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A Critical Review on Physical Characteristics for Identification of Precious and Semiprecious Stones (Ratna and Uparatna)

Dr. Reshma Yaranal[1], Dr. Renuka Suryawanshi[2]

[1]PhD Scholar Department of Rasashastra and Bhaishajya Kalpana PMT's Ayurved College and Shri Eknath Ayurved Rugnalaya Shevgaon , Ahmednagar Maharashtra
Professor and HOD Department of Rasashastra and Bhaishajya Kalpana, B R Harne Ayurvedic Medical Collage Vagani- Karav, Ambernath, Thane Maharashtra
Corresponding Author Email: *drreshmayaranal[at]yahoo.com*

[2]Professor and HOD Department of Rasashastra and Bhaishajya kalpana PMT's Ayurved College and Shri Eknath Ayurved Rugnalaya Shevgaon, Ahmednagar Maharashtra

Abstract: ***Ayurvedic pharmaceutics is one of the fastest growing sectors in the world market. Globalization expects pharmaceutical standardization. Hence, standardization of formulations and preparing drugs that are palatable and acceptable with longer shelf life becomes mandate. Ayurveda makes an extensive use of 'Rasashastra' so; it has become the vital or inseparable component of the therapeutic process. The precious stones used for medicinal purposes in the field of 'Rasashastra' are branded as 'Ratna'. These special stones / gemstones are highly attractive and striking in comparison with other metals and minerals. Gem identification is basically a process of elimination. Gemstones of similar colour undergo non-destructive optical testing until there is only one possible identity. Any single test is indicative only. Most minerals can be characterized and classified by their unique physical properties: hardness, luster, color, streak, specific gravity etc. These properties are related to their chemical composition and bonding. Together, the chemical formula and the crystal lattice determine the physical properties of minerals. So the physical properties and chemical composition are very useful to identify Ayurveda Acharyas have mentioned the characteristics of best raw drug termed as Grahya Lakshana. With help of this classical grahyalakshana and modern scientific technologies for identification of minerals, help in genuine selection of drug which defines the quality of the final product, so identification of any precious stone plays vital role. This review work, study the physical properties; SG, colour, luster, crystal system, RI, etc, and Grahya lakshana as per classics of some precious stone. Such tests are very powerful to study the identification, evaluation, colour improvement and provides genuine precious gem stones.***

Keywords: Ayurveda, Gemstones, Ratna, Uparatna, Garhyalakshanas, Physical Properties

1. Introduction

The origin of 'Rasashastra' has its roots in the 'Ayurvedic Alchemy'. Ayurvedic Alchemy is an important branch of Ayurvedic pharmacology dealing with the use of metals, minerals, gemstones and their processing. All the previous accumulated alchemical ideas were put to practical use and many preparations of mercury and other metals were evolved as helpful accessories in medicine.

Nowadays Ayurveda makes an extensive use of 'Rasashastra' so, it has become the vital or inseparable component of the therapeutic process. Various herbometallic and herbo-mineral formulations are effectively used to treat diseases. Drugs mentioned in Rasashastra are classified as Maharasa, Sadharan rasa, Uparasa, Dhatuvarga, Ratnavarga, etc. The precious stones used for medicinal purposes in the field of 'Rasashastra' are branded as 'Ratna'. These special stones / gemstones are highly attractive and striking in comparison with other metals and minerals.[1]

Gemstone, any of various minerals highly prized for beauty, durability, and rarity. Of the more than 2,000 identified natural minerals, fewer than 100 are used as gemstones and only 16 have achieved importance. These are beryl, Chrysoberyl, Corundum, Diamond, Feldspar, Gamet, Jade, Lazurite, Olivine, Opal, Quartz, Spinel, Topaz, Tourmaline, Turquoise, and Zircon. Some of these minerals provide more than one type of gem; beryl, for example, provides emeralds and aquamarines, while corundum provides rubies and sapphires.

