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An Insight to the Forensic Examination of Gemstones

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ABSTRACT

Forensic Gemology involves the study of Gemstones which are pieces of mineral polished and used for in the preparation of jewellery and ornaments. The gemstones price fluctuates heavily and there are no universally accepted grading systems for the gemstones except diamond. Due to this reason the gemstones are imitated and are sold in the markets by the traders to gain the large monetary profits. Thus there are more chances of fake and unauthentic jewellery being encountered and circulated among people. Sometimes, litigation also involves jewellery that has been lost, stolen, damaged or destroyed whose identification becomes important nm. Thus forensic examination of gemstones becomes very difficult if proper procedures are not outlaid. Therefore keeping in mind the significance of gemstone identification here are certain methodologies discussed to test the authenticity of the gemstones and to find out whether the gemstones are authentic or not.

Keywords: Gemstones, Moh's Scale, IR Spectroscopy, Water

I. INTRODUCTION

Forensic Gemology can be especially important in cases involving diamonds, colored gemstones, watches and fine jewellery. There are hardly any well-established forensic techniques to differentiate whether gemstones have been replaced or switched, causes of damage to jewellery, whether components have been added or removed (alterations), cause of breakage in mounted gemstones, metallurgical testing of alloys to ascertain if they are "correct" for period jewellery, detection of fraudulent antiques, identification of tool marks, are a few of the areas which are frequently encountered questions related to forensic examination of gems or gems authenticity. In these cases, court decisions are based in large part on expert testimony provided in depositions.

Litigation is requiring more forensic experts in varied disciplines than ever before and therefore forensics has become more "centre stage". Because of this public awareness, juries are demanding scientific proof on evidence that is presented. This is a problem because hardly well established procedures for forensic examination techniques, evidence retention, valuation expertise, not to mention a comprehensive laboratories are existing. There are many cases of fraud which are received in the forensic science laboratory and one among them is the fake gemstones. There are innumerable questions as to how original and fake gemstones could be recognised. There are very scanty research works done in this area. This field is still novice to many and as the most eminent area requires a deep study to understand the properties of gems which could be useful in discrimination of true and fake gems. Therefore an attempt has been made to discuss certain parameter which could be beneficial for forensic identification of gemstones.

Gemstones also known as semi-precious gemstones or precious gemstones are used in the preparation of ornaments. Gemstones are obtained from rocks and minerals. Knowing how to identify, gemstones and its treatment is of paramount importance to gemmologist and gem collector. The gems can be amorphous or crystalline in structure. The crystalline gems may possess cubic, monoclinic or triagonal arrangements. The gemstones are also classified in terms of their 'water'. The "Water" here stands for the lustre and transparency. The gems which are most transparent are

called “First Water”, while “Second” and “Third water” are gems of less transparency. The gemstones can be mineral based or organic based. The mineral based gemstones are obtained from rocks which organic based gemstones obtained from fossils. The examples of gemstones are Ruby, Yellow Sapphire, Opal, Pearl, Beryl, Diamond, Emeralds etc. The gemstones are identified on the basis of its physical and optical properties. All the properties of gems depend upon the three dimensional structure and its chemical composition.

II. METHODS AND MATERIAL

OPTICAL PROPERTIES OF GEMSTONES

Of all the properties of gemstones the optical properties are of unsurpassed importance. The optical properties of gemstones are important because they provide the non-destructive means of identification of gemstones. Identification is possible on the basis of colour, lustre, brilliance, scintillations and dispersion as well as phenomenon of play of colours etc. Brilliance and scintillations are the sparkles and flashes of white light emitted from the gemstones while the dispersive refraction is the splitting of white light into several colours. The optical properties of gemstones are affected by the crystalline structure and chemical composition of the gemstones.

A) Luminescence or Fluorescence*:* When gemstones are exposed to the short wave or long wave ultraviolet radiation, they emit the visible light. They are said to be fluorescent. The gemstones are said to be phosphorescent if the luminescence continuous after the exposure to ultraviolet radiation. The phenomenon is due to the absorption of UV radiation by the impurities in the gemstones and the defects in the crystal lattice results in the oscillation of electrons between the energy levels. The colour of fluorescence may be bold-green, organgish-red or whitish blue etc.

B) Lustre: The lustre and brilliance of transparent gems is studied by light reflecting from the surface of the gemstones. The smoother and highly polished surface, more the lustre will be. Greater lustre is also indicated by high light refractivity. The types of lustre observed in gemstones are glassy, resinous, greasy, waxy, pearly and silky.

C) Birefringence and Refraction**:** This is one of the most significant optical property used for the identification of gemstones. When a ray of light is passed in gemstone, the part of light is reflected from the surface while part of the light is entered in the gemstone. Light gets bend when it enters the gemstone depending upon the angle with which the light hits the surface and the velocity of light in two different media. This phenomenon is known as refraction. Greater refraction will result due to the higher angles and greater velocity difference of light in air and gemstone. The index of refraction is constant for the gemstone. When the ray of light hitting a gemstone splits in two rays travelling through gemstone at different speeds in different direction the phenomenon is known as birefringence. Birefringence is also known as double refraction.

