Indian Journal of History of Science, **31**(4), 1996

MŪṢĀVIJÑĀNA OR THE ANCIENT SCIENCE OF CRUCIBLES

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(Received 7 May, 1996)

Although it is well-known that Indian metallurgy had reached great heights during the medieval period, very little is known about the actual techniques adopted by the metallurgist. Sanskrit alchemical texts, written around 11th-16th century AD could be fruitfully explored for this kind of investigation. Some aspects of the development of medieval metallurgy viz. *Mūṣavijñāna* or the science of crucibles is discussed in this article whereby a variety of crucibles, their origin, construction and applications are noted down. Principles behind the choice of crucibles and crucible - linings for a number of crucible reactions are explained. They are substantiated with textual examples. Thus an attempt is made here to contribute towards the reconstruction of medieval Indian chemico-metallurgy.

Key-Words : Crucible-lining, Mūṣa-lepa

It is a well-known fact that Indian metallurgy had reached great heights during the medieval period i.e. 500-1500 AD. Statues of Buddha made of copper, bronze and brass were cast in India, China and other eastern countries under the expertise of Indian monk-metallurgists. It has remained an intriguing fact as to how the medieval metal workers could make large iron pillars which have remained totally rust-free over the centuries. Although these statues and pillars stand testimony to the superior knowledge of metallurgical techniques for the medieval Indian metallurgists; very little is known about the processes adopted by them. Chemical analyses do give an idea as to their composition, yet the methods which could furnish products of this quantity and quality have remained undiscovered. A key to these unsolved problems in the history of medieval science and technology of India possibly lie in a three-fold study :

1. A thorough study of the archaeological finds of the period.

2. Survey of the processes adopted by metal-workers of hilly and undeveloped regions where in all probability medieval methods are still in use, and

3. A study of medieval texts related to metals and metallurgy.

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In the present article we concentrate on the last mode of investigation *viz.* the textual study.

A large number of texts were written, in Sanskrit and other regional languages, between 11th to 16th century AD which were devoted to the so-called transmutation of base metals into gold and silver which is metallurgical alchemy, and to the syntheses of elixirs of life which is physiological alchemy. They resembled those on *āyurveda* or ancient Indian medicine, in terminology and which discussed variety of metals, minerals, plants, extraction and purification of metals, apparatus etc. Alchemical and *āyurvedic* texts differ in their later parts which dealt with alchemical processes and medicinal recipes respectively. It appears that the authors of alchemical texts were also experts of *āyurveda*. It is possible that they were the ones who strayed away from ayurveda and indulged in alchemical experimentation, out of fascination for it. The more they laboured in this field, more were their findings and innovations. Therefore these texts present themselves as a profound source for understanding and assessing the chemico-metallurgical development of the period. Among various topics such as location, identification of ores and extraction of metals from them, fuels, fires and apparatus; the one dealing with *Mūṣā* or crucibles is taken up in this article. It tries to discuss the science of crucibles and crucible-linings as perceived by the alchemist, and made apparent from his selection of crucibles and their linings in a number of crucible - processes.

The article is divided into three sections. Section I discusses etymology of the word *Mūṣā* and also its synonyms. Section II discusses construction and applications of a number of crucibles, giving textual examples whereas section III discusses a number of crucible linings and their applications, again giving examples from texts like *Rasārṇava (RSN), Rasakāmadhenu (RSKN), Rasopaniṣad (RSPD), Rasaratnasamuccaya (RRS), Gorakṣasaṃhitā (GRS) and Rasārṇavakalpa (RSNK)* which are believed to be written between 11th to 14th century AD.

Identification of plants poses some problems. Usually a particular kind of plant has great many synonyms, also a particular plant name could refer to different plants. To overcome this difficulty, close relation of alchemy to *āyurveda* is taken into consideration. Plants are identified with their frequently used names in *āyurvedic* texts i.e. given a particular plant name, the most likely species from the *āyurveda* dictionaries is selected as the most acceptable one.

Origin of the term '*MŪṢĀ*' and its Synonyms.

According to *Rasaratnasamuccaya* (RRS, Chapter 10, Verse 2) a *Mūṣā* is one which destroys faults in metals.

The word *Mūṣā* has its origin in the process of purification of metals to which it is primarily employed.

