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Prediction of Organic Compounds by a Conceptional Diagram

Introduction

Many works have been carried out on the relationship between the chemical structure and individual physical properties of organic compounds. Brühl, Eisenlohr, and many others discussed on the relationship with molecular refraction, Kauffmann, Baly, Shibata, and many others on absorption curves, and Zwett, Martin, and others based their discussions on chromatography, and so on. It is possible, at present, to predict the structure from individual properties and, reversely, predict to some extent the properties from the structure of compounds. However, these methods are all limited to a narrow range, and none are applicable as a general principle. In view of the necessity as well as the advantageousness of carrying out chemical researches by predicting the general outline of a given compound, the writer has designed a difinite measure, based on the origin of general properties of organic compounds, and has devised a method whereby a given compound can be shown on a graph as in the cases of mathematical functions.

This is not only useful in predicting approximate properties and structural range of a given organic compound during the course of chemical experiments but would also be useful in the various application of organic chemistry. For these reasons, this method is explained here.

(1) Regularity of the Properties of Organic Compounds

As is well known, the organic compounds show regularity of properties compared to inorganic compounds, and such regularity may be summarized as follows:

A) The homologs of fundamental hydrocarbons obtained by the elongation of a methane chain show approximately systematic change in physical properties by the increase of one methylene group.

B) Introduction of a substituent or a functional group (such as a nucleus, double or triple bond, etc.) brings an abnormal change in the properties of hydrocarbons of methane series but the degree of such a change is approximately definite in a definite substituent. If the substituent is duplicated, the properties change proportionally.

C) The substituents are fundamentally specific elements or residues of various inorganic compounds, such as H_2O, CO_3H_2, NH_3, NO_2H, SH_2, SO_3H_2, HCl, etc., so that, by taking these substituents as the fundamental compound, organic compounds in general can be assumed as inorganic compounds or specific elements to which a methylene chain had been attached.

Hydrocarbon itself is not an exception if it can be taken as an inorganic compound, H_2, between the two hydrogen atoms of which was inserted a methylene chain.

In homologous series obtained by the introduction of a methylene chain to various substituents or functional groups, the properties change approximately regularly according to the number of the methylene group introduced, as in the case of hydrocarbons.

(2) Origin of the Regularity

The properties of an organic compound is more dependent on the manner of bonding rather than on the kind of elements present. Irrespective of whether it is organic or inorganic, the bonding of two atoms can be classified into covalent bond and ionic bond. Actually, however, it is very rare that a compound consists purely of a covalent or ionic bond and is generally a mixture of two manners of bonding.

The wave function, ψ_{A-B}, of a normal bonding between two atoms, A and B, can approximately be shown by

$$\psi_{A-B}=m\psi_{A:B}+n\psi_{A^+B^-}$$

where $\psi_{A:B}$ indicates the pure covalent bond between A and B and $\psi_{A^+B^-}$ indicates the pure static bonding, i.e. ionic bond, between A and B. The size of coefficients m and n limits the general properties of the two atoms by the bonding.

The above function for two atoms may be enlarged to include general organic compounds composed of numerous atoms. In fundamental hydrocarbons, the first term on the right side of the equation is the controlling factor on the bonding between the atoms. On the other hand, the portions of substituents and functional groups are more or less controlling to give polarity to the compound as a whole.

The fact that hydrocarbons of methane series are not only practically nonpolar but also act to weaken the activity of a substituent when a substituent is introduced in the place of a hydrogen atom, cannot be disregarded. When the activity of a substituent works in the direction of weakening the inherent property of a hydrocarbon, then such an activity is sometimes seen to be strengthened. However, these two properties are fundamentally similar. Moreover, the larger the hydrocarbon residue the larger is the force to weaken such an activity. This fact is nothing new and is daily witnessed by organic chemists. For example, when a hydroxyl or aldehyde group attaches to a small alkyl group the activities of these substituent groups are much more apparent than when attached to a large alkyl group, and the degree of activity is approximately proportional to the length of the chain. It seems odd to say that there is a difference in the magnitude of the nonpolarity of hydrocarbons but when a substituent or a functional group is introduced into a molecule, the length of the chain clearly influences the final properties. The methylenic chain, composed of highly covalent bonds, can become an antagonistic energy when confronted with the static properties of a substituent. The inactivity of higher compounds or the special organic properties which have been known to exist among higher members of organic compunds may be said to lie fundamentally in such antagonistic energy. By induction from such a fact, the hydrocarbons themselves may be said to harbor various antagonistic power that is proportionate to the length of the chain.

