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ŚULBĀRĀKĀLIKĀCCHEDAḤ : MEDIEVAL METHODS FOR CLEANSING METAL SURFACES AND REMOVING TARNISHES

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Cleansing metal surfaces and removing tarnishes is a necessary preliminary step in metallurgical processes, such as electroplating, enamelling, etc. Medieval alchemists who were essentially experimenting with metals also knew its importance as is apparent from the chapter entitled '*Śulbārakālikācchedaḥ*' in *Rasopaniṣad*. The processes therein are classified here with an attempt to explain their chemical nature. Clues to the reasons of application of certain plant products in such operations are found in their chemical constituents. These inferences should be looked upon as introductory to the assessment of the chemical contents of the text, through adequate experiments. Thus, the article tries to unveil an aspect of the metallurgical and chemical know-how of the medieval Indian experimentalists.

INTRODUCTION

There has been a great fascination for metals and metallic objects in human minds since ancient times. This is due to their lustrous and shining appearance and attractive colours besides their other useful properties. Gold is valued universally for this reason. Moreover, its natural resistance to tarnishing has given it the unique place it has enjoyed since prehistoric times. In fact, all freshly cast, pure metals and alloys display their characteristic colours and lustre. Copper is reddish; silver, tin and zinc are white; and brass is yellow. Iron too in pure state is white and lustrous.

When exposed to air, all metals, except gold and platinum, get tarnished due to the formation of thin films of their coloured compounds, most of which are oxides. Thus, copper darkens due to the formation of hydroxo-carbonate or hydroxosulphate of copper. Silver blackens when exposed to sulphur or hydrogen sulphide. Zinc and tin also tranish due to the formation of an oxide film. Iron rusts in moist air and becomes reddish brown due to the formation hydrous oxide.

CLEANSING AND REMOVING TARNISHES

A number of metallurgical processes such as electroplating, passivating, enamelling, etc. require metals with a clean surface. To remove surface-coats of inorganic

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compounds and also to remove other surface contaminations like greases and oils a number of processes are employed in modern metallurgy. They are: cleansing-to remove dirt and grease, pickling - to remove adherent inorganic ontamination and stripping, which is removal of complete coatings.

In the medieval period also a number of methods were in use to remove tarnishes and to restore the metals to their lustrous form. In the course of our study of *Rasopaniṣad* we have come across numerous such methods. *Rasopaniṣad* is a Sanskrit text on alchemy. It is of an unknown date and authorship. Judging from the extent of alchemical knowledge contained in this text, it was possibly written sometime between the eleventh and the thirteenth centuries AD[2]. It consists of 18 chapters, all of which deal with gold-and silver-making processes. Unlike other such texts, the author does not go into the details of apparatus or classification of processes, etc., but describes intricate metallurgical operations, after reviewing a few basic concepts and purification methods.

This fact suggests the advanced state of chemical and alchemical knowledge of the period. A whole chapter entitled '*Śulbārakālikācchedaḥ*' is devoted to these cleansing methods.

These operations were performed prior to the surface treatments, such as amalgamation-gilding, tinging or alloy making. The alchemist believed that they increased the chances of success in further alchemical operations. This is apparent from the following verses of *Rasopaniṣad*:

'Now I will tell you about *Śulbārakālikācchedaḥ*, i.e. removal of black surface tarnishes from copper and brass, which makes them free from impurities and enables them to mix with gold and silver (to produce alchemical gold[3]).

– *Rasopaniṣad*, Chapter 12, I

'Removing black impurities from copper and brass is told in the twelfth chapter, and also the suitable union of their pure parts'.

– *Rasopaniṣad*, Chapter 1, śl. 31-2. 32-1.

Classification of processes and chemistry behind them

A careful study of the processes given in *Rasopaniṣad* and those given in other texts devoted to alchemy, viz. *Rāsarṇava*[5], *Rasārṇavakalpa*[6] and *Rasaratnasamuccaya*[7], reveals that they consisted of

(1) Removing dirt or grease using hot water or alcoholic liquor.

(2) Removing surface tarnishes by cleansing with the right reagent.

