DOCUMENTS

Rein Vihalemm: ‘On the Character of Knowledge in Ancient Chemistry’¹

Translated by Ave Mets²

It is known that “practical chemistry is as old as thinking humanity, engaged in production.” (Menshutkin, 1937, p. 6). Foundations of chemistry have been laid in the observations and practice of “specialists” in processing metals, jewellers, potters and others. A good characterisation of practical chemistry has been provided by J. Bernal. He writes: “The process of smelting ores, of purifying metals, of colouring them, of adding enamels—all involve complex chemical reactions that had to be learned by many trials, mostly unsuccessful. The good results were embodied in recipes which had to be carefully handed down and scrupulously followed.” (Bernal, 1954, p. 85)

In chemistry, the first cognitive level, that of sensory-practical knowledge, corresponds to this characterisation (knowledge is determined, or remains knowledge merely with respect to sensory, practical situation: that is—skill). Fixed in the recipes were practical procedures and all that was observable in the execution of transformations of substances.

J. Bernal has also interesting insights into the genesis of rational thought. He writes,

... the possibility of rational thought for man begins in his relation to his *physical* environment. With a very simple device like a lever, for example, it is possible to know in advance what is going to happen at one end when you move the other. It was on the basis of this eye-hand co-ordination that the rational science of mechanics first grew up. It was in this field, and in

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the first place this field alone, that it was possible to *see* and *feel* intuitively how things worked. (Bernal, 1954, p. 49 [RV has omitted the first emphasis, which is in Bernal])

Clearly, knowledge about such phenomena that one can “see and feel intuitively” becomes relatively autonomous, “breaks free” from, so to say, the actual sensory-practical situation, that is, becomes comprehensible, and has a certain meaning also beyond the sensory-practical situation. However, chemical phenomena could not be comprehensible in the same way. J. Bernal writes: “It was impossible to *see*, in the same rational way, what would happen as a consequence of any action in cookery or brewing. But it was possible to *know* what would happen first by trying and then by remembering or being taught³.” (Bernal, 1954, p. 50)

Cognition begins with a progressive awareness of a practical activity. V. V. Bykov, reflecting on the evolution of cognition, proceeding from the labour process, shows that a direct producer must have knowledge in the form of logical models that reflect the systems of interactions of simple aspects of labour.⁴

However—he writes—in the process of labour, the immediate producer, alongside mechanical interactions, sets into motion complex chemical (for instance, production of paints and their application), biological (animal and land husbandry) interactions. Therefore the logical models of immediate production do not constitute such conceptual systems, all the elements of which would have logical connections. The immediate producer’s logical model is intermittent. (Bykov, 1964, p. 158)

Therefore (i.e. on account of the intermittence of the logical model), at the beginning not only chemical, but also mechanical knowledge was sensory-practical. Knowledge only had a definite meaning in the immediate labour process. Their transfer from one generation to another too happened via learning in the labour process and collective activity. “Only the elaboration of mechanical constructs by means of production and consumption costs established preconditions for the rise of logical models, all elements of whom would be logically interconnected.” (Bykov, 1964, p. 159)

³ Translator’s comment: The Russian version says “contemplating what had been done” instead of “being taught” (Translator’s note).

⁴ Here the definition by Karl Marx is meant: “Elementary factors of the labour process are 1, the personal activity of man, i.e. work itself, 2, the subject of that work, and 3, its instruments.” (Marx, 1887, ch. 7).

There is no purely sensory cognition, since cognition presupposes comprehension of sensed qualities. This comprehension, at the sensory-practical level of cognition happens in an observational-exemplary reasoning on the “background” (“by means”) of direct labour process and collective activity, i.e. in practice.

With the emergence of relatively autonomous rational knowledge, it becomes possible to comprehend sensory qualities not only on the “background” of direct productive activity, but also on the “background” of this rational knowledge by way of *analogy*, construction of model presentations. (Besides, irrational knowledge becomes possible alongside that.)

Allegedly (according to the research by Prof. Davis), chemistry as a definite *inquiry* was born in China (Menshutkin, 1937, p. 16). J. Bernal writes:

chemical ideas originated from the actual method of thinking by analogy [...]. In chemistry there is a fundamental duality—which we now know is due to shortage or excess of electrons—exemplified by metals and non-metals. There is evidence for tracing the first appreciation of this duality to the Chinese, who already in prehistoric times used red cinnabar as a magic substitute for life blood and had resolved it into its elements, sulphur and mercury. Identifying these with the generalized male and female principles, the Yang and the Yin, themselves of totemic origin, the Taoist sect developed a system of alchemy from which it is probable that first Indian and then Arabic alchemy was derived. (Bernal, 1954, p. 203)

The onset of dualism in chemistry and thinking in analogies already corresponds to the second level of cognition, that is, the first rational (i.e., not sensory-practical) knowledge in chemistry, the first expressions of the logic of chemistry. Analogously, as according to the expression of V. I. Lenin, “...man’s practice, repeating itself a thousand million times, becomes consolidated in man’s consciousness by figures of logic” and “on account of this thousand-million-fold repetition, these figures have a stability of prejudice, an axiomatic character” (Lenin, 2007), so also the dualism, the existence of the ‘principles’ of mercury and sulphur obtained the ‘stability of prejudice’, initially in the form of female and male principles.

