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TRANSMUTATION OF BASE-METALS INTO GOLD AS DESCRIBED IN THE TEXT *RASĀRṆAVAKALPA* AND ITS COMPARISON WITH THE PARALLEL CHINESE METHODS

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Rasārṇavakalpa[1] is a Sanskrit text giving alchemical recipes. It is edited and translated into English by Roy and Subbarayappa. They date it an 11th century work. Here an attempt is made to understand the transmutation processes of *Rasārṇavakalpa* from a chemical view point. A close parallel of these methods to those prevalent in China in medieval times is also pointed out.

THE TEXT *Rasārṇavakalpa*

The Sanskrit text *Rasārṇavakalpa* is a part of tāntrik text, *Rudrayāmala*.[2] It was found in the collection of Asiatic Society of Bengal. The author and the date of writing this text is not mentioned in the text. A part of this text is found also in a well-known *Rasaśāstra* text *Rasārṇava* of twelfth century A.D. This text is translated into English by Roy and Subbarayappa who consider it an earlier work, or compilation of yet earlier texts, made around 11th century A.D., since it places more emphasis on the material immortality and transmutation processes, than on iatro-chemical methods.

The older attempts of transmutation of base-metals into gold were proved to be baseless by the modern atomic theory. Still the enterprises of the medieval alchemist, though never yielded what they were looking for, helped to accumulate considerable data which when studied devoid of its superstitious and religious content, disclosed basic facts, which with meticulous experimentation led to the correct ideas about the nature of elements, properties of matter, and theories of chemical combinations and later to the modern atomic theory, bringing the chemical revolution of the eighteenth and nineteenth century to a successful end.

Though, no doubt, only the repetition of the chemical experiments, with all the ingredients involved and strictly observing the directions mentioned in the text, that the true nature of the processes occuring in the so called transmutation of base-metals into gold will be revealed, a close study of the text enables one to draw inferences regarding the processes involved with the help of the present state of chemical knowledge.[3]

CHINESE ALCHEMY

Needham[4] has studied Chinese alchemy extensively throughout the history of China prior to the introduction of modern chemistry, i.e. from 4th-5th century B.C. to the 17th-18th century A.D. There are evidences of gold-making during this entire period and also that of metallic-mineral elixir preparations. Needham divides the gold-making or aurifaction as he calls it, into different categories[5] according to the chemical processes involved in them. They are

(*i*) Uniform substrate alloys
(*ii*) Surface layer enrichment by addition
(*iii*) Surface layer enrichment by withdrawal
(*iv*) Surface film formation
(*v*) Some other special cases.

The gold-making by all the above categories except some of the special cases is found in the text of *Rasārṇavakalpa*.

TRANSMUTATION PROCESSES IN *Rasārṇavakalpa*

The transmutation processes, changing base-metals into noble metals, described in *Rasārṇavakalpa* involve either making a uniform alloy or the formation of gold-coloured films on other metals or alloys. The uniform alloys are of two types, one being simple debasement of noble metals and the other being preparation of an alloy with the desirable colour without having any noble metals in them. The golden films achieved are usually by sulphide films formation or by gilding. At a few places, gilding by amalgamation is also carried out.

(I) UNIFORM SUBSTRATE ALLOYS

Debasement of noble metals

22 carat gold contains 8·3 percent copper and 91·6 percent of gold. By further addition of copper to this 22 carat gold, the colour changes to pale yellow and then bright golden red when the percentages of copper and gold are equal.[6] We come across this kind of debasement of gold by copper in *śloka* 599. The quantities of the two metals added are not mentioned but the product is termed as 'impotent' gold, so it might be reddish and hard. The percentage of gold could not be less than fifty percent even for it to go under the name 'impotent gold', because beyond 50 percent copper will cause a distinct red tinge. In *śloka* 762 a similar process is described. Here a mention is made that the colour of the alloy improves by addition of more and more gold to it.