In this case, the foremost requirement was that the surface layer should be soluble in the reagent used. Secondly, the reagent should not have harmful or corrosive effects on the metal itself. Whenever the surface layer was insoluble or partly soluble, it was first converted into a soluble salt like chloride and then it was washed away. A medium of the right PH was prepared using various plant-juices, inorganic salts, fruit juices or a suitable combination of all of them. This method is comparable with modern pickling methods in which mixtures of diluted mineral acids, such as hydrochloric, nitric or sulphuric acid are used. A mixture of various inorganic salts dissolved in acidic plant juices could give rise to a similar acidic mixture. Even animal faeces could form soluble salts from the respective insoluble salts and thus possibly had a cleansing effect on metals. Use of salt is depicted in the following verse in Rasopanisad:

'When the *kūrpa* (mixture to be placed in a crucible) contain three parts of salt then it is well known as a destroyer of black tarnishes'.

– *Rasopaniṣad*, Chapter II, śl. II-I.

(3) Apart from cleansing, another important method that is noted down for obtaining pure, untarnished metals is melting, purifying and recasting of metals. We see that certain substances have specific function in these operations. Such substances were known to be of the category *Drāvaṇavarga or Drāvaṇāgaṇa*, i.e. substances which are useful in liquifaction of metals. A list of such substances is given in *Rasaratnasamuccaya.*

'*Guḍa* (molasses), *Guggula*, *(Commiphora Mukul)*, *Guñja* (seeds of *Abrus Precatorius*, *Ghṛta* (clarified butter), *madhu* (honey), *Tańkaṇa* (borax)[9]

– *Rasaratnasamuccaya*, Chapter 1, śl. 98

'*Guḍa, Guggula*, are of *Drāvaṇa* category'[10].

– *Rasaratnasamuccaya*, Chapter 3, śl. 91

Tańkaṇa or borax could combine with metal oxide to form a flux which floated on the surface of molten metals and could be removed. Kāca[11] or a salt with saline particles had a similar use.

Oils of plant and animal origin, like *Ghṛta*, could form a dividing layer between pure molten metal and atmospheric oxygen, thus reducing the possibility of further oxidation. Some complex substances of animal and plant origin like lac, wax, molasses, and certain plants like *Guggula* (*Commiphora Mukul* or *Commiphora agallocha*) were specially useful for the reduction of metal oxides by the carbon contained in these substances. It is intriguing though why such rare substances were used instead of using just some wooden twigs, which was the method employed by the Romans for purification

of copper.

Forbes writes in '*Metallurgy in Antiquity*':

'It is now necessary to reduce the copper oxides present This is effected by 'poling' that is forging green logs or trees under the molten metal. The wood reduces the oxides formed, and the product is called 'touch-pitch copper... For small quantities of refined copper for medicinal use roasting with coals and honey is mentioned.[12]

Removal of oxide contamination could make the metal soft and easily miscible with other metals, facilitating the formation of homogeneous alloys. These substances were, therefore, called '*Drāvaṇāṅga*; i.e. important ingredients in liquefaction, or *Drāvaṇapañcak*a, i.e. five liquefier, as is seen in a verse from Rasārṇava.

Guñjā (*Abrus precatorius*), *Taṅkaṇa* (borax), *Madhu* (honey), *Ghṛta* (clarified butter) and Guḍa (molasses) are Drāvaṇapañcaka[13].

– *Rasārṇava*, Chapter 6, śl. 41.

The most effective method is described as the one in which the metal is first converted into its calx by roasting it with various salts, *Viḍa*[14] etc. In the second stage, it is reduced using certain carbon-rich organic compounds. This was known as *Bodhana, Utthāpana* or enlivening.

Metal-Surface Cleansing Methods of Rasopaniṣad

Some examples from the chapter *Śulbārakālikācchedaḥ* are given below.

(1) Washing with hot water to remove water-soluble dirt or grease, as seen in the following verse.

'When washed with the acidic extract of sour rice gruel and hot water, the black impurities are removed[15]'.

