

A new world chemical compounds (homochemical compounds)^{1, 2, 3}

by P. P. von Weimarn

From the Redaction

Petr Petrovich von Weimarn (1879–1935) – Professor of St. Petersburg University, who at a relatively young age became one of the founders of colloid chemistry and earned fame not only in Russia but abroad as well.

In 1916, von Weimarn was offered the post of rector in Yekaterinburg – in the Ural Mining Institute that was ready for opening. Here, Petr Petrovich had to solve many organizational problems associated with opening of the Institute, so almost no time remained for scientific studies, but nevertheless this is where he wrote the article “The new world of chemical compounds” – an overview of his scientific achievements, which we nowadays offer to modern readers.

This article, completed in 1916 in Yekaterinburg, was published in the first issue of the journal “News of the Ural Mining Institute», whose editor was von Weimarn, in two languages: Russian and English, what was a rarity for the Russian scientific journals of that time. And such a publication was not casual.

Von Weimarn, when he created his own scientific journal, conceived it as an international edition, and even wrote a special preface, entitled “On the publication of scientific journals in Russia». In it, in particular, he complained that researches published in the “inaccessible” for the global community languages that include Russian, lead, unfortunately, to the fact that “the outstanding discoveries have no effect on the development of science”.

To overcome this obstacle, he proposed the establishment of a common language for all scientists, which could be, for example, English. As a positive example, von Weimarn mentions practicality of the Japanese people, who also have a very complex language and who “resolved this issue very simply – by printing the work of their scientists in English or German in a good published journals”.

Seems that these reflections of nearly a hundred years ago have not lost their relevance: more and more Russian journals start publishing in foreign languages, and mostly in English.

By publishing his own articles with translation into other languages in the first issue of the journal, von Weimarn established a model for other authors. Today, following this tradition, we in our journal will pay more attention to translations of articles into foreign languages and strive to ensure that our journal has become just such an international publication, as it was seen by his creator – Petr Petrovich von Weimarn.

In one of my works⁴, written 1907, I have principally pointed out that the first and principal leading idea, derived from the totality of our knowledge and my explorations, – an idea, derived from the totality of our knowledge and my own experiments – is the idea of vectoriality of atomic and molecular forces.

In that treatise among other things the impossibility was set forth even to imagine an absolute amorphousness of forces, which keep in equilibrium the atoms in a molecule of any chemical compound, e. g. Fe_2O_3 .

The conclusive carrying through of the mentioned idea in the doctrine of states, resp. in the doc-

trine of colloids, has permitted me to discover some new phenomena and regularities.

The same idea turned out to be very productive in another field also – in the field of chemical compounds.

The assertion that atomic and molecular forces are vectorial, is identical with the principle that *chemical forces have a vectorial character*.

This statement results immediately in the principle that the change from gaseous-fluid state to solid-crystalline is a chemical process and that as we shall see in the following, chemical-homogeneous crystals are the simplest representatives of a very great world of homochemical compounds, i. e. of

¹ Translated from Russian by A. Janek.

² This summary treatise written at the request of the students of the Ural Mining Institute for the students Magazine “Young Russia” was publ. May, 1919.

³ In this paper is shortly explained the evolution of application of the idea of vectoriality in my explorations during ten years, from 1906 to 1916. Since 1917 my scientific occupation has stopped, because that time the Ural Mining Institute has swallowed up all my energy.

⁴ P. P. von Weimarn. Koll.-Zeitsch. 1908. p. 200. Dresden.

such compounds in which the affinity reveals itself between similar atoms⁵.

By virtue of this inference all liquids and gases must be considered as disperse systems of this vectorial polymer-crystal or its other vectorial modifications⁶.

But if chemical-homogeneous crystals are chemical compounds, we are led to the immediate deduction that the valency of atoms of all elements, without exception, cannot be less than six⁷, otherwise in our threedimensional space the phenomena of the growth of crystals would be impossible and the growth of crystals would have either one-sided growth or would receive atomic surfaces and threads of atoms (in case of two valencies) instead of bodies filling the space.

Consequently the atoms of all chemical elements have the same minimal number of valencies (six) and if the number of H-atoms or O-atoms which are combinable with the atoms of different groups of the periodic system of elements is not equal, the reason of this fact lies first of all in the largeness of surface of atoms and in the doubletation.