Lengthening of the methylenic chain naturally means the increase of a molecular weight and the slowing of the molecular motion is generally taken as the cause for such antagonism. However, such antagonistic power lies in a deeper origin as will be apparent, for example, by the comparison of the hydrolytic rate of ethyl butyrate and ethyl acetoacetate, or the acidity of these two acids. Such differences are generally seen in the majority of physical properties. When the size of the hydrocarbon residue becomes extremely large, the physical constants of a compound are almost identical with those of the fundamental hydrocarbon itself.

It is still unknown what causes such an antagonism but the fact is that such antagonism clearly weakens the activity of the static portion. Such antagonism, in other words, the main principle of the organic properties, will henceforth be indicated by the word "organic characters."

That which stands opposite this organic characters, i.e. the static porperties inherent in a substituent, cannot be placed under a uniform standard, as the organic characters, because such static properties are not clearly defined and cannot be measured in so simple a manner as the organic characters. The largest cause of such a failure is the asymmetric static charge which lies at the bottom of this principle. If such a charge is present in each molecule in the original form, their determination will provide enough standard data but in an ordinary state of existence of these compounds, i.e. in a state where numerous molecules are gathered closely, without any space, static neutralization of unknown degree, such as the association of molecules and hydrogen bonding, takes place between the molecules as an essential of static properties that static form peculiar to a molecule becomes distorted. In order to overcome this difficulty, such determination could possibly be made in a vapor phase or in a very diluted form in a nonpolar solvent. However, what is desired is not that in a vapor phase but the static form of a single molecule in a liquid or a solid phase which would be well nigh impossible to fulfill. The dipole moment, dielectric constant, and molecular polarity, which are often determined as the static constants at the present, give conclusion which often disagrees with practical chemical data and the reasons might lie in the above facts.

For the sake of convenience, direct determination of the static properties themselves was given up and a different idea was introduced. Various physical properties are invariably under the influence of static bonding, even if they seem unrelated to static properties. In order to see how the physical porperties are actually influenced, a graph is plotted as in Fig. 1, on orthogonal axes, with the number of carbon atoms on the abscissa and the boiling point on the ordinate. The homologs of methane series hydrocarbons of the general formula, C_nH_{2n+2} would then give a curve as shown by I in Fig. 1. Since the hydrocarbons are composed of almost perfect covalent bond, this boiling point curve is the curve of that entirely due to the van der Waals force, without any polar influence whatsoever. Plotting of the similar curve for a primary straight chain alcohols of the general formula $C_nH_{2n+1}OH$, as an example of a homologous series with one substituent hydroxyl in the terminal of a chain, a similar curve as II in the same graph is obtained. Other series with substituents other than the hydroxyl are indicated by the curves III, IV, and V.