This kind of chemical knowledge differs already in principle from the knowledge fixed in recipes (i.e., from sensory-practical knowledge), since it is relatively autonomous, determinate knowledge outside of practical, concrete situations of performing chemical transformations, it is to some extent understandable even to a non-chemist, to a person who is not preoccupied with chemical

transformations. Yang and Yin, male and female principles, certainly do not explain the properties of sulphur and quicksilver, but this is how rational knowledge is expressed (albeit in the form of analogy)—knowledge about the dualism objectively existing in chemistry.

The fact that precisely sulphur and quicksilver played an important role in the history of chemistry is not accidental. Here, firstly, chemical and physical properties of those substances are important. Sulphur counts as a fairly ubiquitous metalloid and is found in its native state. It burns very well and, when heated, remains a fairly active element that combines with nearly all metals. One must keep in mind that most of the other active metalloids are difficult to discover because they are gases. On the other hand, it should be noted that the combination of sulphur with quicksilver—cinnabar (mercuric sulphide—*HgS*)—is the most important mercury ore. Add to this that splitting cinnabar is relatively easy and metallic mercury has idiosyncratic, prominent external properties (it occurs in a liquid state and easily forms alloys with other metals—amalgams), then it becomes understandable why namely quicksilver and sulphur were the elements, based on the study of which the logic of chemical phenomena began to take shape.

Secondly, one has to keep in mind the governing laws of cognition. Cognition starts by establishing the external properties of objects. Now since fire—a natural and the first most powerful and ordinary factor in the occurrence of chemical transformations—played an important role in socio-historical practice, the properties of substances were explained primarily in relation to fire. Thereby, as B. M. Kedrov writes, at first the cognition of “properties came to be regarded not as relative, but rather as some kind of absolute, eternal, unchanging ‘essences’, or ‘substances’. The ability of a body to ignite and burn, therefore, appeared not as a relation of the said body to fire, which it actually was, but as a kind of ‘principle’, as a burning ‘essence’ concealed in the body, called ‘sulphur’.” (Kedrov, 1946, p. 17) By establishing this ‘principle’ of flammability, the ‘prototype’ was undoubtedly real sulphur.

The study of metals likewise began with the external properties that are found in relation to fire. L. A. Chugaev wrote:

Already the Egyptians developed the idea that all metals are based on some kind of primary substance, conferring to it, as it seems, its most characteristic property—fluidity, thereafter malleability etc.; and low melting lead was taken for this substance [...].

When quicksilver became known [...], then its properties—the liquid state (so-called absolute fluidity), together with the metallic appearance, made such a strong impression that the role of *materia prima* or ‘the soul of metals’ was transferred on it. (Chugaev, 1962, p. 362)

The ancient chemists recognised several types of quicksilver, yet in the role of the general principle, just as in the case of sulphur, it was regarded as a certain special substance—‘the philosophic mercury’.

It should be mentioned that, at a fundamental level, the real evolution of chemistry remained, also during the alchemical period (i.e., basically from the 7th to the beginning of the 16th centuries), at the sensory-practical level of knowledge; the rational aspect was not formed as a relatively autonomous *chemical* knowledge; no new chemical knowledge emerged at the rational level. L. A. Chugaev, for example, rightly notes: “The ideological aspect of alchemy leaned [...] on the philosophical systems of Plato, Aristotle, and Neo-Platonists, to which some other creeds of Eastern origin were adjoined.” (Chugaev, 1962, p. 362) Real chemical knowledge was sensory-practical (those were knowledge about what and how to do and what can thereby be observed), which could possibly only be acquired directly from the master in a chemical laboratory (workshop).

M. P. Crosland in his inquiry into the language of chemistry comes to the following conclusions about alchemy:

- (a) Knowledge of alchemy was not intended for the casual reader.
 - (b) A practical craft could not be learned from books
 - (c) Few alchemical authors wrote from personal experience.
 - (d) Alchemical literature contained many misleading or false statements.
- (Crosland, 1962, p. 45)

Nonetheless, logical generalisations did arise stepwise (although often in form of obscure analogies), and the rational aspect developed in chemical cognition.

As for the ancient Greek philosophical teachings, with which the presentation of the history of chemistry usually begins, it should be noted that they are not so closely related to the emergence and evolution of chemical knowledge. It was only post hoc that attempts were made to associate chemical knowledge with natural philosophical speculations.

J. Bernal rightly notes: “Chemistry had never been part of the classical canon,

and the Aristotelian elements, earth, water, air, and fire, had always had a meteorological and physical aspect, rather than a chemical one" (Bernal, 1954, p. 331). This is exactly what P. Walden wrote about: "His (ancient Greek's—*R. V.*) personal needs, his dependence on the climate, on water, fire, earth, lead him to the four elements. His personal psychology is projected on those elements, therefore equipped with the feelings of friendship, hate (meaning the doctrines of Empedocles—*R. V.*), etc." (Walden, 1921, p. 21).

Neither were the atomistic studies of Leucippus, Democritus, Epicurus, Lucretius Carus directly related to chemical practice; they rather emerged as ideational explanations of certain phenomena which were observed in everyday life. In the poem of Lucretius Carus 'On the Nature of Things', for instance, the following phenomena are considered by the articulation of the atomistic study: wind, water, scent, heat, cold, sound, clothes that grow damp and dry, ring that becomes thin, etc. (Lucretius, 1919, pp. 12–14).

In summary, chemical knowledge in the antiquity was primarily sensory-practical. However, owing to the repetition of the results when performing chemical transformations and reasoning by analogy, some rational knowledge existed too, and to some extent the so-called chemical logic was known.

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