Gem identification is basically a process of elimination. Gemstones of similar colour undergo non-destructive optical testing until there is only one possible identity. Any single test is indicative only.[2]

In Ayurvedic classics, the finest variety of minerals and treasures based on certain physical and physiological characteristics termed as Ghrahyalakshanas (Acceptable characters) to check the acceptable characters classical parameters are not enough presently, so geological and mineralogical identification can help to prepare quality medicine

Considering the Geological aspect of metals and minerals the following parameters need to be evaluated; Nature/Form, Colour, Streak, Cleavage, Fracture, Lustre, Tenacity, Transparency, Crystal Habit, Hardness, Specific Gravity, Taste etc. A proper apprehension and evaluation of these parameters could disclose the ingenuity of the Rasa dravyas (Herbo-mineral drugs) intended to be used for therapeutic purpose. [3]

2. The Physical Properties for Characterization

The Physical properties of minerals are used by Mineralogists to help determine the Identity of a specimen. Some of the tests can be performed easily in the field, while others require laboratory equipment. The list of tests is as follows:

Representing Identification characteristics: [4]

Table 1

1	Luster	9	Tenacity
2	Transparency	10	Cleavage
3	Hardness	11	Fracture
4	Specific gravity	12	Density
5	Crystal system	13	RI values
6	Type	14	Birefringence
7	Polymorph	15	Surface relief
8	Streak	16	Dispersion

1) Luster

Luster is the property of minerals that indicates how much the surface of a Mineral reflects light. The luster of a mineral is affected by the brilliance of the light used to observe the mineral surface.

Luster of a mineral is described in the following terms:
Metallic the mineral is opaque and reflects light as a metal would. Submetallic the mineral is opaque and dull. The mineral is dark colored. Non-metallic the mineral does not reflect light like a metal. Non-metallic minerals are described using modifiers that refer to commonly known qualities. Waxy the mineral looks like paraffin or wax. Vitreous the mineral looks like broken glass. Pearly the mineral appears iridescent, like a pearl. Silky the mineral looks fibrous, like silk. Greasy the mineral looks like oil on water. Resinous the mineral looks like hardened tree sap (resin). Adamantine the mineral looks brilliant, like a diamond.

2) Transparency or Diaphaneity

Diaphaneity is a mineral's degree of transparency or ability to allow light to pass through it. The degree of transparency may also depend on the thickness of the mineral. Transparency of a mineral is related to amount of impurities, inclusions or cleavages.[5]

3) Hardness

Hardness is one of the better properties of minerals to use for identifying a mineral. Hardness is a measure of the mineral's resistance to scratching. The most widely used measuring standard for mineral hardness is the Mohs Scale of mineral hardness, which ranks and standardizes the scratch resistance based on 10 minerals: diamond, 10; corundum, 9; topaz, 8; quartz, 7; orthoclase feldspar, 6; apatite, 5; fluorite, 4; calcite, 3; gypsum, 2; talc, 1. Softer minerals can be scratched by harder minerals because the forces that hold the crystals together are weaker and can be broken by the harder mineral.

4) Specific gravity

Specific gravity, also known as relative density, varies depending upon the chemical composition and crystal structure type. Heavy liquids with a known specific gravity are used to test loose gemstones. Specific gravity is measured by comparing the weight of the gem in air with the weight of the gem suspended in water. In gemology, the terms specific gravity and density are interchangeable.

Specific Gravity Values of Popular Gemstones[6]

Table 2

Gem	SG
Garnet	3.40-4.25
Corundum	3.97-4.03
Topaz	3.53-3.56
Diamond	3.51-3.53
Peridot	3.27-3.48
Tourmaline	2.84-3.10
Beryl	2.66-2.80
Quartz	2.63-2.68
Opal	1.99-2.25
Amber	1.05-1.096

5) Nature of the crystal

Being natural chemical compounds, minerals may occur in any aggregation state, though most of them are known to belong to solid crystalline substances. Amorphous minerals are scarce. As such natural occurrence of minerals may be in the following forms:

a) Crystalline
b) Amorphous
c) Opaque, transparent and translucent
d) Aggregate

6) Crystal Structure

A crystal structure is the orderly geometric spatial arrangement of atoms in the internal structure of a mineral. Depending on the symmetry we can find six types of crystal structure:

a) Isometric
b) Tetragonal
c) Orthorhombic
d) Monoclinic
e) Hexagonal
f) Triclinic

