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Review Article

ANALOGY OF MODERN CHEMICAL PROCESSES WITH PRINCIPLES OF 'RASA SHASTRA' OF AYURVEDIC MEDICINE SYSTEM

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ABSTRACT

Ayurveda is basically a medical science but different branches of science were nurtured by it like biology, genetics, microbiology, clinical medicine, surgery, astronomy, pharmaceutics and metallurgy etc. In this traditional therapeutic system, various categories of formulations have been described in official and traditional literature. Similar to modern system of therapeutics, various units operations were adopted in developing various dosage forms to obtain the desired effect upto the optimum time. Every step has been explained in detail in traditional literature and sight modifications have also been mentioned in some texts. Besides these, numbers of metals, their alloys, metallurgy etc. have also been elaborated for the well being of the society. Hitherto, '*Rasayan'* (chemistry) and the associated studies were also familiar in ancient time. Various chemical like common salt, alkali, borax and compounds of elements like Fe, Cu, Hg and Au etc., were commonly used from in that period and the techniques for making alloys of bronze, brass, and bell metal etc. were also very common. The applicability of natural preservatives like oil, salt and sugar were also much known in ancient time. However; the terms used as stated in traditional literature were not similar to modern time. Also, the alcoholic and acidic fermented products were prepared very commonly. The present study has been focused to assess the similarity of chemical terms mentioned in literature with modern science and technology.

INTRODUCTION

Ancient Indian scholars have a magnificent contribution in the field of science and technology. Ancient India's development in chemistry was more advanced than rest of the world. In any early civilization, metallurgy has remained an activity central to all civilizations and the journey started as the Bronze Age, the Iron Age for all other civilizations. It is believed that the basic idea of 'smelting' reached to ancient India from Mesopotamia and from the Near East and the coinage dating started from the 8th Century B.C. to the 17th Century A.D. In India, certain objects testifying to the higher level of metallurgy had been achieved by the ancient Indians. By the side of Qutub Minar, a World heritage site, in Delhi stands upon an Iron Pillar. The pillar is believed to be casted in the Gupta period around circa 500 AD. The pillar is 7.32 meters tall, tapering from a diameter of 40 cm at the base to 30 cm at the top and the estimated weight is about 6 tonne. It has been standing in the open for last 1500 years withstanding the wind, heat and weather. However, it has not been rusted yet now except very minor natural erosions have been observed. This type of developments of ancient time indicates that the availability of such technologies for rust proof iron was possible. But, it is sated that iron and steel has been discovered few decades before.[1] Metallurgists at Kanpur IIT discovered that a thin layer of "misawite", a complex compound of iron, oxygen and hydrogen protected the cast iron pillar from rust. It has also been proved that the

protective film formation started within three years after erection of the pillar and has been growing ever so slowly since then. After 1,600 years of pillar manufacturing; the film has been grown just one-twentieth of a millimeter thick according to R. Balasubramaniam of the IIT Kanpur. [2] This type of studies related to disclosing ancient development in technological era indicates the well awareness of fundamentals of science and technology among ancient societies.

Material and Methods

Data and evidences were collected from secondary sources which include books, articles, Wikipedia etc.

Stoichiometry and Mole concept

The word 'stoichiometry' has been derived from the Greek word '*Stoicheion'* means 'elements' and '*metrein*' means 'to measure'. The numericals used to balance a chemical equation are known as stoichiometric coefficients. These numbers are essential for solving problems based on chemical equations. The mole method is very useful in such calculations.[3] In *Rasa Shastra*, in *Sada-GunarasabaliJarana* of *Parad,* many authors like *Rasarata* samuchaya,[4] Rasa Tarangani[5] and Anand Prakash[6] advocated the use of sulphur by six times of mercury because in this ratio both of these should react completely. In accordance to modern concepts mole theory, 1 mole of Hg equals to 200.6 gm and 1mole of sulphur equals to 32.07gm. Hence, in order to complete the reactions to stochiometrically, the required amount of sulphur should be six time of mercury (6×32.07 = 192.42) and it is almost equal to requirements of the condition.