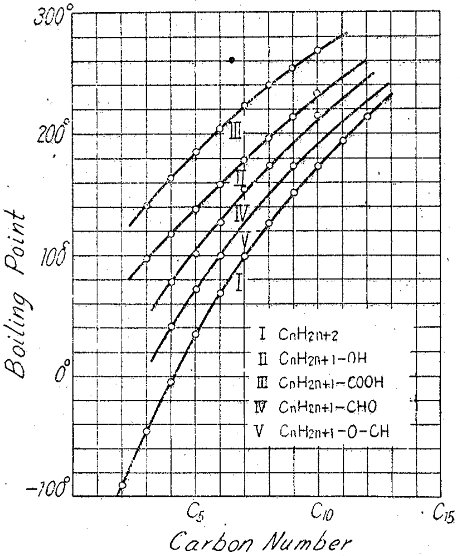

Fig. 1.
Boiling Point Curves of Straight Chain Aliphatic Compounds

These curves show the following three facts. One, that the curve for homologous series of various derivatives of hydrocarbons is approximately parallel to the curve of the fundamental hydrocarbon and this is a common phenomenon in almost all the derivatives and indicates that the influence of one substituent on the original hydrocarbon is approximately the same on individual derivatives of the same series. Second fact is that the curves incline toward the abscissa in approximately the same degree as the number of the carbon atoms increases and finally converge with the line of the original hydrocarbon, which may be interpreted as showing the antagonism of the organic characters. Third is the fact that there is a varied space between each curve and the curve of the original hydrocarbon, and such variation must indicate the difference in the intensity of influence the substituents or functional groups have on the hydrocarbon. That such is not the common property of the oxygen atom itself shown in the same figure can be seen from the fact that the curves for the homologous series of alcohols and ethers are at a different distance from the curve of the hydrocarbon. Such a distance tends to be greater in greater polarity but since they are not necessarily identical, it must show the influence of indirect factors and not the direct influence of the polarity itself.

Not only the boiling points but other physical properties are also similarly influenced. For example, influence on the index of refraction is shown in Fig. 2. However, such

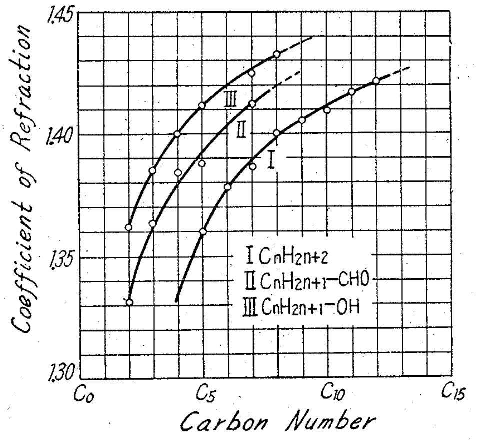

Fig. 2.

Curves of Coefficient of Refraction (Straight Chain Compounds of Aliphatic Homologous Series)

influence is not as far-reaching or as orderly as that on the boiling point and bibliographic data are also lacking, that this point cannot be followed up further. The boiling point was chosen as being the representative constants that can be obtained easily from the existing literature. As for the ease of obtaining from literature, melting points are far better but recent studies have revealed that the crystal lattice remains somewhat intact, without complete decomposition, during melting and the molecule remains in a broken lattice or mosaic form of broken lattice aggregates that the static influence is too individualistic and would make it unsuitable to be used as a common standard. For these reasons, influence on the boiling point was taken up as the indirect measure of static properties. The results concluded from the general intensity of such an influence were found to agree, better than expected, with the chemical experimental facts as described later.

The factor that opposes the organic characters originate in the static properties but is not of itself directly static or polar. It is difficult to designate such an abstract idea but the writer proposes the designation of "inorganic character" as opposed to the organic characters, since the substituent where such influence originates can fundamentally be considered as the residue of an inorganic compound. The substituents and functional groups from which such inorganic characters appear will be designated as the inorganic radicals as a whole. Besides these, gravity and spatial porperties can also be considered as the origin of physical porperties but such impartial factors are neglected.

The standard factors chosen under such considerations, i.e. organic and inorganic characters, approximately limit the physical properties of all organic compounds and an individual compound must be functionally defined by the magnitude of these two factors conformed to a definite equation. For example, a compound with organic characters alone would be the hydrocarbon and any substituent therein would give inorganic characters of a large or a small magnitude, and when organic characters are entirely lost, i.e. when the substituent alone remains, it would finally become an inorganic compound. The inorganic compound at this limit is not a pure, unit-substance such as the organic characters because inorganic compounds are not necessarily composed only of static (ionic) bonds alone and are composed of many and varied elements. This is the reason why the designation of inorganic characters had been adopted with a certain amount of misgivings.

Even if special elements are not included, there are physical properties which indicate the specific structural characteristics of a compound, such as the optical rotation, and properties that can be standardized only by the two fundamental factors are very rare. One of these that is determined in majority of cases is the solubility. Luckily, this solubility is the most common and the most extensive characteristics of compounds in general. Moreover, the fact that the mutual solubility, which is closely related to the similarity between given compounds, is highly dependent on these two factors, seems possible to be utilized as a means of learning the outline of an unknown compound. Such an idea is described below.