The evident fall (alter the IV-th group) of the quantity of H-atoms corresponding to one atom the elements of the V-th – VIII-th groups depends on the steadiness of doublets of H-atoms, then e. g. in a hydrogen-compound of the sixth group to one atom would come six H-atoms which being too near each other, that would invariably cause the formation of H-doublets, in general chemically little active.

The exceedingly light weight of H-atoms, and hence the greater mobility together with steadiness of the doublets of H, hinder the concentration of H-atoms around of an element.

The great absorption of H by the metals of the VIII-th group (e. g. Pt, Pd, et al.) shows distinctly that these metals are the arena of action between the forces endeavoring to keep the doublet closed and the chemical attraction between H-atoms and atoms of the metal, which endeavor to part (to atomise) the H-doublet.

It is easy to understand, why F does not combine neither with N nor with O or Cl, if we consider the steadiness of the doublets of all these elements⁸.

Doubled atoms of such matters, as H, N, F, et al. give the most evident conception of the magnitude of intensity of homochemical forces and the molecules of H, O et al. are examples of the steadiest homochemical compounds.

At a very high temperature, when the valencies which are less temperature-steady are not able to hold together the fast moving atoms (even a steel bar breaks in case of an excessive development of centrifugal force), strong valencies which are hidden in the steadiest doublets begin to unfold their action, enlarging the steadiness of chemical compounds, formed by absorption of heat, at the highest temperatures, and in such enlarging of steadiness there exists no contradiction with the conceptions of kinetic theory [as e. g. W. Oswald⁹ assumed, not considering the doubletation of atoms].

The crystals of Diamond, Pt and hard-fusible metals, doublets of H, O and other elementary matters are examples of the steadiest chemical compounds.

But of course, there are in the class of homochemical rather compounds unstable compounds, too whereby we may find between the representatives of two extremes – stable and little-stable homochemical compounds – representatives of middle stability moderating by their existence the sharp differences between the opposite members of the class.

Little-stable (in usual conditions of our experiments) homochemical compounds have a prominent consequence for the knowledge of the nature of colloid and true solutions and they are so numerous that the lives of hundreds of energetic young investigators would not suffice only to analyze these compounds.

These homochemical compounds represent a new wide world of chemical compounds.

The necessity of their existence may easily be derived theoretically.

The results of the doctrine of colloids (Dispersoidology) have lead me to the necessary conclusion that we must consider chemical compounds as a putting together of smallest particles of matter (atoms), which have not lost but only more or less changed the properties which they have in free state¹⁰.

Hence follows, that if Ba-atoms in a free state form homochemical compounds – crystals, the atoms of the same Ba, being burdened by other different atoms in their heterochemical compounds, will give homochemical compounds between themselves, i. e. BaSO_4 will give homochemical compounds with all other compounds of $\text{Ba}(\text{OH})_2$, halogen, acetic, chloric, nitric, rodanic etc. salts of Ba.

But as in BaSO_4 except the Ba-atom there also is a rest of SO_4 , BaSO_4 must give homochemical compounds with all sulfates of any metals.

⁵ P. P. von Weimarn. Journ. Russ. Chem. Soc. 1916. p. 706.

⁶ P. P. von Weimarn. Grindzüge der Dispersoidchemie. Dresden. p. VII. 1911.

⁷ P. P. von Weimarn. Journ. Russ. Chem. Soc. 1916. p. 1010.

⁸ I cannot reflect in detail upon my doctrine of valency and am obliged to direct those, who take an interest in these questions to my earlier published corresponding paper vid. Journ. Russ. Chem. Soc. 1916. p. 1040 and 1304.

⁹ W. Oswald. Grundriss d. allg. Chemie, 4 Auflage. 378 (1909).

¹⁰ P. P. von Weimarn. Journ. Russ. Chem. Soc. 1914. p. 621.

What is said about BaSO_4 may be repeated about any other salt or matter, be it composed or elementary.

It was just as easy to make the conclusion about the necessity of the existence of these homochemical compounds, as it is to prepare them.

It was only for absence of clear conceptions, concerning their nature and conditions of existence, that till now these compounds were received occasionally, without any system.

As these compounds mostly exist within the limits of not high temperatures (usual pressure) they are received in fluid mediums.

The dissociating power of the medium is in direct dependence on its dielectric constant. For H_2O this constant is 81,7, for $\text{C}_2\text{H}_5\text{OH}$ – 27,4, for $\text{C}_3\text{H}_7\text{OH}$ – 20,4, for $\text{C}_4\text{H}_9\text{OH}$ – even less.

