LAB UPDATE

Zultanite Imitation

By GIT-Gem Testing Laboratory

6 May 2020

Introduction

Phenomenal gemstones are the stones that possess special optical effects, for examples, moonstone showing pearly schiller known as adularescence, labradorite displaying an iridescent effect aka labradorescence etc. Though those phenomena are quite specific for each variety of those gems, there are other more common phenomena, such as cat's eye, star, color-change, that do occur in many varieties of gems. Among those, the color-change, the effect that has been described for the stone displaying different colors in different light sources, is one of the valuable and sought-after phenomena. The stones distinctively represent such effect are alexandrite, color-change sapphire, color-change garnet and the extremely rare color-change diaspore, the so-called zultanite. Color-change diaspores were first reported in the late 1970s in the Milas-Mugla region of South-West Turkey (Weldon, 2006; Hatipoglu and Akgun, 2009).

Recently, GIT-GTL received a color-change faceted stone weighting 7.12 ct, having the oval shape and modified brilliant-fancy cut for testing (Figure 1). This sample was recorded for its gemological properties.

Figure 1. A 7.12 ct stone exhibits strong color-change phenomenon from yellowish green in cool LED light (left) to pinkish orange in warm incandescent light (right). Photo by A. Buathong

Methods

Basic gem instruments were used for the measurement of the stone's properties. External and internal features were observed with high magnification gem microscope. All inclusions images were taken by using a gem microscope with Canon EOS 7D camera attached. The standard light sources, consisting of a Gretag Macbeth 5000° Kelvin lamp and the Gem diamondlite, were used for observing the stone colors.

For the advanced instruments, the Infrared (IR) spectral features of the stone were collected by a Thermo Nicolet 6700 Fourier-Transform Infrared (FTIR) spectrometer in the mid-IR range (6000 - 400 cm^{-1}) with a resolution of 2.0 cm^{-1} and 250 scans, and its Ultraviolet-Visible-Near Infrared (UV-Vis-NIR) spectra were recorded by a PerkinElmer Lambda 950 spectrophotometer in the range 250 - 1000 nm with a sampling interval of 3.0 nm and scan speed of 441 nm per minute. The stone chemical composition was analyzed by an Energy-dispersive X-ray Fluorescence (EDXRF) Eagle III spectrometer.

Results

Gemological properties

This stone displayed a strong color-change effect from yellowish green in daylight to pinkish orange in incandescent light. The basic gemological tests revealed that this stone was single refractive with the RI value of 1.762 and specific gravity (SG) of 3.47. The stone showed no reaction to both long-and short-wave UV radiation.

Microscopic examination of the stone exterior revealed rounded facet junctions, swirl marks and fractures on the surface (Figure 2). Under magnification with dark-field illumination, the stone internal features appeared very clean except a few tiny gas bubbles were noticeable.

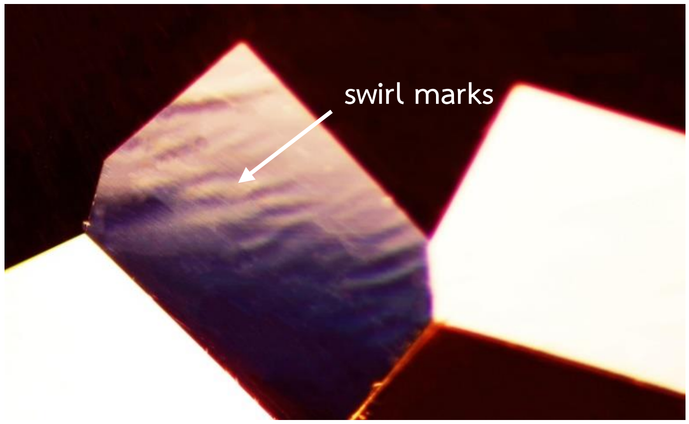

Figure 2. Swirl marks on polished surfaces of the color-change sample, FOV. 2.0 mm. Photo by A. Buathong

Advanced Instrumental Analyses

Chemical Composition

The semi-qualitative chemical analyses of this stone by EDXRF revealed high contents of yttrium, alumina, silicon and minor amounts of praseodymium, neodymium and zirconium (Table 1). Thus, this sample is likely an artificial glass. The praseodymium and neodymium Rare Earth Elements (REE) are probable the main cause of color in this stone (Gaievskyi and Iemelianov, 2015; Yu et al., 2016).