Hg (Mercury)+S(Sulphur)=HgS (Mercuric Sulphide)
1mole(200.7gm)+1mole(32.06gm)=1mole(232.76gm)

Isomeric compound showing variation in colors due to particle size

Different types of *Rasa Bhasma* like *Rasa Parpatti*, *Rasa sindura* & *Sarvangsundar Rasa* are black, red and yellow in color respectively.[7] Variation of colors has also been seen in *Yashada Bhasma* and it is considered due to variation in '*Agni'* i.e. heating treatment.[8] This process of calcination have three types of colour production in '*Yashada Bhasma*'.

- *Samagni* → *Pandu* / Sweta
- *Kharagni*→ Pita
- *Hathagni* → Green

It has also been studied by modern instrumentation techniques that the color difference is due to particle size variations.[9] The differences in particle size of various formulations of *Bhasma* obtained by different treatments of '*Agni*' are associated with adopted method for dosage form development and media used in preparation of *Bhasma*.

Placing coinage metals and zinc metals in same group: *Rasa Vaidya* predicts similarity between *Swarna* (gold), *Rajata* (silver), *Loha* (iron) & *Tamra* (copper). Accepted resemblance between zinc and mercury has also been stated.

Coinage Metals place in same *Varga*

IB sub group of the periodic table consists of three metals-copper, silver and gold. These are collectively called as copper metals (copper being the predominant member) or coinage metals or currency metals because these have been used in the past in making coins for currency.[10] Except iron, these three metals were placed in '*Shudhaloha'* by Rasavagbhatta. [11]

Similarity between Mercury and Zinc

Group 12 (IIB) of the long form of periodic table consists of three elements namely zinc cadmium and mercury. These are collectively called as 'zinc metals' as zinc is predominant member. The melting and boiling point are low. These are volatile in nature and easily convert into vapour state. [12] According to '*Rasa shastra'* Mercury and Calamine (ore of Zinc) both are thermally unstable metals and one who have is capable of making these to thermally stable shall become the master of this science. [13]

Tin and lead place in same *Varga*

Group 14 or IV A of long form of periodic table consist of five elements- carbon, silicon, germanium, tin, and lead. The last two elements (tin and lead) of this series were categorized in *Puttiloha* by Rasvagbhatta[11] under *Lohavarga.*

Naming of elements

The name sulphur has been derived from Sanskrit word '*Sulveri'* meaning 'killer of copper'. [14] Hg is the modern chemical symbol for mercury. It comes from hydrargyrum, a Latin form of the Greek word 'hydrogyrus' which is a compound word meaning "water Silver"-since it is liquid like water and shiny like silver.[15] *Galad Rupaya Nibhabam* is one of the synonyms of *Parad* (Mercury) whose meaning is Liquid silver.[16]

Solid state and Crystallography

Solid substances are frequently classified as either crystalline or amorphous. Crystalline solids are characterized by regular and ordered arrangement of particles. The X-ray diffraction studies reveal that their ultimate particles (viz.,

molecules, atoms or ions) are arranged in a definite pattern throughout the entire three-dimensional net-work of a crystal. However, a small class of non-crystalline solids known as amorphous solids, has no well-defined ordered structure.[17] *Puspa Kasis* (Ferrous Sulphate) is found in two forms- (1) *Balukakasis* & (2) *Puspakasis.* The first forms is crystalline in nature while second is amorphous in nature.[18] Further, different crystal systems have been mentioned i.e., *Vakranta*[19] -Hexagonal, *Vazara*[20] -Tetrahedral bipyramidal, *Vimal*[21]-Tetragonal, *Abhraka*[22]– Foliated (Monoclinic).

Instrumentation used in *Rasa Shastra*

Various processes performed during *Rasa Kriya* require special type of instruments and arrangements of these instruments.

- *Baluka Yantra*[23]- Sand Bath
- *Dola Yantra*[24]- Indirect heating arrangement
- *Tryak Patana yantra*[25]-Downward displacement apparatus
- *Babkayantra*-Distillation apparatus
- *Putta*[26]- basic type of furnace
- *Mussa*[27]- crucible

Flame Test

A flame test is an analytic procedure used in chemistry to detect the presence of certain elements, primarily metals ions, based on each element's characteristic emission spectrum. The color of flame in general also depends on temperature.[28] In 12thcentury, Acharya Barvanand Yogi described flame test as *Jwala Parikasha* in his book 'Rasanva'. [29]

Metallurgical processes

Various processes are applied for the production of metals and their products in Rasa Shastra. [30]

- Washing- Rinsing with water to remove soluble impurities and dirt. It is mentioned as '*Dhawan'* or '*Nimalilkaran'.* [31]
- Smelting- The ore is mixed with coke/ silica/ limestone and introduced in a furnace. It is mentioned as '*Awapa'.* [32]
- Quenching[30]-It is the rapid cooling of a piece of metal in water, oil or air to obtain certain material properties. This process has been ascribed as '*Nirwapana*'[33], '*Nishak*' & '*Sanpan*' in 'Rasa Shastra'.