A *Mūsā* is one which destroys faults in metals. (RRS 10.2)

Further the synonyms of *Mūṣā* given in a verse from RRS describe its properties and applications. The experts of alchemy call *Mūṣā* also as

Kroncikā - one which has a beak like that of a *kronca* bird (a heron) (for pouring molten metals?)

Kumudī - one which makes metals white i.e. purifies them.

Kārahāṭikā - one which makes *hāṭaka* or gold.

Pācanī - one which heats or digests

Vahnimitra - friend of fire, i.e. one which stands fire.

Crucibles were always made for a single use. After completion of the operation, the crucible was broken to take the product out. A verse from *Rasakāmadhenu* is indicative of this practice.

Strongly heat lead using bellows, in a crucible made using earthworm essence. Then break that crucible and get the fine powder.

(RSKN 2.207)

Similarly in Gorakṣa *saṃhitā* when the crucible is broken, the essence falls down. (GRS 5.231)

Classification of Crucibles, their Constructions and Applications.

Discovery of metals and their various applications paved way to the science of metallurgy of which crucibles were an inevitable part. Earlier crucibles were used for just extraction and purification of metals. Increase in the number of known metals led to experimentation in alloy-making and also in gold-making i.e. alchemy, which flourished in the later half of the medieval period. Crucibles were now modified for their specific uses in alchemy thus developing the science of crucibles. Constructions of some prominent categories were as follows :

1. *Sāmānyamūṣā* (ordinary crucible) : Crucibles were usually made of earth and iron-powder. Apart from these two substances horse-dung, powdered coal, burnt chaff

of grains were also added. After mixing the well-ground substances and after adding some moistening agents like milk, a fine paste was made and crucibles of various shapes and sizes were constructed from it. Moulded crucibles were then roasted in a furnace to make them hard, durable and heat-resistant. A crucible made from the above substances was a *Sāmānyamūṣā* which was employed in common operations like melting and extraction of metals from their respective ores, where high temperatures were not needed.

2. *Vajramūṣā* (diamond crucible) : It was a specially made hard-crucible which contained specific proportion of the above ingredients. It was used for extraction of metals from ores, where moderate temperatures are needed.
(RRS 5-171, 230); RSN, 14-151)

3. *Yogamūṣā* (combining crucible) : This kind of *Mūṣā* was made of burnt chaff, powdered and burnt coals, earth from a place where white ants abound, and a *biḍa* which is a preparation of various alkalies, acids, salts etc. After constructing this crucible, it was smeared with *biḍa* on both inner and outer surfaces and then dried well. This *Mūṣā* was used for the cultivation of mercury. It is said that it could render mercury very powerful.

4. *Vajradrāvanīmūṣā* (diamond-melting crucible) : It was made of very fine earth obtained from lakes, earthworm or cochineal essence, burnt chaff moistened in buffalo-milk. This could stand high temperatures and it is said that even diamonds could be melted in such a crucible. (RRS 10-12)

5. *Varamūṣā* and *Gāramūṣā* (superior crucible and a lake-earth crucible) : They were made of different proportions of burnt coal, chaff, black earth and the earth obtained from lakes. These crucibles could stand fire for increasing time periods.
(RRS 10-15, 10-13)

6. *Varnamūṣā* (dyeing crucible) : This was again a special kind of crucible which was made of red-coloured earth, juices of red-medicinal herbs such as *Manjiṣṭha (Rubia cordifolia*, Linn.), flower of Kusumbha (*Carthamus tictorus* Linn), lac, essences of cochineal and earthworms. This crucible acquired a red colour and bestowed excellent colour to the calx of mercury or other metals, which were roasted in it. (RRS 10-17)

7. *Raupyamūṣā* (crucible for silver) : This is a special crucible made of white-earth, medicinal herbs which are white such as *Śvetagunjā* (a variety of *Abrus precatorus* Linn., having white seeds), *Nadyāvarta* (*Ervatamia divaricata* Linn.) etc. When a calx of silver is made in this crucible it becomes very white in colour. (RRS 10-17)

Furthermore *mūṣā* is classified into two categories. *Prakāṣamūṣā* - an open crucible and *Andha* or *Mūkamūṣā* - a closed crucible. Depending upon whether or not the ingredients could be exposed to air, or a volatile component let pass; either an open or a closed crucible was used in chemical operations. (GRS 5-213), RSN 14-67, 72).