7) Crystal Form (Habit)

Crystal form indicates Shape of crystal .Based on shape crystal can be classified as
Massive – Ex: *Rajavartha*
Cubic - ex: Pyrite

8) Color

Color can be explained in two ways that is Metallic, Non metallic. A mineral exhibits a consistent and unique colour when seen on a freshly broken minerals surface. While this trait may not be evident in numerous minerals, commercial minerals are primarily recognized by their characteristic colors. The colour of a substance is best defined by crystal field formalism in which ions crystal containing predominantly unpaired electrons. These typically come from partially filled d shell elements like, Cr, Mn, Fe, V, Co, Ni, and Cu, or partially filled f shell elements like actinides and lanthanides. If electron shells are completely filled with electron or if shell is empty

then due to absence of unpaired electron that results in colorless properties as in Cr^{6+}, Ce^{4+}, or Cu^{+}. Fe is plenty available then that other minerals (about 5% of the earth's crust) and is therefore the most dominant color contributor in minerals.

9) Streak

Streak is the colour of the mineral in powdered form. Streak shows the true color of the mineral. In large solid form, trace minerals can change the color appearance of a mineral by reflecting the light in a certain way. Trace minerals have little influence on the reflection of the small powdery particles of the streak. The streak of metallic minerals tends to appear dark because the small particles of the streak absorb the light hitting them. Non-metallic particles tend to reflect most of the light so they appear lighter in color or almost white. Because streak is a more accurate illustration of the mineral's color, streak is a more reliable property of minerals than color for identification.

10) Tenacity

Tenacity is the characteristic that describes how the particles of a mineral hold together or resist separation.

11) Cleavage

Cleavage or parting is the tendency of minerals to split along certain definite planes. The cleavage plane is closely related to crystalline form and internal atomic structure and therefore is generally parallel to crystal faces. Minerals may show several cleavages and also the degree of perfection of each cleavage plane.

12) Fracture

The character of the fracture displayed on the broken or chipped surfaces of a mineral is an important property. The fracture surface is not the smooth surface of a cleavage plane but is an irregular surface, usually totally independent of cleavage

13) Refractive Index

One of the tests to determine the gem's identity is to measure the refraction of light in the gem. Every material has a critical angle, above which point light is reflected back internally. This can be measured and thus used to determine the gem's identity. Typically this is measured using a refractometer, although it is possible to measure it using a microscope

14) Identification by spectroscopy

This method uses a similar principle to how a prism works to separate white light into its component colors. A gemological spectroscope is employed to analyze the selective absorption of light in the gem material. Essentially, when light passes from one medium to another, it bends. Blue light bends more than red light. How much the light bends will vary depending on the gem material. Coloring agents or chromophores show bands in the spectroscope and indicate which element is responsible for the gem's color.

15) Identification by inclusions

Inclusions can help gemologist to determine whether or not a gemstone is natural, synthetic or treated (i.e. fracture-filled or heated). [7]

16) Odor

Most minerals have no odor unless they are acted upon in one of the following ways: moistened, heated, breathed upon, or rubbed.
Example: Lashuna gandha of Ghandhaka

17) Taste

Only soluble minerals have a taste, but it is very important that minerals not be placed in the mouth or on the tongue

18) Fluorescence

This is the property of substances, which emit light when subjected to irradiation with ultra-violet (UV), cathode or other short wave rays. Such luminescence remains only till the substance is kept under irradiation. It is a characteristic feature of some minerals. Ultra-violet radiation has a range of wave length from 400nm to 200 nm. The range from 200nm to 300nm is called short wave (or far UV rays) and from 300 to 400 nm is called long wave (or near UV rays). Short wave UV lamp has been used in present determinations

19) Twinning

A twinned crystal contains two or more single crystals with identical packing but in different orientations. Simple twinned crystals may be contact twins or penetration twins. Contact twins share a single composition surface often appearing as mirror images across the boundary. In penetration twins the individual crystals have the appearance of passing through each other in a symmetrical manner. If several twin crystal part share aligned by the same twin law they are referred to as multiple or repeated twins. If these multiple twins are aligned in parallel they are called polysynthetic twins. When the multiple twins are not parallel they are cyclic twins.

