CHEMISTRY-PHYSICS

Three-Dimensional Molecules
"A Classic Of Science"

Crystals of Organic Compounds May Be "Right-Handed" or "Left-Handed" According to the Way Their Atoms Unite

LA CHIMIE DANS L'ESPACE (Chemistry in Space), by J. H. Van 't Hoff. Rotterdam: P. M. Bazendijk. 1875. Translated for the SCIENCE NEWS LETTER, *by Helen M. Davis.*

IT IS organic chemistry—the chemistry of carbon—which gave birth to the beautiful theory of atomicity, that allows representation of the molecule as a group of atoms joined together according to certain laws and forming a complete and stable system. It makes use of very simple symbols, indicating at once the qualitative and quantitative composition and the chemical character, symbols which allow us to predict exactly the role which such and such a compound will play under the influence of a certain reaction. It is organic chemistry, I repeat, which has given birth to this theory, it is the same which will give it its growth in precision.

The hypothesis of atomic constitution does not simply give a concise and simple form to observations already made; it is not merely an ingenious notation, but a theory, a generalization, it predicts; that is the mark of its truth. We may challenge the value of proofs deduced qualitatively, but those which manifest themselves by figures are unexceptionable. What is then the criterion of a true theory? The reply to that question is simple: it is found in the number of possible isomers of a body; thus the atomic theory declares itself rigorously, there its consequences appear confirmed or invalidated.

When we inquire of the facts: *We see that in many cases the number of isomers in existence surpasses that which theory predicts.* We do not dare admit it; we hide it under the terms, physical or geometrical isomerism; we have recourse to the biatomicity of carbon; we close the chain of its atoms; but the truth is that: *Present theory is unable to predict isomers exactly.*

One who is guided by an hypothesis based on numerical principles exclusively, and judging everything with impartiality, arrives at contradictory facts. One who, on the other hand, has the prudence to remain undecided on certain questions, will be able to use those facts, with which his predecessor has come into conflict, to develop a new theory to rescue the old one from something apparently fatal to its success.

In a brochure which was prepared in Holland, I made an attempt at a theory of structural formulas in space; I called for discussion of my ideas; I wished to profit by the results.

I was given the honor of inserting a French translation in the Netherlands Archives, but for what I so much desired, an opinion, a discussion, I have waited in vain. Every new hypothesis, if I may be permitted so to speak of this, ought to pass through two distinct phases; it ought first to show whether it presents in its interpretation of known facts any advantage over those which already exist; then, if it has received this support, it is still necessary that experiment show the truth of its predictions. It is in the first phase that the judgment of scientists is so desirable. I have not found it in Holland.

At the same time, M. Le Bel has come out in favor of a part of my theory at the meeting of the Chemical Society of Paris, November 5, 1874, and at that of March 19 of this year M. Berthelot was willing to present some remarks upon our ideas; I seized this occasion to beg the eminent chemist to accept the expression of my lively gratitude.

It appears therefore that the moment has come to present my theory with the development which it has since received and to ask a judgment from foreign scientists.

Rotterdam
May, 1875.

Discussion of the Theory

The present theory has two weak points; it does not take a stand on the matter of determining what relative
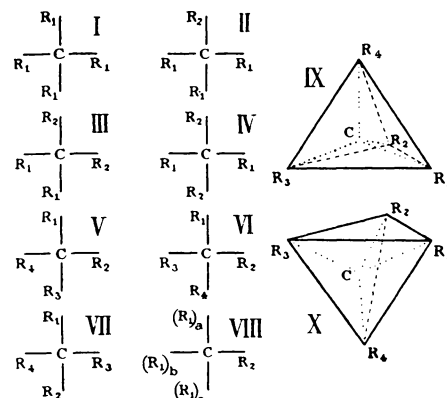
STRUCTURAL FORMULAS
As conveniently drawn in one plane, and as Van 't Hoff believed they exist in three-dimensional space. The tetrahedra represent the central carbon atom, the R's represent groups of organic radicles. The two figures are mirror images of each other.

position the atoms occupy in the molecule, nor upon their motion.

As a result of this, doubt still covers all questions of static or dynamic chemistry; rational progress tells us that it will be necessary in the beginning to work in the first direction. There is always the objection that each motion changes the form of the system which we are trying to fix. But the motion of the atoms in the molecule must be periodic[1]; we can therefore show the relative position of the atoms in one phase of their motion.

It is evident that the result of such a conception is incomplete. A very small unforeseen difference, which could be due to a modification of vibratory motion passing through one phase, might cause isomerism unexplainable by a static formula. Thus it would be important not to ascribe to a difference in constitution something which would be effaced by the mode of motion; we would however meet it again at the same point in time and space. My way of reckoning indicates then a minimum, not a maximum of cases of isomerism.

A primary reason has already frequently made us realize the insufficiency of present formulas: they represent in one plane the molecule which has three dimensions. One might say that a sys-

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[1] If the kind of molecule is a function of the motion of the atoms we cannot have equality in the one without periodicity in the other.

tem drawn in a plane acquires three dimensions by moving, but this objection is merely specious. I propose to show that in considering only atoms in one plane we arrive at results in contradiction to the facts; it is necessary therefore to change at least for the chemistry of carbon.

