospect. Finally you indicate the possibility that this astonishingly rapid and smoothly running reaction could also play a significant part in the processes of Nature.

Since 1928 the synthesis of dienes has been developed in various directions by numerous workers, and its significance has become more and more obvious. You have yourselves, partly together, partly independently, worked with great success in the field you have opened up. The external circumstances were not always of the best for reasons which we all know. We have been told that you, Professor Diels, were in the past years unable to do any experimental work. And yet your thoughts played keenly upon scientific problems and we hope that you will soon have the opportunity of approaching the problems experimentally as well. You, Professor Alder, in spite of limited facilities for work, are again fully active. During the past year you have, by your splendid work on the steric and energetic conditions in the polycyclic systems, successfully maintained your position as the leading research worker in this field.

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