Śloka 81, line one, describes the preparation of an alloy of gold, silver and copper, approximately in the proportions 1:2:6 by weight of the respective metals.

Simple debasement of silver with copper, the colour remains white until the latter reaches some 50 percent, after which it is yellowish until 70 percent and then distinctly red[7]. In certain conditions, therefore, a gold-like alloy could be obtained with silver and copper alone. The *śloka* 473 gives the method of preparation of this silver-copper alloy. The colour is described as that of rising sun, i.e. reddish. Hence the percentage of copper must be above 70 percent. The quantities mentioned in this *śloka* also agree to this, the addition of one-fourteenth part of silver, two times to copper would give the alloy with approximately 85 percent of copper. *śloka* 184 gives the alloy of gold with lead.

Uniform alloys without noble metal as a constituent

The uniform alloys of the second type, i.e. without having noble metal as their constituent, are prepared by two methods. First is amalgamation and second being brass-making. The fact that amalgams of various metals, tin, lead, copper are silver coloured and that of silver is golden, is made use of in these gold making processes. The preparation of tin-amalgam is described in *śloka* 803. The amalgamation of copper in *ślokas* 260, 363, 404 and that of lead in *śloka* 803. In *ślokas* 131-132, the method of amalgamation is combined with that of debasement of gold. By the addition of increasing amounts of gold to the copper amalgam, the required golden alloy is obtained with decreasing amounts of mercury. *Ślokas* 357-358 describe the amalgamation of silver to give a golden coloured alloy. Here the heating is in a close crucible whereby mercury is not allowed to volatalise and escape.

The *ślokas* 370 to 372 give the method for brass-making by using calamine or zinc carbonate. (Here it is interesting to note that both in India and China brass-making is very ancient, but calamine method is comparatively a later development.[8,9] Copper, copper sulphate and calamine are heated in presence of sulphur, glass (*kāca*)* and four kinds of basic substances; two of which are plants and two are minerals. The quantities of copper, copper sulphate and calamine added are such as to give approximately proportion of copper to zinc as 2:1. This is the proportion in common brass. The reducing action of sulphur is made use of in this process. Heating of zinc carbonate and copper sulphate will evolve acidic gases such as carbon dioxide, sulphur di and tri oxides which are neutralised by the basic substances which are added initially. Sulphur reduces oxides of zinc and copper to respective metals which form an alloy, i.e. brass. Oxides of sulphur which are again formed will react with the four basic substances, to form salts. Glass acts as a flux in this reaction.

The property of arsenic when present in copper to the extent of two percent giving copper a golden colour is utilised in *śloka* 405.[10]

**Note added by referee:*

As substance in any alchemical and chemical preparations, *kāca* indicates two salts:

(*a*) *Kācalavaṇa*, i.e. factitious salt procured by boiling earth impregnated with saline particle (*kāca*).

(*b*) Black salt, i.e. *viṭlavaṇa*.

Surface film formation

The other category of transmutation processes is that of a surface film formation. This surface film is either of gold itself or of a yellow coloured compound formed on the surface layer, usually a sulphide.

(II) Surface Layer Enrichment by Addition

Before the invention of electro-plating the gilding and silvering of metal objects by means of mercury amalgams was by far the commonest method in the East as well as in the West.[11] If gold is dissolved in boiling mercury a butter-like amalgam is obtained and this is smeared over the cleansed metal surface, adhering as molten tin does when a piece of iron or copper is dipped into it. When the mercury is volatalised by heat, leaving a smooth gilded surface on which further layers can be deposited if this process is repeated.

Mercury was known in the West since Aristotle's time. The properties of mercury were first explored in China, in the Warring States, i.e. fourth century B.C. and by the second century A.D., amalgamation gilding was a standard practice.

The descriptions of this kind of amalgamation gilding are found in the *ślokas* 150, 720, 600-602.