Moreover the steadiness of homochemical compounds as well as that of the heterochemical, is in inverse ratio to the temperature.

Having realized (since 1907) the colloidal synthesis of different matters (about 200) at different temperatures (+100 to –100) in mixtures of H_2O with $\text{C}_2\text{H}_5\text{OH}$ and $\text{C}_4\text{H}_9\text{OH}$, I have had the opportunity to convince myself of the rightness of the following principle: homochemical compounds with any other matter gives, in corresponding conditions, in case of common atoms or atomic groups.

The existence of these homochemical compounds has given me the possibility to elaborate an universal preparation-method of colloidal solutions (the method of dispergation and of dispersoidal parasitism) which represent in many respects models of true solutions and I can advance the following principle¹¹: *“as well as it possible to draw to a straight line in a plain only one parallel and many inclined, whereby some of these lines scarcely deflect from the parallel direction, so it is also possible to prepare a series of colloidal solutions of the same matter in the most different degrees of stability, but one can never prepare a colloidal solution with boundless stability, the latter being peculiar only to the true solution”*.

With colloidal solution of BaSO_4 in a 50 per cent alcohol (concentration of the solution 0,25 per cent) demonstrated by me in the I Mendelejeff Congress 1907 has present till now; colloidal solutions with the concentration of some per cent and even decades of per cents of the same matter in a $\text{C}_2\text{H}_5\text{OH}-\text{H}_2\text{O}$ medium are stable for some months and weeks and any matter can be received in such stable and high-concentrated state.

This is withal not a theoretical conclusion but simply a conclusion from my own great experimental material.

The preparation and exploration of the above mentioned stable colloidal solutions has permitted me to give a general theory of solutions and the process of solution, where little-stable homochemical (partly heterochemical) compounds are of a great consideration¹².

Homochemical and heterochemical attraction acts also as an important part in the phenomena of supersaturation.

Which are the laws of these little-stable homochemical compounds?

The same as those of heterochemical compounds.

The homochemical compounds crystallize very well, their chemical composition is often very simple, e. g. one molecule to one molecule or one molecule to two molecules.

Many of them are melting without dissociation; those compounds can be received again reversibly from solvents which do not dissociate them perfectly.

As examples may be mentioned the homochemical compounds of AgJ with KJ (molecule to molecule) and AgJ with KJ (molecule to molecule) which, received long ago (1827 and 1832) in needles, have been prepared by my experiments in beautiful full crystals; the first is melting at about 95°, the second turns yellow (reversibly) at about 200°, because of a slackening of the combination and is melting at about 500°.

As the formation of homochemical compounds of this type takes place principally on account of the attraction of atoms (e. g. Ag) heaved by different atoms (e. g. J and NO_3) between which the attraction is less than between homogeneous (e. g. only Ag and only AgNO_3), these compounds are more easy-melting (e. g. the homochemical compound of AgJ and AgNO_3 is melting at 95°, AgJ at 526°, AgNO_3 at 209°) and more loose (e. g. crystals of the homochemical compound of AgJ and KJ are going to the surface of the solution which has separated them; in this solution crystals of KJ and AgJ are sinking) than their components.

One must not conclude that these are specific properties of homochemical compounds.

Water, though having a higher melting-point than its components, dissociates easier than the doublets of H and O, and there are many heterochemical compounds which are melting below their components and dissociate at usual pressure before reaching the melting-point.

Very often, if not always, a heterochemical compound which is melting above both of his components, exists, because of the strongest valencies,

¹¹ P. P. von Weimarn. Koll-Zeitsch. VIII (1911). Seite 25. XII. 307 (1913).

¹² P. P. von Weimarn. Outlines of dispersoidologie theory of true solutions. Petrograd. 1913.

which are hidden in doubled and more composed molecules.

The above treated homochemical compounds which are of such great importance in colloidal synthesis exist in dynamic state, in a state of moving equilibrium, and in solution, and are submitted in these cases to the law of acting masses; therefore in the case of a great excess of one component these compounds can be received in aqueous solutions, too and permit to prepare stable colloidal solutions, e. g. BaSO_4 in a H_2O -medium [e. g. system of $\text{Ba}(\text{CH}_3\text{COO})_2$ and $\text{Al}_2(\text{SO}_4)_3$ in H_2O].

At rising temperature and falling concentration these homochemical compounds separate the less soluble part in precipitate; and on corresponding conditions, the stablest colloidal solutions can be received.