(3) Graphic Representation of an Organic Compound

In order to represent any given organic compound on a graph by the magnitude of

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its organic and inorganic characters, the two factors will be quantified as follows:

(a) **Quantity of Organic Characters** Methylene group is taken as the unit and is measured by the number of carbon atoms that represent the group. One carbon atom is taken as 20 and $-CH_3$, $>CH_2$, $\geqslant CH$, and $>C<$ are all taken as one carbon. Hydrogen atom is disregarded because the lack of hydrogen indicates substitution or branching and the former is taken care of by the consideration of inorganic characters and the latter can be more or less corrected.

(b) **Quantity of Inorganic Characters** Hydroxyl group is taken as the standard for the comparison of the influence of static characters on the boiling point. In order to make the comparison with organic characters easier, the influence of one hydroxyl is taken as 100. In other words, the distance between the curve of a methane series hydrocarbons and the curve of saturated, univalent, primary straight-chain alcohol homologs, is taken as 100. The quantity for the influence of other substituents is calculated by the comparison of a distance between the curve of methane series hydrocarbons and the curve of any optional substituted homologs with the distance of the abovementioned hydrocarbon and alcohol curves. When bibliographic data are lacking, the comparison is made of the distance between the two points of the same number of carbon atoms on the curves, although experiences have shown that such a comparison must be made at a point above C_5. For substances that do not give a boiling point, some other means are taken. Quantity of inorganic characters possessed by some of the common inorganic radicals is shown in Table I.

TABLE I.

Substituent	Inorg. Char.	Substituent (amphoteric)	Org. Char.	Inorg. Char.
Light metal	500	R_4BiOH	80	250
Heavy metal	400	R_4SbOH	60	250
$-AsO_3H_2$, $-AsO_2H$	300	R_4AsOH	40	250
$-SO_2-NH-CO-$, $-N=N-NH_2$	260	R_4POH	20	250
$\equiv N-OH$, $-SO_3H$, $-NH-SO_2-NH-$	250	$>SO_2$	40	110
$-CO-NH-CO-NH-CO-$	250	$-CSSH$	120	80
$\equiv S-OH$, $-CO-NH-CO-NH-$	240	$-S-CN$	90	80
$-SO_2-NH-$	240	$-CSOH$, $-COSH$	80	80
$-CS-NH-$, $-CO-NH-CO-$	230	$-NCS$	90	75
$=N-OH$, $-NH-CO-NH-$	220	$-NO_2$	70	70
$=N-NH-$, $-CO-NH-NH-$	210	$-Bi<$	80	70
$-CO-NH-$	200	$-Sb<$	60	70
$-COOH$	150	$-As<$, $-CN$	40	70
Lactone	120	$-P<$	20	70
$-CO-O-CO-$	110	$-CSSR$	130	50
Anthracene, Phenanthrene (nucleus)	105	$-CSOR$, $-COSR$	80	50
$-OH$	100	$-NO$	50	50
$>Hg$	95	$-O-NO_2-$	60	40
$-NH-NH-$, $-O-CO-O-$	80	$-NC$	40	40
$-N<$ (amine character)	70	$-Sb=Sb-$	90	30
$>CO$	65	$-As=As-$	60	30
$-COOR$	60	$-P=P-$, $-NCO$	30	30
Naphthalene, Quinoline (nucleus)	60	$-O-NO$, $-SH$, $>S$	40	25
$>C=NH$	50	$=S$	50	10
$-N=N-$	30	$-I$	80	10
$-O-$	20	$-Br$	60	10
Benzene (nucleus)	15	$-Cl$	40	10
Nucleus	10	$-F$	5	5
$\mid\!\equiv$	3	Iso $>-$	−10	0
$\mid\!=$	2	Tert. $\geqslant-$	−20	0

In the above Table, R_4BiOH and others shown in a separate column give extreme deviation from the actual quantity if physical constants are determined from values

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calculated from the standard position on the boiling point curve. These must be due either to the fact that they contain a large amount of covalent bond inside the inorganic radical that cannot be ignored or the polarity had been weakened by the balance of the atomic group. In any case, such deviation can be wiped out by considering that this inorganic radical concurrently possesses organic characters to some extent. In such cases, corrections were made by the consideration of solubility and partition coefficient. The boiling point curve, in such cases, shift toward the right from its original position by the number of organic characters concurrently held, coming nearer the curve of the original hydrocarbons.