Table 1. *Chemical contents of the color-change stone, measured by EDXRF.*

Element Oxides (wt.%)	Al_2O_3	SiO_2	Pr_2O_3	Nd_2O_3	Y_2O_3	ZrO_2
Studied sample	22.97	18.42	7.18	6.77	38.45	6.22

Mid-IR Spectrum

Infrared spectrum of this sample showed absorption bands in the 2000 - 7000 cm^{-1} range with the absorption peak at approximately 3517, 3901, 4209, 5250, and 5805 cm^{-1} (Figure 3).

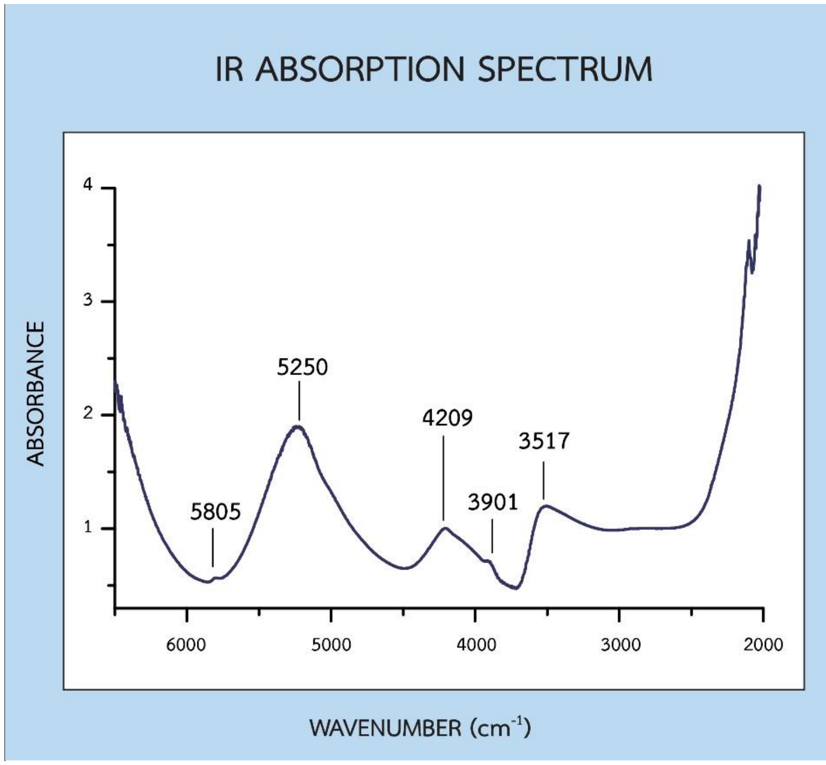

Figure 3. FTIR spectrum of the color-change sample showing several absorption bands at approximately 3517, 4209, 5250 cm^{-1}

UV-Vis-NIR Spectrum

The UV-Vis-NIR absorption spectrum of this sample showed absorption bands at 271, 326, 356, 443, 470, 482, 512, 525, 582, 681, 746 and 803 nm (Figure 4). The bands at 443, 482, and 525 nm are likely related to Pr^{3+} (Yu et al., 2016; Sasi kumar et al., 2017), while those at 582, 681, 746 and 803 nm are probably associated with Nd^{3+} (Yu et al., 2016; Mohan et al., 2007). As shown in Figure 4, the absorption bands related to these REE have created the strong transmission window in green-yellow-orange region of the visible spectrum. As daylight is more abundant in shorter blue and green wavelengths, the stone thus appears yellowish green under sunlight. However, when the stone is viewing under incandescent light which is relatively richer in longer (redder) wavelength, the stone then appears orange.