There were a few more varieties of crucibles which were named according to their size and shape e.g. *Golamūṣā* (spherical), *RRS* (10-28); *Vṛntakamūṣā* (of the size of an egg-plant), *RRS* (10-24); *Mahamūṣā* (a large one), *Manjuṣāmūṣā* (box-shaped) etc. *Pakvamūṣā*, (a roasted crucible) *Bhaṣmamūṣā* (made of calx), *Śuṣkamūṣā* (a dry crucible) were the names given according to the ingredients used and process employed in their construction.

Furthermore *Gorakṣasamhita*, a 13th century AD text, mentions following types crucibles :

Garbhamūṣā - made of earth, having a round mouth and heated using grain-husk. (GRS 5-172, 73).

Agnimūṣā - fibre-crucible (GRS 6-575, 5.146).

Gandhamūṣā - sulphur-crucible (GRS 5-128, 5-227).

Manimūṣā - precious stone-crucible (GRS 6-34, 36).

In some texts like *Rasopaniṣad*, the author does not provide classification or systematic description of crucibles or their uses. But from the choice of crucible he makes it is apparent that he had the basic knowledge of their construction and application.

1. An ordinary crucible is used for the operations of non-ferrous metals having low melting points.[8] e.g. tin.

'Take powdered mica and an equal amount of silver in a crucible, close it and heat. Similarly place tin in a crucible, the amount being one and a half times (that of mica or silver).' (RSPD 3-7)

2. When the mixture to be heated contained mercury, an iron vessel was used, since iron does not readily form an amalgam with mercury[9].

Make a paste of salt, mica and juice of plant *Arjuna* (*Terminalia arjuna* Linn). Heat it and grind in a stone-mortar and add mercury to it. Add superior mercury to the fresh juice and mix over fire made of chaff in a good iron vessel. (RSPD 16-273)

Likewise in yet another verse mixing and heating of mica and mercury is carried out in an iron vessel[10].

The kind of roots which are used for the mixing of mica, the same kind should be used for the mixing of mercury. Firstly mix them in the day-time and with that itself steam it at night.

Place a handful of it in an iron vessel and heat using fire made of rice husk. First mix one-thirty second part and successively increase to one-eighth part. (RSPD 17-31).

3. It is known[11] that organic matter used in the making of crucible modifies the properties of the metal melted in it like increasing mechanical strength or plasticity. We see that a specially-made crucible, with fine-earth and leaves of plant *kṛṣnārjuna* (*Terminalia arjuna* Linn. or *Lagerstroemia speciosa* Linn) is used for melting iron sheets. It could stand high temperature required for melting iron (Mp of iron is 1030°C).

Take plant *kṛṣnārjuna*[12] alongwith its leaves.

Take finely powdered clay and with it make a crucible. Place the iron sheet into it and melt it. (RSPD 16-249)

4. A special container called *kācapātra* (a glass-vessel), which was possibly made of earth containing saline particles, is employed for heating very strong mixture which would corrode ordinary crucibles[13]

Now I will narrate the operation *Jāraṇā* in the case of ordinary liquifaction methods. The important liquifaction method consists of the one in which amber-extract is mixed.

Add one part each of the substances of red variety, *upaviṣa* (minor poison) that called *gandha* (Sulphur) and natron. Add three parts of rock-salt, mercury, *viṣa* (poison) and *sauvarcala* (salt petre or nitre) one by one.

Add half the quantity of mercury to it and powder them all. When it becomes homogeneous, after several grindings, then place it in a glass-vessel.

Take hundred parts of liquor and mix it with moss and amber and dry in the sun. Perform this operation hundred times, using alkali, bile, acid and that which is obtained from urine.

When it is mixed with visa and alkali it becomes capable of liquifying metals. (RSPD 15-188 to 192.1)

MŪṢĀLEPA Or Crucible-Lining

Not only that the medieval alchemist could construct a number of different crucibles suited for different chemical operations, or suited for a particular reaction mixture; he also lined them with various pastes to serve some specific functions. These linings (also the process) were called *Mūṣālepa.*

Different categories of *lepas* are as follows:

1. The one used to securely close the joints and cracks. This *lepa* was given on the outer surface of the crucible and lid. It reduced the possibility of escape of volatile ingredients and also that of heat.