Let us consult the simplest graphic method, that which leads to the lowest number of isomers: Let us represent the four affinities of each carbon atom by four lines, drawn in a plane, perpendicular to each other; let them be R_1, R_2, etc., of monatomic groups:

Then a compound of the formula $C(R_1)_4$ would be represented by fig. 1, and would not admit of isomers; it is the same with the class of compounds shown by the formula $C(R_1)_3 R_2$ (fig. 2);

But $C(R_1)_2 (R_2)_2$ and $C(R_1)_2 R_2 R_3$ allow each two images (fig. 3 and 4) of two isomers;

Likewise with the formula $C(R_1 R_2 R_3 R_4)$ we can construct three symbols, shown in figs. 5, 6 and 7.

In summation, we have a number of isomers resulting from the simplest hypothesis, concerning the development of formulas in one plane; the number is evidently much greater than those known at the present time; every other attempt would give more of them.

Second drawback: Let us take the formula $C(R_1)_3 R_2$ represented by fig. 8; it is evident that the group R_1, shown by $(R_1)_b$ ought to have different properties from that indicated by $(R_1)_a$: that is to say that in a compound such as methyl chloride one with three atoms of hydrogen ought to have a special character; yet the result does not justify it; let us then leave these formulas to look at those which result when we consider them in space.

In imagining the affinities of the carbon atom, directed toward the apexes

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THE BIRD THAT IS MOSTLY BEAK

The Toucan

—native to the American Tropics, naturally created interest in the early post-Columbian century. His write-up in

Historia Animalium

by CONRAD GESNER

will be the

NEXT WEEK'S CLASSIC OF SCIENCE

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of a tetrahedron, whose center would be occupied by the atom itself, theory is in accord with fact. Indeed no one has ever caught a hint of the existence of isomers for the compounds represented by the formulas $C(R_1)_4$, $C(R_1)_3 R_2$, $C(R_1)_2 (R_2)_2$ and $C(R_1)_2 R_2 R_3$; only in the formula $C(R_1 R_2 R_3 R_4)$ one case of isomerism appears; it exhibits the difference of figs. 9 and 10; in fact if one supposes himself standing on the line $R_1 R_3$, his head at R_1, looking at $R_2 R_4$, R_2 would be turned to the right (fig. 9) or to the left (fig. 10) of the spectator, in other words: *In the case where the four affinities of the carbon atom are satisfied by four groups different from one another, we can have two and only two different tetrahedra, which are mirror images one of the other, and can never doubt this idea, namely, that we are dealing with two formulas isomeric in space.*

The Asymmetric Carbon Atom

The main result of our hypothesis has been to predict many isomers, which present theory cannot do, in connection with compounds containing one or more asymmetric carbon atoms.

Indeed it can predict that isomerism which, as we have seen, does not appear in any striking difference in chemical properties; there is indeed great similarity in reactions, so that it is known in general under the name of physical or geometric isomerism.

It is evident that differences will be discovered the more readily the greater they are; so that descriptions of isomerism or the identity of such bodies are still very new.

The work of M. Wislicenus on the lactic acids has interested me very much, also the discussion between his pupils MM. Friedel and Langermarck over the existence of two or three ethylene iodobromides. Here we are dealing actually with compounds containing asymmetric carbon atoms:

$CH_3.CH(OH) CO_2H$ and $CH Br I CH_3$
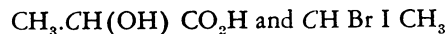
Although the chemical properties of the isomers in question resemble one another so much, they have not the same physical properties. The way in which these bodies behave in respect to polarized light interests me especially; I have indeed recently reached the following conclusion:

Every carbon compound, which in solution effects a deviation in the plane of polarization, possesses an asymmetric carbon atom.

I have concluded that we find here a proof in support of my hypothesis, for the rotary power which bodies in solution possess arises from the kind of molecule, and not from a special grouping of them; so the differences in this property ought to relate to those in the construction of the molecule.

Science News Letter, June 6, 1931

Government Tests Show That Gasoline Dopes Are Useless

GASOLINE dopes sold to be added to motor fuel were found in an extensive series of U. S. Bureau of Standards tests to be valueless in improving any feature of engine performance.

Conclusions drawn by Dr. H. C. Dickinson, chief of the division of heat and power, show that such dopes, exclusive of well-known knock suppressors which are sold mixed with the gasoline, cannot be expected to improve starting, decrease crankcase dilution, or prevent vapor lock. Some 150 dopes were tested.

"As the result of the normal failure to reach perfection," Dr. Dickinson explained in a report to the American Chemical Society, "the motor vehicle offers a new field for the former dopesters of human ills. In fact, the psychological factors which have played such a large part in the distribution of drugs and medicines are equally potent in their effect on the marketing of fuel dopes.

"The starting characteristics of a fuel cannot be revolutionized by the addition of any foreign material in amounts much less than one per cent. The completeness of evaporation also, like the ability to start, is controlled by the general volatility of the gasoline and cannot be appreciably affected by the addition of material in small amounts.

"Vapor lock or the stoppage of the engine due to interference with the normal fuel feed has been increased re-