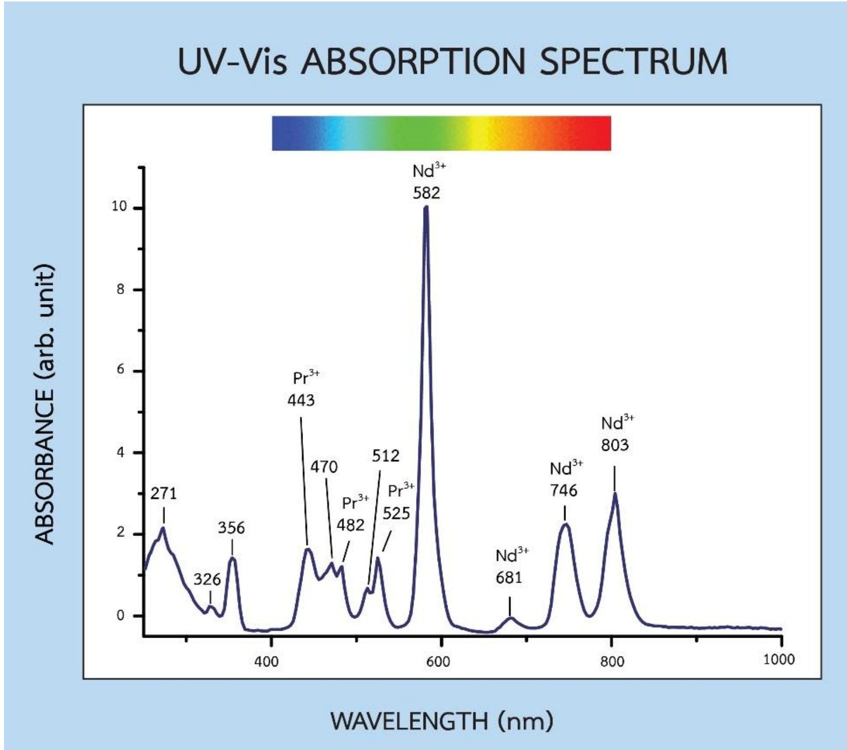

Figure 4. UV-Vis-NIR absorption spectrum of the color-change stone showing Pr^{3+} and Nd^{3+} related absorption bands. Note: Absorption bands in UV range are not identified.

Discussion & Conclusions

Even though the general appearances of the stone, such as the color-change phenomenon, some of the basic gemological properties, resemble those of natural color-change diaspore or zultanite (see Table 2), the exact nature of this color-change sample, nonetheless, can be distinguished fairly easily by the key identifying features, for examples, its single refraction properties, some microscopic features (i.e., swirl marks, a few tiny gas bubbles), as well as the unique chemical composition of a highly refractive man-made glass and the distinct UV-Vis-NIR and FTIR absorption spectra that clearly differ from those of zultanite. Therefore, this color-change stone is rather called 'zultanite imitation'. It should also be noted that a fairly similar color-change stone (yellowish green in fluorescent light and brownish yellow in incandescent light) made from artificial (Pr-Nd-Gd) glass was also reported as the zultanite Imitation (Yu et al., 2016).

Finally, as the zultanite is an extremely rare and expensive gem, whenever a stone is being offered as zultanite, we recommended trader, jewelers or collectors to request for an identification report from a reliable gem laboratory before purchasing.

Table 2. *Summary of the properties of the color-change stone versus those of zultanite.*

Properties	Color-Change stone (this study)	Zultanite (Anthony et al., n.d.; Hatipoglu and Akgun, 2009; Hatipoglu et al., 2010)
Color	yellowish green in daylight and pinkish orange in incandescent light	olive-green in daylight and brownish purplish pink in incandescent light
Refraction	Single	Double (Biaxial+)
RI	1.76	1.702 to 1.750
Pleochroism	none	strong (Biref: 0.048)
Cleavage	none	Perfect
SG	3.47	3.2-3.5
Fluorescence	inert to both LWUV & SWUV	inert to both LWUV & SWUV
Inclusions	swirl marks, a few tiny gas bubbles	natural inclusions
Chemical components	Pr-Nd-Zr-Y-Al-Si glass	AlO(OH) with traces of Fe, Cr, Ti or Mn
UV-Vis-NIR spectrum	absorption bands at 271, 326, 356, 443, 470, 482, 512, 525, 582, 681, 746 and 803 nm	absorption bands at 450, 397, 385, 371 nm
FTIR spectrum	absorption bands at 3517, 4209, 5250 cm^{-1}	absorption bands at 670, 750, 950, 1080, 1960, 2100, 2900, 3000 cm^{-1}

Acknowledgements

The authors would like to express ours thanks to Deputy Director, Mr. Thanong Leelawatanasuk and advisory teams, namely, Dr. Visut Pisutha-Arnond and Mrs. Wilawan Atichat for their extensive reviews of this article.

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