– *Rasopaniṣad*, Chapter 12, 11.

(2) Washing with alchoholic liquor to remove greases and oils.

'Take a vessel made of bronze and moisten it with alchoholic liquor[16].

– *Rasopaniṣad*, Chapter 12, śl. 2-1.

(3) Dipping in acidic juices or acidic extracts to remove inorganic tarnishes.

'When washed with acidic extract of sour rice gruel and hot water, the black

impurities are removed.'

– *Rasopaniṣad*, Chapter 12, śl. 11.

Before using the vessel for a chemical operation, it is filled with a mixture of acidic juices to remove the tarnishes. This is observed in the following verses.

'The *cāraṇa* operation is recommended in the case of metal, steel and precious stones by keeping them in a bronze vessel into which acids of plants *Badara, Āmalaka, Trintriṇika Bījapura* are added and above it mica, rock salt and acid of plant *Dādima* are kept for six days[17]

– *Rasopaniṣad*, chapter 15, śl. 187.

In an earlier chapter, the author has given a list of plants and fruits with acidic juices.

'*Badara Āmalaka, Ciñcā, Dāḍima, Bījapūraka, Jambīra*, fruit of *Nāraṅga* and *Āmlavetasa.*

Cāṅgeyi, Āmalakā, trees of *Caṇaka* and *Āmalaka*, fruit of *Sauvīra* and *Āmra*; butter-milk, all these are known as of the acid category [18]

– Rasopaniṣad, Chapter 4, śl. 30, 31.

(4) Dipping in a mixture containing acid and alkaline juices is the method adopted in the case of metal tin, because it is soluble in strong acid and bases. The alchemist is careful not to make too acidic or basic a solution. Tin oxide being amphoteric in nature would dissolve in such a solution to give a lustrous finish to the metal.

'Take alkaline extracts of plants *Kuṭaja* and *Arka*, and *Viḍa*. Sprinkle the juice of plants *Nirguṇḍi* and *Brāhmī*, also that of plants *Gandha*, all *Gokṣuraka* in the juice of *Brāhmī* and *Anantā* plants. Powder, all kinds of bones and also *Viṣa* and *bīja* in equal proportions. After mixing several times add them to the oil of sesamum. By this method, tin becomes pure and resembles a conch-shell, milk and the moon[19].

– *Rasopaniṣad* Chapter 13, śl. 8,9, 10-1.

(5) Salts are used, sometimes in the form of a *Viḍa*, which is essentially muriate of soda, to convert insoluble oxide and other kinds of inorganic tarnishes into soluble salts. In modern metallurgy also, tarnish on copper or brass surface is removed by immersing the work pieces in dil. HCI (muriatic acid) or dil. H_2So_4 solution, followed by thorough rinsing.

A detailed account of surface-cleansing of brass-sheets is given in the following verses of *Rasopaniṣad*. In this process, acidic and alkaline juices along with salts and *Viḍa* are smeared on brass sheets and are kept underground for 6 months ! The author says that a heavenly gold-like brass, without tarnishes, is obtained.

'Take roots of plant *Prapunnāga* and grind them after moistening with cow's urine.

Take bark of plant *Mahāvṛkṣa* and mix it with five parts of plant *Aṣvamāra*. Heat it in a woman's urine several times till it becomes denser.

Take the juice of yellow flowers which are available, also take lac of plant *Palāśa*: Also take the juice of plant *Badarī, Tintiṇī, jihvā* and *Āmalaka.*

After making a careful scrutiny heat with an equal amount of salt as directed Then bring ripe Viḍa and mix well with the juice of plant Vaṭa and dry in the sun.

Again mix it with the menstrual exudation and dry in the sun. Bring the best kind of Viḍa. Take sheets of purified brass, and rub till they resemble gold.

Smear plenty of Viḍa on them and place near the earth. In 6 months' time it becomes heavenly gold without black colouration and a *Pakṣaghātina* (i.e. which does not volatalise in fire)[20] is obtained.