(4) Organic Conceptional Diagram

In an orthogonal axes, organic characters are taken on the abscissa and inorganic characters on the ordinate. By these coordinates, the position of an organic compound is limited. Such graph is designated as the organic conceptional diagram and the act of determining their position will be called a location. Such conceptional diagram will make a connection between the position on the diagram and the properties and structure of a compound.

Duplication of a different or the same inorganic radical does not become an arithmetic sum. If the positions of the two radicals are close, extreme deviation will occur but as a general, they may be taken as an arithmetic sum. Corrections of individual radical has not been made as yet. The area between the two axes is called the substance field and the line drawn parallel with the organic axis from a given point on this field is called the homologous line because the homologous series of the compound taken as the point will be located on this line. Radiating lines drawn through the original point will be called the equiratio line because on those will be located the compounds with equal ratios of the two characters. Of these radiating lines, the one that bisects the angle between the two axes is specifically called the bisection line and the compounds located on this line will possess the two characters in equal quantities. Some typical examples are shown in Fig. 3.

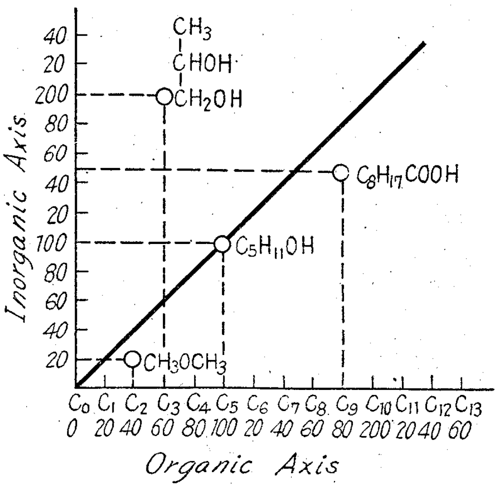

Fig. 3.
Conceptional Diagram I

(5) Relativity of Organic Compounds and Conceptional Diagram

A common fact among organic compounds is that allied compounds dissolve each other, as the saying, like dissolves like (similalo similibus solventur), goes. Many have tried to explain this fact on various principles but none have succeeded fully. The conceptional digram explains this fact as follows:

(a) **Relationship of allied chemical structures**: The member of the homologous series are also structurally related and the members of the neighboring two series are the most closely related that they generally dissolve each other and their physical properties are extremely similar. The same may be said of the two neighboring members on the homologous line on the conceptional diagram. Even if they are on the homologous line, the mutual solubility decreases by the increase of the distance between the two, with attendant difference in their properties.

The compounds with similar structures, other than the homologous series, are analogs. For example, the location of three analogous compounds of $CHCl_3$, $CHBr_3$, and CHI_3 will give the respective organic character totals of 140, 200, and 260, with inorganic characters of 30, 30, and 30, which means that these three will be located on one homologous line, as if these compounds were homologs. The reasons for their mutual solubility can be assumed from such a fact.

(b) **Relationship of allied ratio between organic and inorganic characters**: As an example, pyrrolidine, amyl alcohol, and diethyl oxalate will be taken. As a matter of fact, these three easily dissolve each other but they are not of homologous series, nor are they analogous. Their dielectric constants are also varied. The only point that is similar in these three compounds is the ratio of organic to inorganic characters which is equal in the three as can be seen from the following Table II.

TABLE II.

	Structure	Dielectric Constant	Organic Character	Inorganic Character	Org. Char. / Inorg. Char.
Pyrrolidine	CH_2–CH_2 | >NH CH_2–CH_2	6.3	80	80	$^1/_1$
Amyl alcohol	$C_5H_{11}OH$	4.7	100	100	$^1/_1$
Diethyl oxalate	$COOC_2H_5$ | $COOC_2H_5$	8.0	120	120	$^1/_1$

When located on the conceptional digram, these compounds are found on one equiratio line drawn through the original point. Even if the ratio is not completely equal but only somewhat close, the compounds possess the ability to dissolve each other. As a separate example, comparative examination is made in the following Table III of the solubility of dibromobenzene in various solvents and intramolecular pressure, dielectric constants, and ratio of organic to inorganic characters.