2. The one which is used to reduce the porosity of the crucible. This *lepa* was on the inner surface of the crucible and it reduced the absorption of molten metals into the body of the crucible.

3. The one which provided reducing agents like sulphates and sulphides, organic matter containing carbon which helped in :

(i) the reduction of metallic ores to pure metals and

(ii) synthesis of a homogeneous alloy by reducing the traces of oxides of metals used in alloy-making.

4. The one which provided acidic or basic atmospheres required for a particular chemical process.

5. The one which provided a non-absorbent coating to the inner surface of the crucible, especially to reduce the possibility of absorption of noble metals which are in the mixture.

6. The one that provided a small trace of a necessary ingredient to the reaction mixture, which helped in modifying the physical properties of the alloy.

Following are the examples of each kind of *lepa* :

1. To check the possibilities of escape of ingredients :

(i) The *lepa* used for sealing the crucible and lid was called as *Mudrā* and the process as *Mudraṇa.* In *Rasārṇavakalpa* we find that the author instructs to seal the crucible, while describing the process of brass-making with copper, copper sulphate and

calamine. It was to retain the volatile ingredient like zinc in the reaction mixture.

After again adding powdered '*kāca*' (earth containing saline particles) seal the crucible. Then heat it in fire made of cow-dung cakes till copper melts.

(RSNK 372)

(ii) In *Rasopaniṣad* we find that the author has taken precaution not to let mercury escape by volatilization, by applying the paste on the outer surface of the crucible and also by wrapping it with a cloth and tying with a thread.

With that very substance cover the paste and smear the outer surface of the crucible.Then cover it with a cloth and tie it with a thread. After placing, smear it with Tuttha (copper sulphate) which is obtained from the earth, and heat it in a closed crucible in the fire made by burning cowdung cakes till it becomes hot.

(RSPD 13-15, 16)

2. To reduce the porosity of the Crucible :

If the crucible is porous it would absorb certain amount of reactants, or molten metals. To reduce this possibility a fine paste *consisting* usually of ground grains of *Māṣā* (*Phaseolus radiatus* Linn.) and powdered seeds of *gunja* (*Abrus precatorous* Linn) was used. Its cement-like texture sealed the pores on the inner surface of the crucible. This paste was also used for covering the joints and making the closed crucible air-tight.

A 'lepa'[17] made using chalk, salt, powdered grains of plant *Māṣā* (*Phaseolus mungo* Linn), molasses, Bdellium, plant *Atasī* (*Linum usitatissimum* Linn), powdered on a grinding stone, is highly respected. (RSKN, p. 14)

also take powdered mixture of conch and grain of plant *Māṣāka* and smear it well with it so that no pores remain. (RSPD 16-208)

3. To provide a reducing atmosphere :

When the chemical process to be carried out in the crucible is that of reduction, the lining consisting of sulphur, carbon in the form of soot (as reducing agents), faeces, blood or other parts of animals which provide carbon for reduction is employed. Usually these linings are used for reducing the calx of metals, to obtain metals in their pure form.

(i) To carryout reduction process :

Reduction of an ore, using organic matter like blood of a goat, five produces of

a cow (milk, curds, ghee, urine and faeces) is carried out in Chapter 16 of *Rasopaniṣad.* Powdered ore is mixed with the above substances and the paste is then smeared on the inner surface of the crucible. When the lining is dry, crucible is heated, when the essence of the ore separates out which is further used in transmutation of metals.[19]

In the state of *Pippali* there are rocks of metal gold (probably golden coloured silver pyrites). Bring them with efforts and make them into a smooth powder. Mix all these substances which are powdered, with horse's blood, and dry in the sun. Further liquify them using human blood for seven days. Again make them into a paste using the juice of a plant *Tulsī* (*Ocimum scentum* Linn) and *Pañcagavya* (five produces of a cow). Then collect the superior *rasa* by using the method of *chidrayantra* i.e. a container having a hole at the bottom. When copper is brought into its contact it transmutes copper in the proportion one is to hundred. (RSPD 16-12-15)

Rasaratnasamuccaya mentions this very method for collecting the essence of *vimala* or iron pyrite which is the sulphide ore of iron.