In the above process for removing tarnishes from brass, powdered roots of plant *Prapunnāga*, moistened in cow's urine, are used. We have seen that the author was aware of the chemical properties of various plant juices. Acidic extracts of plant Ciñcā (tamarind or *Pithecellobium dulce*) or *Badara* (Zizyphus jujuba), etc. and alkaline extracts of plants (*Butea monosperma*) or Arka (*calotropis gigiantea*), etc.; and their mixtures had specific applications. Plant *Prapunnāga*, which is synonymous with Cakramarda (*Cassia Tora),* is classified in an earlier chapter under the category *Upaviṣa or* minor poison. Since the author knew its chemical and possibly medicinal properties and used it in the above process instead of the more common plants mentioned above, we may conjecturally surmise that it had a specific function other than providing the solution of required strength of acidity or basicity (PH in modern terminology). To investigate the specific function of this ingredient, let us look into the chemical constituents of this plant.

Prapunnāga or *cakramarda* is used as a laxative. It is also used to cure skin-diseases. In fact, there are some varieties of 'casia' listed in the *Glossary of Indian Medicinal Plants*[22]. All of them have similar applications. They contain anthraquinone derivatives, such as rhein, oxymethylanthraquinone or emodin and chrysophanic acid. All of these are polynuclear aromatic compounds having similar structures which are closely related to naphthalene[23] or anthracene.

In *'Chemistry of organic compounds'*[24], the author notes:

'Although the chief interest and importance of naphthalene and anthracene derivatives centres around the coal tar dye industry, coal tar is not the only source of these substances. Naphthalene, anthracene and phenanthrene derivatives (or substances closely allied to them, as, for example, the corresponding quinones) have been found in the vegetable kingdom.

Derivatives of anthraquinone are quite widely distributed. Hydroxyl derivatives of a methylanthraquione occur as glucosides in a number of plants. Plant extracts containing such materials are known under the general name of emodine and are used as drugs chiefly because of their laxative and purgative action. Chrysophanic acid, 1, 8-dihydroxy -3-methyl-9, 10-anthraquinone, may be cited as an illustration of the substances occurring in such drugs.'

It is known that the byproducts of coal-tar distillation act as pickling inhibitors, i.e. they permit the reaction between acids and oxides and other corrosion products, but inhibit that between the acid and clean-metal surface.

The *author of Modern Practice in the pickling of metals and related processes*[25] has explained the action of pickling inhibitors in the following paragraph.

'A piece of metal is only rarely uniformly covered with rust; more often a thick rust layer lies adjascent to more or less bare metal. In this case the base metal areas are attacked at once while at the rust-patches no attack on the metal takes place at first. As a result more metal is removed from those areas which are bare or are only lightly covered with rust..... This causes appreciable roughening of the metal surface as well as excessive consumption of the pickling acid... . Inhibitors markedly reduce the acid consumption and diminish the attack on the basis metal ... Their effect in most cases is due to the formation of a protective film on the metal surface but not on rust or inorganic contaminations.'

The author further notes that certain nitrogen and sulphur-containing organic compounds with high molecular weights act as inhibitors.

It is possible that the chemical constituents of the plant *Prapunnāga*, which are structurally similar to such coal-tar derivatives, act as inhibitors and facilitate cleansing of tarnished brass by acids, without causing much harm to the clean metal. Addition of urine possibly formed amino-drivatives of the above polynuclear aromatice compounds, thus forming the high molecular weight, nitrogen-containing organic compounds which are found to be useful inhibitors.

It appears that centuries of experimentation possibly led the alchemist to understand the favourable effects of these plant products mixed with urine, in cleansing metal-surface using the acids of plant origin, such as *Āmalaka, Badara*, etc. and also a

mixture of dilute mineral acids, which could have been obtained by the addition of various salts and *Viḍa.*

The other plant used, viz. *Mahāvṛkṣa*[26], which has a synonym, *Pilu (Salvadora oleoides),* contains trimethylamine and might have had a similar application.