20) Conductivity

Conductivity is the measure of the ease at which an electric charge or heat can pass through a material. A conductor is a material which gives very little resistance to the flow of an electric current or thermal energy. Materials are classified as metals, semiconductors, and insulators. Metals are the most conductive and insulators (wood, plastic) the least conductive.

21) Acid test (fizz test)

In this test you can test chemical properties for some minerals. For example, a few drops of hydrochloric acid (dilute or concentrated) can be used to see bubbles form the mineral. Ex: iron pyrite

22) Flame test

In flam test when mineral subjected to flame, the color of flame will change. Ex: gold-yellow color flame.

23) Raman spectroscopy

Raman spectroscopy (named after Sir C. V. Raman) is a spectroscopic technique used to observe vibrational, rotational and other low-frequency modes in a system. It relies on inelastic scattering, or Raman scattering, of monochromatic light, usually from a laser in the visible, near infrared, or near ultraviolet range. The laser light interacts with molecular vibrations, phonons or other excitations in

the system, resulting in the energy of the laser photons being shifted up or down. The shift in energy gives information about the vibrational modes in the system. Infrared spectroscopy yields similar, but complementary, information. Typically, a sample is illuminated with a laser beam. Light from the illuminated spot is collected with a lens and sent through a monochromatic. Wavelengths close to the laser line due to elastic Rayleigh scattering are filtered out while the rest of the collected light is dispersed on to a detector.

24) Energy Dispersive X-ray Fluorescence (EDXRF)

Energy Dispersive X-ray Fluorescence (EDXRF) is one of two general types of X-ray Fluorescence techniques used for elemental analysis applications. In EDXRF spectrometers, all of the elements in the sample are excited simultaneously, and an energy dispersive detector in combination with a multi-channel analyzer is used to simultaneously collect the fluorescence radiation emitted from the sample and then separate the different energies of the characteristic radiation from each of the different sample elements. Resolution of EDXRF systems is dependent upon the detector, and typically ranges from 150 eV – 600 eV. The principal advantages of EDXRF systems are their Simplicity, fast operation, lack of moving parts, and high source efficiency. X-ray optics can be used to enhance EDXRF instrumentation. [8]

3. Result

We can identify gem quality according to physical properties: crystal system, colour, refractive index, double refraction, doubling of back facet edges, specific gravity, hardness, luster, dispersin, uv test and inclusion. Inclusions are particle of solid, liquid or gaseous material enclosed within a gemstone. The nature of such inclusions provides a powerful clue to the origin of the stone, and enables natural stone to be distinguished from their synthetic counterparts. Physical properties of some gems:[9]

Table 3

Gem	Ruby	Sapphire	Jade
Crystal system	Trigonal	Trigonal	Monoclinic
Colour	RED	Blue Colourless	White, Green
RT	1.76-1.77	1.76-1.77	1.67
DR	0.008	0.008	
SG	3.99	3.99	3.33
HARDNESS	9	9	6.5
LASTER	Vitreous	Vitreous	VITREOUS
UV LONG	GLOW	FAINT GLOW	INERT
SHORT	INERT	INERT	INERT

In Ayurveda Ratna (precious stones) is exclusively known as precious stone because of its attractive appearances and of its high and high costing. These are classified on the basis of; structure, relation to the planets, opacity & transparency, beauty and scarcity[10].They are:

Name of Ratnas

Table 4

S No	Ratna	English name	Chemical Identity	Hardness	Density	Color	Colour as per Classical text	RI
1	Manikya	Ruby	Al2O3	9	4	Red	Rakta kamala Patra	1.76
2	Muktaphala	Pearl	CaCO3	3.5	2.65 to 2.89	Silver White	Sweta	
3	Pravala	Coral	CaCO3	3.5	2.6 to 2.7	Red	Arakta (Deep red)	
4	Tarkshya	Emerald	Be3Al2(SiO3)	7.5	2.71	Green	Harid varna	1.57
5	Pushparaga	Topaz	Al(FOH)2SiO4	8	3.6	Golden yellow	Suwarna varna	1.76-1.77
6	Vajra	Diamond	C	10	3.6	White	Lustrous like electricity	2.42
7	Nilam	Sapphire	Al2O3	9	4	Deep blue	Nilam	1.76
8	Gomeda	Zircon	ZrSiO4	7.5	4.65 to 4.71	Dark Brown	Colour of Gomutra	1.73-1.15
9	Vaidurya	Cats eye	BeOAl2O3	8.5	3.5 to 3.8	Yellowish Green	Krushna varna	1.75