TABLE III.

Solvent	Org. Char.	Inorg. Char.	Org. Char. / Inorg. Char.	Solubility of *p*-Dibromobenzene	Inner Pressure of Solvent	Dielec. Const.
Hexane	120	0	∞	0.08	0.56	1.75
Benzene	120	15	8.0	21.7	0.46	2.29
p-Dibromobenzene	240	35	7.0	—	1.09	4.59
Carbon disulfide	120	20	6.0	22.4	1.18	2.76
Carbon tetrachloride	180	40	4.5	19.3	0.81	2.24
Ether	80	20	4.0	18.3	0.62	4.33
Nitrobenzene	190	85	2.2	17.4	1.07	35.70
Aniline	120	85	1.4	10.7	1.40	7.00
Phenol	120	115	1.0	4.6	1.40	9.68
Ethyl alcohol	40	100	0.4	1.9	2.90	25.80

As can be seen from the table, the ratio of organic to inorganic characters agrees far better with chemical facts than other constants.

(c) **Cumulative effect of allied relationship**: Relationship of allied chemical structure and that of the ratio of organic to inorganic characters are each independent and such relations should be cumulative. The fact that the two neighboring members on the homologous line possess the ability to dissolve each other is indicative of such an effect. Of the homologous series, the two neighboring members have the nearest ratios.

The relationship between the two neighboring members on the equiratio line differs according to the inclination of the line. When the equiratio line coincides with the inorganic axis (ordinate), the cumulative effect of the two relationships is zero and the relationship of the ratio alone controls the mutual solubility. As the equiratio line nears the organic axis (abscissa), the cumulative effect becomes larger until the effect becomes 100% at the limit of organic axis. It follows, therefore, that the relativity of the compounds near the organic axis, as well as their mutual solubility, is much higher than between those near the inorganic axis. The members of the methane series hydrocarbons on the limit line of organic axis are of equal ratio as well as of homologous series that not only their mutual solubility but the majority of their physical properties are extremely similar, as is well known.

(6) Individuality of Compounds and the Conceptional Diagram

On locating all the organic compounds on the conceptional diagram and examining their distribution on the substance field and difference of their physical properties, numerous important facts become known. Summarization of such facts are shown in the conceptional diagram II.

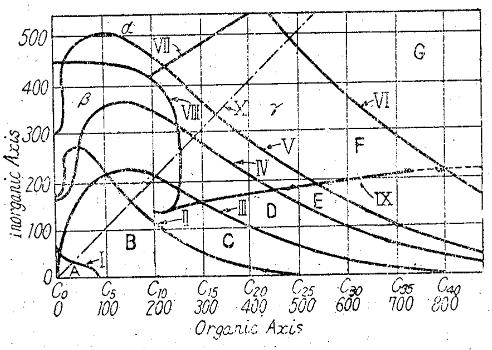

Fig. 4.
Conceptional Diagram II

I	Gas border line
II	Liquid border line
III	Odoriferous border line
IV	Volatile border line
V	Fusible border line
VI	Crystallizable border line
VII	Granular crystal border line
VIII	Granular and needle-shaped crystal coexisting border line
IX	Tabular crystal border line
X	Bisection line

A	Gas range
B	Liquid range
C	Odor range
D	Volatile range
E	Fusible range
F	Crystal range
G	Amorphous range
α	Granular crystal range
β	Granular and needle-shaped crystal coexisting range
γ	Needle crystal range
δ	Tabular crystal range

The border lines between each field on this diagram are not geometrical but are fairly obscure. A compound which is actually a solid but is located on the diagram within the liquid range is such that it easily undergoes liquefaction with the increase of room temperature, while a liquid substance that is located on the diagram within the solid range is either a viscous or a semisolid substance. Extreme deviation from actual conditions indicates the presence of a special conditions such as hydrogen bonding, polymerization, etc. It may be better to term the space as border zone rather than a line.

This organic conceptional diagram II will clearly show that locating of organic compounds on the gragh indicates the physical properties of these compounds. Inversely, knowing the physical properties of a substance, it becomes possible to predict the approximate structural range of the compound by examining its position on the conceptional diagram. The manner of application will be shown below by examples.