(6) A total conversion of impure metal to its compounds by means of heating with acids, alkalies, salts, *Viḍas* and forming the calx of the metal is described here. It is subsequently reduced in the operation '*Bodhana*' or 'enlivening' in the presence of plant or animal products, such as honey, wax, molasses, etc., when pure metal is obtained back. In this case, the product is freshly cast pure metal with a clean, shining surface. No wonder that this is described as the best method of cleansing.

'All the metals are to be purified using all the kinds of *māsas, Āsavas* made in liquor.

Further with all the kinds of acids, alongwith *viṣas*, alkalies mixed with oil, urine, milk, etc. Salts, as available, are taken and slowly heated over low fire.

Take the juice of red flowers of the young, red and yellow varieties of shrubs. Add it to the above mixture and throw bile and faeces into it.

Asafoetida, *trikaṭu*, all the kinds of *Upaviṣas*, *bījas*, bitumen, *laktaṣuṇa*, and *Kaṅkuṣṭha* are added to it many times.

Copper which is heated in this way is placed when it becomes pure and is made into sheets. Then using a pair of tongs, take it out and make *Dhurdhūri*[27] into it.

Again hammer it till it is broken into pieces. Then make it into a lump and using the paste of the metal, collect the essence.

Take that copper which is obtained by *Pātana* operation. It resembles the early morning[28] sun'.

– *Rasopaniṣad*, Chapter 12, śl. 45-1 to 49.

'... Using green pyrite, iron, realgar, and borax take (the metal) whose physical shape and six characteristic properties are killed and then heat it in a closed crucible. then powder it and enliven using honey and clarified butter.

After awakening it grind it well in acid so that its physical shape is lost, then an intelligent one should heat it in kanyasa of a more common variety, in the proportion one is to three.

It makes copper resemble the flower of plant kuṣmāṇḍī'[29]

– *Rasopaniṣad*, chapter 12, śl. 36-2, 37, 38, 39-1.

GOLD AND SILVER-MAKING WITH PURIFIED COPPER AND BRASS

We have seen that the chief aim of the alchemist behind the cleansing of metal surfaces was to synthesize alchemical golds and silvers. He used the processed metals in right proportions along with requisite amounts of pure gold and silver, which were added to improve the colour and texture of the alloy. Let us look into some such processes which will give the endeavour of metal-surface-cleansing the proper perspective.

(A) Alchemical gold and silver from copper

1. Copper thus purified by the above methods is used to make gold and silver'[30].

2. 'When one-tenth of its weight of gold is added to it (copper), it attains the colour Guñja seeds'[31].

– *Rasopaniṣad* Chapter 12, śl. 50-1.

3. 'For selling purpose add reasonable amount of silver to it'[32].

– *Rasopaniṣad* Chapter 12, śl. 50-1.

In the above case, reddish gold could have been obtained by the addition of one-tenth the amount of gold to that of purified copper. The author advises addition of requisite amount of silver to it to make it saleable. This probably improved the colour from reddish to yellow.

The following verses give a number of copper-gold alloys, where the proportion copper: gold varies over 2:1, 1:1 and 6:1 approximately.

'Take two parts of red copper and one that of a good quality gold.

When mixed with gold it attains the colour and lustre of fire of *khadira* wood. An intelligent one should take one part of copper and one that of gold and mix them together.

Then it becomes one that is called *Mātṛkottara* kind of gold which the great sages are fond of. Now take three parts of that copper and two parts of gold.

This is the method called *Hemaṣaṣṭha* according to Mahodadhi'[33].

– *Rasopaniṣad*, Chapter 12, śl. 23-2, to 26-1.

Mātṛkottara (one which is better than *Mātṛka*) kind of gold is the one which contains equal amounts of gold and copper. Incidentally, *Mātṛka* kind of gold was the

one which contained 25% of gold and 75% of copper, as is apparent from the following verse of the seventh chapter.

'The heavenly gold named *caturthasāra* (containing ¼th part of pure gold) resembles *Mātṛka* kind of gold'[34].

– *Rasopaniṣad*, Chapter 7, śl. 56.

Hemaṣaṣṭha, a kind of alchemical gold, apparently contained 1/6th part of gold to that of copper. In the above verse, three parts of pure copper are added to two parts or the first category of alchemical gold which contained copper and gold in the ratio 2:1, so that in the final alloy Cu:Au is 13:2, which is approximately 6:1.