Upratna (semiprecious gems):

Gems which are having less attractive, lesser lustre, transparency, hardness, durability compared to ratnas are Uparatnas. [11]

Table 5

Sr No	Upratna	English name	Chemical Identity	Hardness	Color	Grahya Lakshana
1	Vaikranta	Tourmaline	Mg,Mn,Fe,Ca,Na,K,Li, H,F,Al3,B2,SiO_4,O_2	4	Wide range	*Masruna* (soft in touch) *Guru* (heavy), 8 edges, 8 surfaces, white, yellow, black, or coffee color
2	Suryakanta	Sun stone/ Feldspar	Na_2O Al_2O_3 $6SiO_2$ + CaO, Al_2O_3 $2SiO_2$)	6	Wide range	*Vimala* (Crystal clear), Nistusha (no whitish lines, Snigdha (soft touch), and shines when rubbed on an even surface
3	Candrakanta	Moon stone	(KAl Si_3O_8)	6	Wide range	Crystal clea, lustrous, cold to touch, yellowish shade,
4	Rajavarta	Lapis Iazuli/ Altra Marine	Na4 (S_3Al) $Al_2(SiO_4)3$	5.5	Intense Blue	Crystal clear lustrous smooth, bluish and heavy and radiant as neck of peacock
5	Perojaka	Turquoise	CuAl6(PO4)4(OH)8 5H2O	6	Wide range	-
6	Sphatika	Quartz/ Rock Crystal	SiO2	7	White	Snigdha, crystal clear,
7	Vyomyasma	Jade	NaAl(SiO3)	7	Varies	-

4. Discussion

The physical properties and chemical composition are very useful to identify and evaluate the gems. Every gem has specific gravity and RI, so we can easily identify according to these value. X- ray is very useful in the testing of gems and its simulates. The use of direct radiography relies on the fact that different materials have varying degrees of transparency to x ray. This assists comparison of diamond and its substitute; diamonds are transparent to x- ray, stimulants are not. It is also useful for detecting glass fracture filling in gem. Scattered electron reflections are detected at very high magnification. When you determine the gem stone, it is important to consider that whether the stone is natural or synthetic or enchanced? Is the colour natural or not? Are there any noticeable inclusion.

Raw drug identification and authentication is an important step in this process. Since ancient times a great emphasis given to identification of best quality raw drug before being used in a formulation. Ayurveda Acharyas have mentioned the characteristics of best raw drug. Grahyalakshana is suggesting the accepted quality of a drug and it is helpful in the selection of good quality raw drugs. As per many

So Raw drug identification and authentication is an important step in quality control and standardization process. Since ancient times a great emphasis given to identification of best quality raw drug before being used in a formulation. Ayurveda Acharyas have mentioned the characteristics of best raw drug. Grahyalakshana is suggesting the accepted quality of a drug and it is helpful in the selection of good quality raw drugs. As per many Rasashastra classics, the drugs are classified into various groups like Maharasa, uprasa, sadharan rasa etc. Grahyalakshanas are very important in identifying the originality of the drug in raw form that eases human understanding. In present days, along with classical grahyagrahyatva; identification of minerals on the basis of geological parameters should be also coupled. It will help in flawless selection of the ethical raw material [12]

5. Conclusion

This review work study the physical properties; SG, HN, colour, luster, crystal system, RI, dispersion etc by using laboratory instruments of Gems. Such tests are very powerful to study the identification, evaluation, colour improvement and provides the increase of their value of some gem stones for the genuinity of raw material, further can be safely used for Pharmaceutical purpose.

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