Powdered *vimala* is mixed with borax, and calx of plant *Meṣaśṛngī* (*Gymnema sylvestre* Rox.). Further it is mixed with the juice of plant *Lacucī* (*Artocarpus lakoocha* Roxb) and a paste is obtained. This paste is smeared on the inner surface of the crucible, dried and crucible is then tied. Further it is roasted in a closed crucible when an essence resembling lead is obtained, which is called *Rasāyana* (an elixir)[20].
(RRS 2.101-102)

Likewise *Gorakṣasaṃhitā* gives a similar method for collecting mica essence.
(GRS 5-293).

(ii) To make homogeneous alloys :

When the process carried out in a crucible is that of making an alloy of pure metals, care has to be taken so that while melting, the metals do not get oxidized. Therefore a closed crucible is used. Furthermore the crucible in which metals are melted is smeared with organic matter like blood, bile which reduce any oxide formed in the process, thus ensuring a homogeneous and sparkling alloy.

A *lepa*[21] made by mixing blood with *kumkum* (red dye), bile of peacock, and cow bezoar, is highly respected. Thereafter when roasted in the fire made of coal, using bellows (the alloy) shines like fire. (RSPD 2-35.2, 36)

A similar use of sulphur is observed in the process of alloy-making, when the crucible called *Gandhamūṣā* or a sulphur-crucible (crucible smeared with a mixtur

containing sulphur) is mentioned in *Gorakṣasaṃhitā*. (GRS 5.128)

Substances which facilitate homogeneous mixing of metals are listed in a verse from *Rasahṛdayatantra* (RSHDT)[22] as follows :

When wool, borax, bitumen, *karṇakṣimala* (dirt from ears and eyes?), cochinella and a crab are ground in woman's milk it can homogeneously mix all the alloys[23]. (RSHDT, 23-6)

4. To provide acidic or basic atmospheres for a particular chemical process :

(i) Acidic Atmosphere-

A *lepa* used for calcination or *jāraṇa* operation consisted of a mixture of various salts, sour rice gruel, alkaline calxes of plants like *Palāsa* (*Butea monosperma* Linn) and *Apāmārga* (*Achyranthes aspera* Linn) and other plant juices.

Take powdered plant *Palāsa*[24] and *Apāmārga*, carbonates of potash, sour rice, gruel, nitrate of sodium or potassium, ferrous sulphate, seas-salt, rock-salt, black-salt, borax, sal-ammoniac, camphor and pyrite mixed in equal amounts and ground in milky juices of plants *Snuhi* (*Euphorbia nerifolia* Linn) and *Arka* (*Calotropis giganta* Linn) and smear the crucible with it.

(ii) Basic Atmosphere-

Basic atmosphere which is required for the purification of silver (since Ag_2S, AgCl and Ag_2O are soluble in strong alkaline solutions) is provided by a *lepa* consisting of alkaline extract of plant *Moksa* (*Stereospermum suaveolens* D.C.), earth and brick-powder. It is well-known that burning of bricks produced ammonium chloride (which was called *Cullikalavana* or 'salt deposited in the hearth' for that reason). On heating it gives out ammonia in which silver halides are readily soluble. (RSN 4-46)

As to the antiquity of this salt *Navasāra* or *Cullikālavana* (Sal ammoniac), it was definitely known to India alchemists in 12th-13th century AD. *Rasārnava* (12th century AD) and *Gorakṣasamhitā* (13th century AD) include it as one of the five or six salts known at that time. (RSN 5-32; GRS 2-58)

Author of *Gorakṣasaṃhitā* clearly states,

Navasāra is a salt, white and fine which is obtained from heating of bricks and it is the same as *Cullikālvaṇa* or the salt obtained from the hearth of a furnace. (GRS 2-59)

Rasaratnasamuccaya (14th century AD) quotes the above verse no. 58 of GRS and further adds that it is also obtained by heating the wood of plants *Karira* (*Capparis decidua* Edgew) and *Pilu* (*Salvadora oleoides* Dene). RRS being an ayurvedic text goes on to state the medicinal applications of *Navasara.* (RRS 3.127-129)

Rasārṇava uses brick-powder for removing tarnish from mercury. (RSN 10.46-7)

It is ammonium chloride in the brick-powder that is being effective here.