(B) Alchemical gold from brass

When gold was added to brass in the proportion 1:8, 1:9 or 1:10, it made brass looks more gold-like. It could be used as gold for all practical purposes. This is apparent from the following verses.

'When mixed with one-tenth or one-eighth part, it becomes the best *kalyāna* kind of gold'[35].

– *Rasopaniṣad*, Chapter 12, śl. 59-1.

'When one-tenth of its weight of gold is added to it, it becomes superior gold'[36].

– *Rasopaniṣad*, Chapter 12, śl. 68-1.

Conclusion

Cleansing metal surfaces and removing tarnishes is considered as a necessary operation to be carried out before electroplating and enamelling in modern metallurgy. Medieval Indian alchemists who were trying to make gold and silver coloured alloys or amalgams from base metals also employed such methods to obtain clean, lustrous metals before they were melted together to get homogeneous alloys. The alchemist believed that removal of dirt or tarnishes increased the chances of success in further chemical operations.

A close study of the twelfth chapter *Sulbārakālikācchedaḥ* or 'Removal of black surface tarnishes from copper or brass' of *Rasopaniṣad* enables one to understand the extent of knowledge, in this respect, the alchemist had accumulated, over the centuries and how he could adopt particular methods to achieve specific goals. An attempt is made here to classify these processes into six different categories.

There is an indication that the alchemist had guessed the use of roots of plants

like *Prapunnāga* (*Cassia tora*), which contained high polynuclear aromatic compounds with structures similar to anthracene, as inhibitors in operations which are similar to pickling methods. A short account of alchemical golds and silvers made using pure metals is also given. This throws some light on an aspect of metallurgical and chemical knowhow of medieval Indian experimentalists.

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3. शुल्बारकालिकाच्छेदो प्रवक्ष्याम्यथ रंजनम्।
यथा युज्जति हेमेन तारेण गतकल्मषम्।।1।।

– *Rasopaniṣad*, Chapter 12, śl. 1

4. शुल्बारकालिकाच्छेदो द्वादशे परिकीर्त्यते। 31-line 2
मेळनं च यथायोगं शुद्धयोऽङ्गयोस्तयोः। 32-line 1

– *Rasopaniṣad*, Chapter 1, śl. 31, 32

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8. त्रिभागलवणं कूर्प तमोघ्नं इति कीर्तितम्।।11-1।।

– *Rasopaniṣad*, Chapter 10, śl. 98

9. गुडगुग्गुळु गुञ्जा घृतमधुटंकणानि।

– *Rasaratnasamuccaya*, Chapter 10, śl. 98.

10. गुडगुग्गुळु आदि द्रावणगणः।।

– *Rasaratnasamuccaya*, Chapter 3, śl. 91

11. *Kāca* - A synthesized salt obtained by boiling earth impregnated with saline particles, also called *kācalavaṇa*.

12. Forbes, R.J., *Metallurgy in Antiquity*, E.J. Brill, Leiden, Netherlands, 1950, p. 307.

13. गुञ्जाटंकणमध्वाज्यगुड़ा द्रावणपंचकम्।।41।।

– *Rasārṇava*, Cahpter 5, śl 41

14. *Viḍa* - *Viṭa-lavaṇa* or black salt with a small protion of embelic myrobalan. The produce of muriate of soda, with small quantities of muriate fo lime, sulphur and oxide of iron.

15. कांचिकेन सुखोष्णेन प्रक्षाल्य गतकालिकम्।।11-2।।

– *Rasārṇava*, Chapter 12, śl. 11-2

16. कांस्यपात्रं सुराक्लिन्नं तिळतैलेन लेपयेत्।।11-21।।

– *Rasārṇava*, Chapter 12, śl. 2-1.

17. बदरामलकतिन्तिणिकबीजपूरैस्तुपरि खेचरसिन्धुडाडिमाम्लैः।
षड़होषितकांसभाजनस्थं धनतीक्ष्णोपलचारणं प्रशस्तम्।।87।।

– *Rasārṇava*, Chapter 15, śl. 187.