(III) Surface Layer Enrichment by Withdrawal

A little different kind of gilding is carried out in the *ślokas* 602-603. This is the process Needham[12] names as 'surface-layer enrichment by withdrawal' of the base-metal. Either an alloy of the noble metal or that of other metals with a layer of noble metal alloy on the surface is used in this method. When heated, the base-metal from the surface layer is oxidised and removed usually with the help of an acid. The noble metal remains unchanged and this leaves its layer on the surface of the alloy. In the above mentioned *śloka*, copper is first coated with copper-gold alloy and subsequent heating causes copper to form copper oxides which are dissolved in the organic acids, whereas gold remains unchanged and gilding is thus achieved. The plant *rudantī* containing organic acid is used in the process.

(IV) Sulphide Film Formation and Tinging

A thin film of yellow sulphide of copper is formed on the surface when copper is exposed to sulphur. The sulphur-giving substances are cinnabar, realgar, orpiment and sulphurous waters. A clear indication of the sulphide film formation is in *śloka* 79. In this kind of process[13] sal ammoniac is used to protect the metal surface from oxidation which helps to make the surface clear and formation of a good sulphide film. The use of ammonium salts for cleaning the metal surface is noticed in *śloka* 744. Sulphurous waters are used as sulphur-giving agents in *śloka* 697.

Both chloride and carbonate of ammonia attack and colour many metals. This is probably the process in *ślokas* 113-114.[14]

Dyeing lead with *mañjiṣṭhā* i.e. madder in the presence of sal-ammoniac is noticed in *śloka* 110.

Plants with characteristic constituents and chemical actions are met with throughout the text. The appropriate application of plants and their extracts reveals the extensive research and experimentation carried out by the alchemists. Some of the plants are used as organic dyes[15], reducing agents[16], organic acids[17] and bases[18].

In this way, we find that gold-making by all the first four categories mentioned by Needham in Chinese context is described in the text of *Rasārṇavakalpa*.

(V) Special Cases

Some processes which Needham considers as special cases are absent in *Rasārṇavakalpa* and these special cases invariably give purple gold.[19] This variety of purple gold contained 95 percent Cu, 1 percent Ag and 1÷05 percent Au and the purple film was formed upon treatment with solutions of copper acetate, copper sulphate and acetic acid. Probably Indians did not revere purple colour as the Chinese did and the purple sheen gold found no base in India. Also many syntheses giving the combinations of different metals, yielding purple alloys which are found in Chinese texts are absent in the above Indian text.

Mosaic gold is conspicuously absent. Ko Hung[20], the 4th century Chinese alchemist, describes a process for making stannic sulphide i.e. mosaic gold, by hearing tin, sulphur and salammoniac. All these substances are frequently mentioned in *Rasārṇavakalpa*, in a number of syntheses but not that of mosaic gold.

Mention of 'poisonous water' in Chinese Text

Needham[21] mentions a passage from the text '*Yu-Yang Tsa Tsu*' written by Tuan Chheng-Shih in the year 863 A.D. The writer gives an account of the happenings in the year 648 A.D., in which an Indian Prince A-Lo-Na Shun (A transliteration of a word Aruna Chandra meaning The red Moon) was captured by the Chinese ambassador, Wang-Hsuan-Tshe, and was presented to the Chinese emperor. An Indian scholar named Na-Lo-Mi-So-Po (The original Sanskrit word Nārāyanasvāmin is conjectured by Needham but Nārāyanmiśra is probably a better choice) who accompanied the captured Indian prince, describes a kind of water to the Chinese emperor, who is interested to get drugs of prolonging life. This was described as produced in mountains, in stone vessels and stored in a gourd. It has the property of dissolving herb, wood, gold, iron and also human flesh. It occurred in seven colours and transliterated by the Chinese historian as *Pan-Chha-Cho-shui*, i.e. *Pan-chha-cho* water.