Take two parts of the alkali made from plant *mokṣa* (*Stereospermum suaveolens* D.C.) and two parts of those of earth containing brick-powder, for the purification of silver. It is the best for bestowing the superior colour[26].

5. To provide a non-absorbant coating :

When the crucibles are made using ashes, parts of plant, to increase their mechanical strength they contain certain amount of fat and hence are liable to break when hot or they tend to absorb molten metals[27]. To reduce the amount of moisture or fat-content is especially necessary if the metals being melted in them contain precious metals like gold. For this purpose burnt bones especially from animal-heads or horns of deers or spines of fish are most suitable. In *Rasopaniṣad* we find a special *lepa* made of bone ash, horns of ram, borax and faeces used for this purpose.

A wise man should liquify the essence of mica and gold in equal quantities[28]. When *Hemkāca* is added to it, both become homogeneous. Roast all the kinds of bones, sheep-horn and borax. Add faeces to it and smear it on the inner surface of a crucible and heat several times using bellows. (RSPD 15.128-129)

Also in *Rasahṛdayatantra*, crucible is made of bone ash which is made from goat's bone. Further a *lepa* consisting of a mixture of borax and other substances like *Gunja* seeds is used.

Make a hemispherical crucible using burnt bones of a goat. For making an alloy, smear it using borax, *Viṣa* and seeds of plant *Gunjā* till all the pores are filled[29]. (RSHDT 11-13)

Use of the bones of an elephant is noticed in *Rasārṇava*, for smearing the crucible in which an alloy of gold is synthesized.

'A far-sighted one should smear the crucible with a paste made of burnt bones of an elephant. Always for making an alloy of gold the substances are to be kept in a closed crucible[30]. (RSN17-139)

6. To provide specific ingredients modify the colour :

Making a green alloy from tin and other metals.

In this case a peculiar use of the *lepa* is observed. The *lepa* contains *Pārthiva tuttha* (*tuttha* obtained from the earth) which could contain both copper and zinc sulphates and carbonates.

The formation of a bright green coloured alloy described in the verses from chapter thirteen of *RSPD* could be explained only if we assume that some small percentages of copper and zinc from the *lepa* went into the reaction mixture consisting of tin, mica, and gold.

An alloy of gold, silver and copper in a particular proportion of approximately 60% Au, 30% Ag and 10% Cu is fairly green coloured[31]. If silver is replaced by pure tin, again a green product could be expected, since pure tin largely resembles silver. This green colour improves when half of copper is replaced by zinc both from the *Pārthiva tuttha*. Then the composition of the final alloy which is emerald-like could be 60% Au, 30% Sn, 5% Cu and 5% Zn approximately.

The verses describing the process are

The alloy of tin and mica with equal amount of gold is placed in a closed crucible alongwith *vimala* and roasted. When it is accomplished in a *Kūrpatuttha* it resembles an emerald in colour and lustre[32]. (RSPD 13.20-2, 21-1)

The study of crucible and crucible-linings reveal the chemical-metallurgical insights of the alchemist. Though the reactions carried out in a crucible were on a small scale, they might have similarities with those carried out in a furnace and their study could lead to solve some unsolved problems of the medieval chemistry and metallurgy. Thorough studies of such isolated topics taken together will no doubt throw much light on the overall chemical-metallurgical development of the period.

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5. मूष्णाति दोषान्मूषेयान् सा मूषा इति निगधते। (*Rasaratnasamuccaya* 10-2)

6. मूषा हि क्रोन्चिका प्रोक्ता कुमुदी करहाटिका।
पाचनी वाहने च रसवादिभिरीर्यते।। *Rasaratnasamuccaya* (10-1)
Goraksasaṃhitā - edited by Janardhan Pandeya, No. 10 of Saraswati Bhavana Book Series, Varanasi, 1977.

नाग भूनागभूषायाध्मापयेद् सुदृढ़ यथा।
विस्फोटय मूषिकां तां च चूर्ण सूक्ष्म विधाय च।। *Rasarnavakalpa* (2.207)

क्लिद्यते तु यथा मूषा पतितं तु तदा भचेत्। *Gorakṣasaṃhitā* (5.231-1)

7. *Rasaratnasamuccaya*, 10th chapter, verses 6 to 21.