18. बदरामळचिञ्चा च दाडिमं बीजपूरकम्।
जम्बीरं फलनारङ्गमाम्लवेतसमेव च।।30।।

चांगेयी चाम्लका वृक्षाश्चणकामलमेव च।
सौवीरामतक्रं च सर्वे चाम्लगणाः स्मृताः।।31।।

– *Rasārṇava,* Chapter 4, śl. 30, 31

19. कुटजार्कविटक्षारे निर्गुण्डीब्रह्मवृक्षयोः।
गन्धगोक्षुरके ब्रह्म्यानन्तायां च निषेचयेत्।।8।।

सञ्चूर्ण्य सर्वाण्यस्थीनि विषबीजसमानि च।
प्रतिवाप्य बहून् वारान् तिळतैले निषेचयेत्।।19।।

एवं शुद्धं भवेद् वङ्गं शङ्खक्षीरेन्दुसन्निभम्।।10-1।।

– *Rasārṇava,* Chapter 13, śl. 8, 9, 10-1.

20. प्रपुन्नागस्य मूलानि पिष्ट्वा गोमूत्रसंप्लुतम्।।62-2।।

महावृक्षत्वचेन्मिश्रमश्वमारस्य पञ्चकम्।
स्त्रीमूत्रं पाचितं भूयो यावद्बहळतां ब्रजेत्।।63।।

21. पीतपुष्परसं चाति यथालाभं पलांशजम्।
बदरीतिन्त्रिजिहवामामळक्यां रसं तथा।।64।।

निरीक्ष पाचयेत् सम्यग् लवणानि यथक्रमम्।
तत्पक्वं विडमादाय भावंयेद् वटजे रसे।।65।।

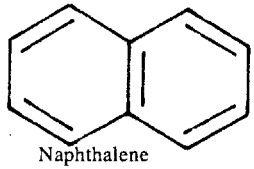
पुनः स्त्रीरजसा भाव्य गृहणीयाद् बीजमुत्तमम्।
आरं पत्रीकृतं शुद्धं निघृष्टं कनकोपमम्।।66।।

तं विडं बहळं लिप्य स्थापयेद् भूमिसन्निधौ।
षण्मासात् कनकं दिव्यं निस्तमं पक्षघातिनम्।।67।।

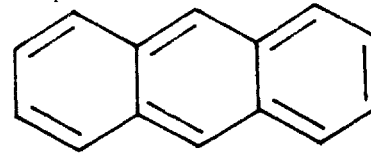
– *Rasārṇava,* Chapter 12, śl. 62-1, to 67.

22. Chopra, R.N. , Nayar, S.L., Chopra, I.C., *Glossary of Indian medicinal Plants,* Council of Scientific and Industrial Research, New Delhi, 1956. p. 55.

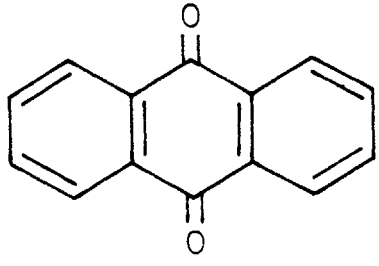
23.



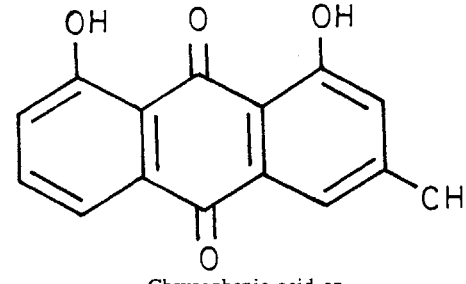
Naphthalene



Anthracene



Anthraquinone



Chrysophanic acid or
1, 8- Dihydroxy-3-methyl-9-10 anthraquinone.