Particle-size estimation by surface tension

Various traditional methods are prescribed in the Ayurvedic compendia for characterization of the *Bhasma.* These methods are still in practice and have a great importance in evaluation of *Bhasma*. Some of these methods are as *Varna, Nischandra, Varitara, Unamapariksha, Rekhapurnata, Apunarbhava* & *Niruta*.

Varitara test is applied to study lightness and fineness of *Bhasma* and it is floating character of *Bhasma* on stagnant water surface. A little amount of *Bhasma* is taken in between index finger and thumb and sprinkled it slowly on stagnant water surface from short distance. Properly incinerated *Bhasma* should float on water-surface. [34]

In this method, two principle of physical chemistry are accompanying first is colloidal dispersion and second is surface tension of liquid or water.

Finely divided particles of any substance with diameters lying within 10-2000 Å range dispersed in any medium constitute 'colloidal system'. [35] It is well-known that it is not possible to visualize any particle whose diameter is less than that half of the wave length of the light used. The lowest wave length of visible light is about 0.4µ. Thus, it is not possible to see a particle of its diameter is less than 0.2µ. Therefore 0.2µ is regarded as upper limit and lower limit is10Å of the colloidal range. The methods for preparation of colloidal systems are breaking down the coarser aggregates into particles of colloidal size and grouping molecules into larger aggregates of colloidal size.

The most obvious method of dispersion consists of breaking down the coarser solid by mechanical grinding. This is done by *Bhawana* (wet tituration) with the help of mortar & pestle. In this way, the size of particle is reduced to such extent that their surface area increases many times.

Surface of a liquid behaves as it is in a state of tension. The force that tends to contract the surface of a liquid is known as surface tension. Surface tension may be defined as the force in dynes acting at right angles to the surface of a liquid along one centimeter length of the surface.[36] It would take a force of 72.8 dynes to break a surface film of water at 25^{0}C.

The density of *Bhasma* particles become so much lower than the original substance due to increase in surface area that the law of buoyancy is satisfied. The ultimate result is that *Bhasma* particles float on water surface. Hence, the particle size of *Bhasma* ranges between 10Å to 0.2µ.

Corrosion of iron

Corrosion is defined as the gradual transformation of a metal into its combined state because of the reaction with the environment.

Metals are usually extracted from their ores. [37] The nature tries to convert them again into the ore form. When iron is exposed to moist air, it is covered with a reddish-brown coating which can easily be detached. The reddish brown coating is called 'rust' ($Fe_2O_3.3H_2O$). In 'Rasa Tarangani' this rust is termed as *Mandura,* [38] also stated that it must be used after 60 year for making medicine. A 100 year old *Mandura* is best in quality.

Clarification of Mudy water

Katak is one of the substances used in the clarification of water told by Acharya Sushruta. [39] *Katak* (*Strychnos potatorum*) seeds are very hard and non-poisonous. Clarification of muddy water by paste prepared from seeds is due to combined action of colloids and alkaloids present in it. The albumin and other colloids sensitize the suspension and the coagulation is then caused by the alkaloid ions.[40] It is also used in refining of *Dasmularista*[41], an alcoholic preparation.

CONCLUSION

Ancient Indian scholars had performed so many important researches, phenomenon and theorems in different field of science but due lack of interest and lethargic attitude of medieval and modern Indians, these researches got the new terminology and modern form e.g. Pythagoreans theorem (*Baudhayana*), law of gravity (*Bhaskaracharya*) and invention of decimal system, and Still so many ancient researches are not fully comprehensible as these are in *Sutra* (codified) forms and most of the researchers have lack of interest in 'Sanskrit' texts. Moreover, it can be concluded that in Ayurveda so many principles and fundaments of sciences in general and of chemistry in particular are described that these have broad scope of their applicability for the welfare of human being.

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