This above description meets with that of poisonous water described in *Rasārṇavakalpa*[22]. Poisonous water, i.e. *vioṣdaka* is also characterised by three colours red, yellow and black (The mixtures or dilutions might produce more colours). *Viṣodaka* is called by that name because it is destroyer of animal, bird and human beings. *Viṣodaka* is mentioned as an excellent substance which bestows perfection in alchemical undertakings. The uses of this poisonous water for rejuvenation and transmutations of metals are described in *ślokas* 743 to 745.[23] This is also stored in the hollow portion of bitter gourd. Yet another kind of water is described as produced in mountains and used for transmutation of metals and for imparting perpetual youth. Probably both the waters were described by the Indian scholar of 7th century in Chinese court.[24]

Needham[25] conjectures the *Pan-Chha-cho-shui* as a transliteration of 'Panjab Water'. Thus he is suggesting the word *pañca* meaning five in Sanskrit (*Pañca-āp*= Panjab). A more probable origin can be the word *pañca-viṣa* as a kind of water which dissolves or kills all the five elements. Attaching the word *udaka* for water, i.e. *shui* we get a word *pañca-viṣa-udaka* or *pañca-viṣadaka*. When *pañca-viṣodaka* was transliterated it gave the word *Pan-chha-cho-shui*. Thus, etymology of the word *paṇ-chha-cho*-water also brings us near *viṣodaka* as found in *Rasārṇavakalpa*.

The aforesaid account is in a way important because its date is firm, i.e. 7th century A.D. This suggests that some of the chemicals and processes described in *Rasārṇavakalpa* were known even 4-5 centuries earlier. Also it gives an evidence of the transmission of ideas of mineral acids from India to China at that early date.

In connection with the story of the Indian scholar in Chinese court, Needham[26] remarks, "This story suggests the desirability of further researches on the borderline between Chinese and Indian chemical technology".

CONCLUSION

A close study of the gold-making processes or aurifaction in *Rasārṇavakalpa* reveals similarities between these processes to those current in Chinese alchemy. Most of the processes mentioned in the Chinese texts are also found in this text; hence they might have been transmitted from one country to another, the exact direction and period of transmission is a question of further research.

The description of mineral acids given in *Rasārṇavakalpa* agrees with that given by the 7th century Indian scholar in Chinese court, which suggests that *Viṣodaka kalpa* part of the text of *Rasārṇavakolpa* was written or its chemical contents known in India at least five centuries earlier, though the compilation of the text took place in 11th century A.D., as suggested by Roy and Subbarayappa. Also it supports Needham's opinion about the transmission of ideas about mineral acids from India to China by 7th century A.D.

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[9]Needham, J., *SCC* Vol. 5, Part II, p. 213.
[10]———, *SCC* Vol. 5, Part II, p. 223.
[11]———, *SCC* Vol. 5, Part II, p. 247.
[12]———. *SCC* Vol. 5, Part II, p. 250.
[13]Roy, M. and Subbarayappa, B. V., *RSK*, p. 68.
[14]Needham, J., *SCC*. Vol. 5, Part IV, p. 434.
[15]Chopra R. N. and others, *Indigenous Drugs of India*, Second edition, Calcutta, 1958, p. 466. *Kaṭutumbi (Langenaria vulgaris)*, which is Indian bottle gourd, has a musk-like odour. Musk itself stains the paper yellow.
Kuṣmāṇḍī, (Benincasa cerifera), i.e. wax gourd also contains a yellow dye.
[16]*ibid.*, p. 386, *Citrak*, i.e., plumbagin is mentioned to contain a reducing sugar.
[17]*Mātuluṅga*, *(Citrus medical)* contains citric acid., see *RSK*, p. 124.
[18]Roy, M. and Subbarayappa, B. V., *RSK*., pp. 121, 123. *Apāmārga* contains saponins and kadali, amines which are bases.
[19]Needham, J., *SCC*. Vol. 5, Part II, p. 257, 264.
[20]———, *SCC* Vol. 5, part II, p. 271.
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