Example 1—What is the approximate physical properties of methylthiopropylaldehyde diethylacetal?

By locating the substance on the digram, it is seen that the compound is placed in the liquid range, near the border line, approximately in the center of odor range, and within the volatile range. It is nearly equal in ratio to ether and is located nearer to the organic axis. The compound will, therefore, be an odoriferous, viscous liquid, distill without decomposition, will not mix with water, and will dissolve easily in ether, benzene, and petroleum ether, with specific gravity below 1. These assumptions agree well with the actual substance.

Example 2—A heavy viscous liquid, almost odorless, and strongly acid. It mixes well with water but is almost insoluble in ether and benzene, sinking to a lower layer. When heated, it decomposes without volatilization. What would be the approximate structural range of this substance?

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The substance is located within the liquid range, outside the volatile range and such a location is limited to the narrow liquid range near the inorganic axis, jutting out of the volatile border line. This range includes substances of 1~2 carbon atoms and limited to inorganic characters of 180~260. Since the substance is strongly acid, it is probably methyl sulfate, methyl or ethyl sulfonate, or glycolic acid.

Example 3—Odorless and tasteless crystalline powder, sparingly soluble in water, alcohol, ether, or petroleum ether; melting range is very high, melting without decomposition at around 300° and sublimes very gradually. What would be the approximate structure of this substance?

The substance is located within a fusion range, outside the odoriferous range. Since the substance is insoluble in various solvents, it is difficut to know whether it is in the side of organic or inorganic axis. The fact that it sublimes with difficulty indicates that it should be located on the inner side of the volatile border line. Hydrocarbons and aliphatic derivatives with only one inorganic radical do not possess such a high melting point as 300°, so that the substance could not be near the organic axis. If it were located near the organic axis, it must show at least a small amount of solubility in solvents with large organic characters, by the cumulative effect of the two relationships. If the substance possessed free inorganic radicals such as the hydroxyl, amino, and carboxyl groups, the melting points generally become high but such a compound would undergo decomposition at the melting point and do not sublime easily (a kind of volatility), so that the location could not be very near the inorganic axis. It follows, therefore, that this substance must be located near the bisection line, probably at the intersection of the line through the inside of the volatile border line and bisection line. The number of carbon atoms would be around 14~16, the substance probably possesses inorganic characters through several of groups stable to heating, such as $=CO$, $-NO_2$, $-NR_2$, $-OR$, and $-COOR$, or possesses a total of around 300 of inorganic characters by the presence of anthracene or phenanthrene nucleus. Such compounds can be often found among anthraquinone derivatives.

(7) Systematization of Organic Solvents and Conceptional Diagram

The fact that organic solvents play an important role in the presumption of unknown compounds can be seen from the foregoing examples. The solvents are important in that they constantly come into contact with the particular compound during chemical procedures, such as purification, isolation, extraction, reaction, and solubilization. Utilization of such solvents, distributed over the substance field, as a mark and by the manner of solubility in such solvents, a more precise data may be offered for the presumption of unknown compounds.

Generally speaking, solubilizing power of organic solvents has been discussed purely from experiences and no rational means have been found to predict their solubilizing properties. The conceptional digram has been able to clearly systematize such properties and has enabled the prediction of solubilizing properties. Inversely, also, the diagram will make it possible to prepare a new solvent which possesses the desired solubilizing properties.

(a) **Location of a solvent and mixed solvents** The location of an individual solvent can be determined as soon as it is located on the diagram. If a solid in a state of fusion can be considered as a solvent, the position of such a substance would deviate from its position as a solid. However, when only an approximation is desired, the solid position can be taken as the location of the solvent. The location of a mixed solvent can be determined in a following manner.