But far from all homochemical compounds can be separated in a gross-dispersed state – in gross crystals; many of them, owing to the fundamental law of Dispersoidology¹³ exist only in a high-dispersed state – an important fact for the knowledge of the process of solution¹⁴.

Some of such dynamic homochemical compounds can be transformed into static compounds by a great degradation of temperature and can be isolated in large crystals.

The method of fusion, so well known and by some explorers considered as an universal method for finding chemical compounds, very often does not fix at all not only homochemical compounds, but also very steady heterochemical compounds, which form themselves at high temperatures.

It is remarkable, that the method of fusion (and other analogic physico-chemical methods) fixes only some compounds, existing on the conditions given.

Extraordinarily steady compounds, which can form themselves at highest (e. g. in consequence of the slackening of the doublets) and lowest temperatures cannot be fixed by this method.

Homochemical compounds, which have permitted me, as said above, to prepare such colloidal solutions, which are in many respects models of true solutions, permit also to imitate chemical reactions of association, dissociation and reciprocal reaction.

For instance, the particles of a colloidal precipitate of BaSO_4 in alcohol-water medium, the surface of which is covered, on account of homochemical attraction, with molecules of MnSO_4 , separate themselves and change into colloidal-solved state if any Ba-salt is added; in the other way, particles of such a colloidal solutions unite themselves and give a pre-

cipitate, if SO_4 -salt is added.

The imitation of the reaction of association, dissociation and reciprocal reaction gets more interesting when two colloidal solutions of one and the same matter are mixed, but with different homochemical compounds at the surface of the particles, e. g. in alcohol-water medium at -10° , colloidal solution of AgJ with an excess of KJ, and colloidal solution of the same AgJ with an excess of AgNO_3 .

In dependence on the greatness of the excess of KJ and AgNO_3 and of the volumes of colloidal solutions to the mixed, one can force the particles to unite themselves, to set and to dissociate again and to disperse.

Homochemical compound permit to make some very important conclusions concerning nature of chemical compound and to fill the interval between so-called «true» and «adsorbotional» compounds.

The research into this question is very important for chemistry generally, yet goes far beyond the frame of this article¹⁵.

I will mention by the way, that different appearances of so-called «physical» attraction between matters are phenomena of the same atomic forces, which in corresponding conditions give the most station chemical compounds and the feebleness of this attraction, compared to the attraction of atoms in free state, is caused by the fact that the attracting atoms are heaved by other atoms.

This conclusion concerns not only homochemical but also heterochemical attraction of atoms of matters being in contact.

The endless dispute between followers of «chemical» and «physical» theories must be considered from the standpoints developed in this paper as quite lacking any scientific sense, since the matter in question are the appearances of in reality exactly the same forces.

Only the different intensity of this appearance and together with this difference the very distinctive variations in the structure of the matters in contact, can be admitted as the principles of a rational systematic of the essentially inseparable «physical» and «chemical» phenomena.

Therefore only those theories can be exact which do not diminish neither the «physical» nor the «chemical» phenomena of atomic forces, these theories must be called «physico-chemical» theories¹⁶.

Homochemical and heterochemical attractions of atoms in contacting matters are very important not only in the appearances of catalysis but also in

¹³ P. P. von Weimarn. Notes of Petrograd Mining Institute. 1913. p. 138. Koll.-Zeitsch. (1913). Seite 124.

¹⁴ P. P. von Weimarn. Outlines of dispersoidologie theory of true solutions. Petrograd. 1913.

¹⁵ See my earlier works concerning this question. Grindzüge der Dispersoidchemie. Dresden. 1911. p. 19-20. Journ. Russ. Chem. Soc. 1911. p. 1915-1918.

¹⁶ P. P. von Weimarn. Koll.-Zeitschr. 1909. p. 156.

the appearances of electrocution by voltaic and frictional electricity.

The young science «Dispersoidology» permits to illuminate from new standpoints such a multitude in most different parts of Natural Science that the Individual explorer really feels the greatest tragedy of not-corresponding of forces and time with the number of problems which Dispersoidology enables to solve with extreme thoroughness.

One must regret that an explorer has only two hands for experimenting, that a day has only 24

hours and that the life is short.

But where one individual explorer has not enough forces a corporate group of explorers could succeed.

Th s staff of young energetic scientific investigators ought to be afforded by the Mining Institute and I am sure it will afford them.

*Petrograd – Ekaterinburg
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