24. Conant, J.B. and Blatt, A.H. *The Chemistry of Organic compounds,* Collier-Macmillan Ltd., London, 1961, p. 530.

25. Straschill, Max, *Modern practice in the pickling of metals and related processes.* tr. from the German by Staff of electroplating and metal finishing. Robert Droper Ltd., Teddington 1963. p. 4

26. *Mahāvṛkṣa,* Salvadora Oleoides Contains trimethylamine. See Chopra RN ... p. 219

27. *Dhurdhuri* - Heating the metal till smoke comes out

28. सर्वाण्यपि च धातूनि सर्वमासैः सुरासवैः ।।43।।

सर्वाम्लैः सविषैः क्षारैः स्नेहमूत्रपयोयुतैः ।
लवणाश्च यथालाभं शनैर्मुद्वग्निना पचेत् ।।44।।

तरूणां रक्तपित्तानां गुल्मानां रक्तपुष्पजम् ।
रसं दत्त्वा तु पचेत् पित्त विष्ठाश्च निक्षिपेत् ।।45।।

हिङ्गु त्रिकटुकं चैव सर्वोपविषबीजकम् ।
शिळाजतुं लक्ष्णशुनं कड्कुष्ठं च क्षिपेद् बुधः ।।46।।

एवं विपाचितं स्थाप्य ताम्रं पत्रीकृतं शुभम् ।
सन्दंशेन गृहीत्वाग्नौ तस्मिन् धूर्धूरि कारयेत् ।।47।।

ताडयित्वा पुनश्चापि यावच्छकलतां ब्रजेत् ।
पिण्डिबन्धं ततः कृत्वा लोहकल्केन पातयेत् ।।48।।

पातितं ताम्रमुदधृत्य बाळार्कसदृशप्रभम् ।।49-1।।

– *Rasārṇava,* Chapter 12, śl. 45-1 to 49

29. हरिमाक्षिक लोहेन शिळया टङ्कणेन च ।।36-2।।

षड्गुणं निहतं वङ्गं पुटपाकान्धमूषितम् ।
एषांमेव चूर्णेन मध्वाजेन विबोधितम् ।।37।।

बोधितं बोधितं चाम्ले सुपिष्टं नष्ट विग्रहम् ।
पाचयेत् कन्यसे मुख्ये तृतीयेन तु बुद्धिमान् ।।38।।

ततः सञ्जायते शुल्कं कूष्माण्डीपुष्पसन्निभम् ।।39-1।।

– *Rasārṇava,* Chapter 12, śl. 36-2 to 39-1

30. एवं संशोधितं ताम्रं हेमतारे नियोजयेत् ।।42।।

– *Rasārṇava,* Chapter 12, śl. 42-2.

31. दशांशं हेमसंयुक्तं गुंजावर्णसमप्रभम् ।।49-21।।

– *Rasārṇava,* Chapter 12, śl. 49-2.

32. विक्रयार्थं तु रजतं मात्रा विज्ञाय दापयेत् ।।50-1।।

– *Rasārṇava,* Chapter 12, śl. 50-1

33. रक्तशुल्बस्य भागौ द्वौ भागौ हेमवरस्य तु ।।23-1।।

संयुक्तं कनकं भाति खदिराङ्गारसप्रभम् ।
ताम्रं भागं च हेमं च समं संयोजयेद् बुधः ।।24।।

मातृकोत्तरमित्याहुरनुरक्तं महर्षिभिः ।
तत् ताम्रस्य त्रयो भागाः द्विभागं हेमभागिकम् ।
हेमषष्ठं क्रिया ह्येषां महोदधिमतोद्धृता ।।26-1।।

– *Rasārṇava,* Chapter 12, śl. 23-1 to 26-1

34. चतुर्थसारं कनकं दिव्यं तन्मातृकासमम् ।।56-2।।

– *Rasārṇava*, Chapter 7, śl. 56.2.

35. दशांशेनाष्टमांशेन युक्तं कल्याणमुत्तमम् ।।59-1।।

– *Rasārṇava*, Chapter 12, śl. 59-1.

36. दशांशे हेमसंयुक्तं कनकं श्रेष्ठमावहेत् ।।68-1।।

– *Rasārṇava*, Chapter 12, śl. 69-1