D) Dispersion and Pleochroism: When light is refracted or bent upon entering the denser medium the phenomenon is associated with each different wavelength of light and this separation of white light in to components of colour is called dispersion.The phenomenon of Pleochroism is closely related to optical axes. Only the stones of anisotropic group can split light in two rays. These two rays may emerge in different colours or in two intensities of same colour.

PHYSICAL PROPERTIES OF GEMSTONES

A) Cleavage and Fracture**:** Cleavage and fractures refers to the characteristics manner in which the gem will break when external force or stress is applied. The ease of breaking will affect the durability, an important attribute of gems. Minerals break in parallel along the planes of atomic weakness, creating smooth flat surfaces. This break is called cleavage. Fracture is a break in a direction other than cleavage planes and results when the bonding forces are similar in all direction. The break is seen in quartz, opal etc.

B) Hardness: Hardness is defined as the relative resistance to being scratched. For this purpose the ten point Moh’s Scale is most commonly used.

Mohs Hardness	Mineral
1	Talc
2	Gypsum
3	Calcite
4	Fluorite
5	Apatite
6	Feldspar
7	Quartz
8	Topaz
9	Corundum
10	Diamond

Table-1: The Moh's hardeness Scale numbered from 1 to 10 against the Minerals.

According to the table the softest material is Talc which is designated as 1 and hardest substance is diamond which is designated as 10.

C) Specific Gravity: The specific gravity of gemstone is the ratio of weight of the material to the weight of the same volume of water at 4˚C temperature. Gemstones composed of heavy minerals have high specific gravity than those composed of lighter elements. Also the gemstones having the high intermolecular force of attraction will have high specific gravity. The specific gravity of gemstone can also be measured by using the heavy liquids. The gemstone is placed in a heavy liquid whose specific gravity is known. If the gem floats on the liquid, the specific gravity is less than that of liquid. It will get sink if specific gravity is high and will remain suspended if specific gravity is very close to that of liquid.

D) Toughness or Tenacity: Toughness or tenacity is the resistance of gemstones to crushing, breaking or tearing. It is ability of gemstone to withstand the pressure or impact. The tenacity of gemstone includes flexible, elastic, malleable, sectile and ductile. A gem is said to be elastic in nature if it gets bend and return to its original position. The factor of brittleness is very important in consideration of gemstone cutting and polishing.

MAGNETIC AND ELECTRIC PROPERTIES OF GEMSTONES

A) Magnetism and Electric Conductivity: Those gemstones which are attracted by the magnetic field are said to be magnetic in nature. The property of electrical conductivity depends upon the metallic bonding. Most of the gems lack metallic bonding; hence they act as semiconductors or insulators.

B) Piezoelectricity: Also known as pressure electricity. The electricity is induced by means of pressure. The property is shown by gems which lacks the centre of symmetry in crystalline structure. The axes of crystals have different properties at opposite ends of polar axis, and when the pressure is exerted at these ends, electricity can flow by creating the potential difference.

C) Pyroelectricity: Also known as heat electricity. When the gems are heated with sun, the positive and negative charges can build up in gems.

***D) Thermal Conductivity*:** According to the crystal system the heat is conducted in the gemstones. Some gemstones are good conductors of heat while some are bad conductors. Gemstones withdraws the heat from the body thus feels cold to touch. Some gemstones are poor conductors of heat and will not withdraw the heat, thus feel warm to touch.

III. CONCLUSION

The gemstones can be analysed by testing the following properties to confirm its authenticity. The physical, optical and electromagnetic property differs with gemstones because each gemstone is composed of different constituent particles and they also differ in the crystalline structure. The difference in chemical composition and crystalline structure develops the individual characteristic of gemstone.The above mentioned techniques are some of the physical techniques which could be used for the forensic identification, comparison and authentication of gemstones. One of the key requirements in forensic gem identification is that the methods used should be non-destructive, the tests such as streak test and acid tests are generally avoided. Cleavage and crystal shapes are most useful for identification of uncut stones. Whereas RI and SG are the most important characteristics tests which could be performed for cut gemstones. Apart from this another non-destructive instrumental technique called X-Ray fluorescence could be used for identification and comparison on the basis of elemental composition of the gemstones.Among the latest technology Gemprint® is

the world's most sophisticated, non-invasive, positive diamond identification technology. Each diamond has unique optical "fingerprint" which is called gemprint. The data base of each diamond is created which further matched with diamond in question. This Gemprint® can then be used to positively identify the diamond in the event that it is stolen, lost or even accidentally switched with another diamond. Thus last but not the least there are physical, chemical and instrumental methods which could be used logically for the forensic identification of gems and gemstones.

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