8. अभ्रचूर्ण समं तारं मूषां कृत्वन्थमृषितम्।
तत्समं वङ्गमूषायां स्थापितं सार्थितं पुत:।। *Rasopaniṣad* (8.7)

9. लवणाभ्रवनार्जुनाम्बुपिष्टं पुरितं त्रिखलु चारयेद् रसेन्द्रम्।
सुरसं सुरसे तुषारिनेमध्ये रसमभ्रं च चरेत् खुलोहपात्रे।। *Rasopaniṣad* (16.273)

10. यन्मूत्याच्चारयेदभ्रं तन्मूत्याच्चारयेद्रसम्।
पूर्वाह्ने चारयित्वा तु तेनैव स्वेदयेन्निशि।।

11. Hoover H.C. and Hoover L.H. (tr.) *De Re Metallica of Georgious Agricola*. Dover Publications, New York, 1950, p. 228.

12. कुष्णार्जुनसपत्रैस्तु श्लष्णमृत्तिकया सह।
मूषां कृत्वा तु संस्याप्य द्रावयेल्लोहपत्रकम्।। *Rasopaniṣad* (16.249)

13. नारणाकरणं वक्षे सामान्यं द्रावणाविधिम्।
लोहानां द्रावणं मुख्यमग्निजारुनमिश्रितम्।।
रक्तोपविषगन्धहकमेकक स्वर्चिचका भवेत्।
त्रिसिन्धुभि: पारतरसं वा विषसौवर्चलमेकत:।।
भागार्थ पारतरसं सर्वमेकत्र चूर्णयेत्।
एकदेशगतं भूय: स्थापितं काचभाजने।।
मदिरां तु शंतभाव्य जलशूकेन नारुण।
शतश: शतशो भूय: क्षारपित्ताम्लमूत्रजै:।।
विषक्षारैश्च तं भाव्य लोहानां द्रावण भवेत्।। *Rasopaniṣad* (15.188-190)

14. काचचूर्ण पुनर्दत्वा मुद्रयेन्मूषिकां ततः।
करीषाग्नौ ततो ध्मात्वा यायत्ताग्रद्रवं भवेत्।। *Rasārṇavakalpa* verse no. 372.

15. Roy, Mira and Subbarayappa, B.V. (ed.) *Rasārṇavakalpa* Indian National Science Academy, New Delhi 1976.

16. तेनैवाच्छाद्य तत्कालकं बाहयतः सम्प्रलेपयेत।
ततो वस्त्रेण सम्प्रेक्ष वान्थितं सूत्ररज्जुता।।
स्थापितं पार्थिवे तुल्ये लिप्तवा चाप्यन्थम्तिम्।
दहेत्तं गोमयेनाग्नौ यदा तन्मूषतापितम्।। *Rasopaniṣad* (13.15-16)

17. खटिका लवणं माषचूर्ण गुडपुरौ तथा।
अतसी च इषच्चूर्ण मृल्लेपादिषु पूजितम्।। *Rasakamadhenu*, p. 14.

18. शंङ्खमाणक पिष्टेन निश्छिन्द्र लेपयेत् भृशम्। *Rasopaniṣad* (16.208)

19. ततः पिप्पलिसंस्थानाः पाषाणा हेमथातवः।
तानादाय प्रयत्येन श्लक्ष्णचूर्णानि कारयेत्।।
चूर्णीकृतांस्तु तान सर्वानु हयरक्तेन भावयेत्।
मानुषेण च रक्तेन सप्तवारान् द्रवीकृतान्।।
पुनस्तु तुलसीतोये पञ्चगव्येन पेषयेत।
शोषीयत्वा यथान्यायं मूषालेपं तु कारयेत्।। *Rasopaniṣad* (16-12-14)

20. सटङ्क लकुच द्रावैमेष श्रृङस्याश्च भस्मना।
पिष्टोमूषोदरे लिप्तःसंशोष्य च निरुद्ध च।।
षट्प्रस्थ कोकिलैर्ध्मातो विमलः सीससत्रिभः।
सत्वं मुञ्चति तुद्यक्तो रसः स्यात् स रसायनः।। *Rasaratnasamuccaya* (2.101-2)