Mixture of Two kinds of Solvents: In an equimolar mixture, the mean value of the organic and inorganic characters of the two solvents is taken as the coordinates, giving the location of a hypothetical, single solvent. In a mixture of two kinds of solvents, A and B, whose respective organic characters are p and p', inorganic characters, q and q', the organic character, X, and inorganic character, Y, will be

$$X=\frac{p+p'}{2} \qquad Y=\frac{q+q'}{2}$$

If the mixing ratio is not equimolar, but m mole of A and n mole of B, then

$$X'=\frac{mp+np'}{m+n} \qquad Y'=\frac{mq+nq'}{m+n}$$

To prepare a mixed solvent by mixing two solvents A and B so as to obtain one that would most dissolve a certain compound, the procedure will be as follows:

Take the coordinate of the solute as a and b. If x mole of $B(p', q')$ is to be taken against 1 mole of $A(p, q)$, the point at which the ratio of organic to inorganic characters of the mixed solvent agrees with that of the solute, is the point of maximum solubility. Therefore, the following equation will then be established.

$$\frac{b}{a}=\frac{q+Xq'}{p+Xp'} \qquad X=\frac{aq-bp}{bp'-aq'}$$

where $aq-bp\neq 0$ and $bp'-aq'\neq 0$, or $\frac{q}{p}\gtrless\frac{b}{a}\gtrless\frac{q'}{p'}$.

The organic character α, and inorganic character β, of the mixed solvent will be

$$\alpha=a\frac{q(p-p')-p(q-q')}{b(p-p')-a(q-q')} \qquad \beta=b\frac{q(p-p')-p(q-q')}{b(p-p')-a(q-q')}$$

Mixture of more than two kinds of solvents: In this case, additive mean of the first two solvents is obtained, then the additive mean with that and the third solvent is taken, and so on, to obtain the location of the mixed solvent.

To obtain a mixing ratio of a solvent composed of more than two kinds of solvents, for example, three kinds of solvents, $L(p, q)$, $L'(p', q')$, $L''(p'', q'')$, ..., which would dissolve a certain solute (a, b), the following equation is obtained

$$\frac{b}{a}=\frac{q+wq'+vq''}{p+wp'+vp''}$$

where the molar numbers of L' and L'' are w and v, respectively, against 1 mole of L. Since there is only one equation for two variables, the answer is indefinite. If the ratio of L' and L'' is made definite, the mixing ratio becomes established.

If $v=\lambda w$, then

$$w=\frac{aq-bp}{b(p'+\lambda p'')-a(q'+\lambda q'')}$$

$$\text{where } \frac{q}{p}\gtrless\frac{b}{a}\gtrless\frac{q'+\lambda q''}{p'+\lambda p''}$$

In the case of more than four kinds of solvents, a definite ratio for the two most important solvents is first determined, and the third and fourth solvents are combined successively.

(b) Solubilizing field of a solvent A field in which the solubilzing power of a solvent extends is a fusiform area with the solvent itself as a center and the original point as one of the extreme points. The other point of fusiform extremity narrows down much more gently than to the original point.

The fusiform is composed of three concentric layers, the innermost layer may be assumed as the most easily soluble field, the middle layer the easily soluble field, and the outermost layer the sparingly soluble field. The width of the total fusiform is approximately around 60° by angle.

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(8) Physiological Action and the Conceptional Diagram

The organic compounds must possess both the organic and inorganic characters in order to show good physiological effects because they must diffuse through two different layers in the living body, i.e. fats and lipoid layers rich in organic characters and cell fluids and lymph fluids rich in inorganic characters. For these reasons, the majority of effective drugs available at present are located near the bisection line, and those that are nearer the organic or inorganic axis do not possess any marked physiological effect. The writer, therefore, prefers to designate the field around the central bisection line as the physiological action field. Glycerol and lower aliphatic sulfones, which possess excessive inorganic characters, begin to show a fair amount of hypnotic properties as the organic characters are increased and the compounds are located near the bisection line. Lengthening of an alkyl chain in resorcinol, by the successive addition of methylene groups, gives a compound of the optimal anthelmintic charaters in hexylresorcinol, located slightly past the bisection line. The ratio of organic to inorganic characters in local anesthetics lies approximately in the range of 1.1∼1.3, while that of recent antibiotics is also 1.0∼1.2.

Summary

1. Founded on the origin of the organic compounds, two standard factors, organic and inorganic characters, are introduced.
2. A conceptional diagram is proposed in which the optional organic compound is presented graphically with organic and inorganic characters as the two factors.
3. A conceptional diagram makes it possible to predict the properties and/or structures of organic compounds by approximation.
4. Some useful items in organic chemistry are shown by the conceptional diagram.

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