21. कुङकुमं शिखिपितंच रोचना गोशरीरना।
षादङगारमध्यस्थं ध्यातं वार्हनेसमप्रभम्।। *Rasopaniṣad* (2-35-36)

22. Misra, Chaturbhuja (ed) *Rasahṛdayatantra* by Govind Bhagvatpad with commentary of *Mughavābodhini*, Bombay 1911.

23. उर्णाटडकण गिरिजतुकर्णाक्षमलेन्द्र गोपकर्कटकैः।
नारीपयसा पिष्टैः सर्वव्दन्व्दानि हि लन्ति।। *Rasahṛdayatantra* (23.6)

24. पालाशभस्मापामार्ग यवक्षार काञ्जिकम्।
सौवर्चलं कासीसं सामुद्रं सैन्थवं तथा।।
आसुरी टडकणं चैव नरसारस्तथेव च।
कर्पूर चैव माक्षिकं समभागानि कारयेत।।
स्नुहयर्कु दुग्ध देवैशे मूषालेपं तु कास्येत्।। *Rasārnava* (4.145-46)

25. सामुद्रं सैन्धवं चैव चूलिकालवणं तथा।
सौवर्चलंच कांच च लवणा: पञ्च कीर्तिता:।। *Rasārnava* (5.32)

लवणा: पर् समाख्ता: सामुद्रं सैन्धवं विडम्।
सौवर्चलं रोमकंच चुलिका लवणं तथा।।
इष्टकादफने जातं, पाण्डुर लवणं लघु।
तदुक्तं नवसाराख्यं चुलिका लवणं हि तत्।। *Gorakṣasaṃhitā* (2-58-59)

करीरपीलुकाष्ठेषु पच्यमानेषु चोभ्दव:।
क्षारौडसौ नवसार: यच्चूलिकालवणाभिध:।।
इष्टिकादफने जातं पाण्डुरं लवणं लघु।
तदुक्तं नवसाराख्यं चुलिकालवणं हि तत्।।
रसेन्द्रनारणं लोहनारणं जठराग्निकृत जारणं।
विडाख्यं च त्रिदोक्षघ्नं चूलिकालवणम्।। *Rasaratnasamuccaya* (3.127-129)

धूमसारगुव्योष रजनीसित सर्षपै:।
इष्टिकाकाग्निकाणाभि: त्रिदिनं मर्दयेत्तत:।।
निर्मलो जायतो सूत: मत्प्रभावं प्रकाशयेत् *Rasārnava* (10.46-7)

26. मोक्षक्षारस्य भागौ व्दौ इष्टकांश समन्वितौ।
मृद्भागास्त्रणुध्यर्थ उत्तम वरवर्णिनी।। *Rasārnava* (4-46)

27. Hoover H.C. and Hoover L.H. (tr.) *De Re Metallica of Georgious Agricola*. Dover Publications, New York. 1950, p. 229.

28. अभ्रसत्वं च हेमं च समं द्रावयते बुध:।
योजितं हेमकाचेन तद्चयं सगतांत्रजेत्।।
दग्धवा सर्वाणि चास्थीनि मेषश्रृडंग सटडवणम्।
विष्ठावर्ग च सँलिप्य मूषायां धामयेद् भृशम्।। *Rasopaniṣad* (15.128-9)

29. छागास्थिभस्म निर्मित मूषां कृत्वैव मल्लकाकारम्।
दलयोगे धनरन्था टडकणविशगुण्जाकृतलेयाम्।। *Rasahṛdayatantra* (11-13)

30. नागास्थिभस्मनिर्मित मूषां लिप्तवा विचक्षण:।
निक्षिपेद् अन्यमूषायां नित्यं हेमदलं भवेत्।। *Rasārnava* (17-139)

31. Forbes, R.J., *Metallurgy in Antiquity*, E.J. Brill, Leiden, Netherlands, 1950, p. 153.

32. वडगाभ्रहेमसहितं विमलं चान्थमूषेतम्।
निर्वाहितं कूर्पतुत्थे भवेन्मरतकप्रभम्।। *Rasopaniṣad* (13-20-2, 21-1)