'Tairus' Created Gems: Part 1 - Beryl

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Introduction

Synthetic stones today are an integral part of the gem & Jewellery industry which offers a wider range to the consumers to choose from and at a cheaper price. However, these also pose problems for the consumers as well as retailers if not disclosed properly. It is now almost a year; we documented “Synthetic Beryl” imitating copper-bearing blue-to-green elbaite tourmaline, referred to as ‘*Paraíba’* in the trade (Choudhary & Golecha, 2007). This material was produced by Tairus Created Gems (Novosibirsk, Russia) mainly to take the advantage of the popularity of ‘*Paraíba’* tourmalines. Thereafter, we procured sets of various coloured beryls and corundum from the same manufacturer for our research and reference purpose. The study of these sets has been divided into two parts; this issue describes the study of beryl set, while the study of corundum set will be published in the next issue.

The Beryl set consisted of five colour varieties (figure 1), namely, green (emerald), light blue (aquamarine), electric greenish blue (paraíba type), purple pink and orange red. All specimens were faceted as square step and measured 6 X 6 mm.

Figure 1: These faceted samples measuring 6 X 6 mm each were procured from the Tairus Co. Ltd. Bangkok, Thailand. Mainly five colours viz., green (emerald), light blue (aquamarine), electric greenish blue (paraíba type), purple pink and orange red were available

Standard gemmological tests and advanced analysis on FTIR and EDXRF were performed on all the samples for records even when all samples were readily identifiable as the product of hydrothermal process. All samples displayed strong 'chevron' growth which was even seen with an unaided eye.

Visual observations: The emerald was bluish green colour with moderate saturation; aquamarine displayed the characteristic light blue colour while the paraíba type exhibited a typical bright and electric greenish blue colour; purple pink and orange red colours were distinctly saturated. All specimens other than the aquamarine variety displayed a strong degree of dichroism, which was seen even with the unaided eyes; as the specimens were rotated and observed in different directions these pleochroic colours became obvious. Further, in darker coloured varieties such as purple pink or orange red, a distinctive 'undulating' or a 'chevron' growth pattern was visible even to the unaided eyes making them readily identifiable as products of 'hydrothermal' process.

Gemmological Properties

The gemmological properties have been summarized in table 1 and discussed below.

Refractive Index: The lowest R.I value varied from 1.583 to 1.590 while the higher from 1.590 to 1.600 with birefringence of 0.007 to 0.010. The values varied as per the colour variety as given in the Table 1. R.I values for the paraíba type beryl were unusually high and reached up to 1.600.

Specific Gravity: The SG values ranged from 2.69 for emerald colour to 2.76 for paraíba colour, which is unusually high for a beryl of synthetic origin (Smirnov et al, 1999).

Pleochroism: Dichroism varied from weak in aquamarine to very strong in darker coloured varieties like purple pink or orange red. Emerald and paraíba colours exhibited pleochroism of moderate intensities; the principal colours seen were yellowish green ('parallel' optic axis) and bluish green ('perpendicular' to optic axis) for the emerald colour (figure 2.top) while greenish blue ('parallel' optic axis) and blue ('perpendicular' to optic axis) for paraíba colour. Purple pink and orange red varieties displayed a strong degree of dichroism; the purple pink (figure 2.centre) variety displayed orange pink ('parallel' optic axis) and purplish pink ('perpendicular' to optic axis) while orange red (figure 2.bottom) variety exhibited orange red ('parallel' optic axis) and purplish red ('perpendicular' to optic axis).

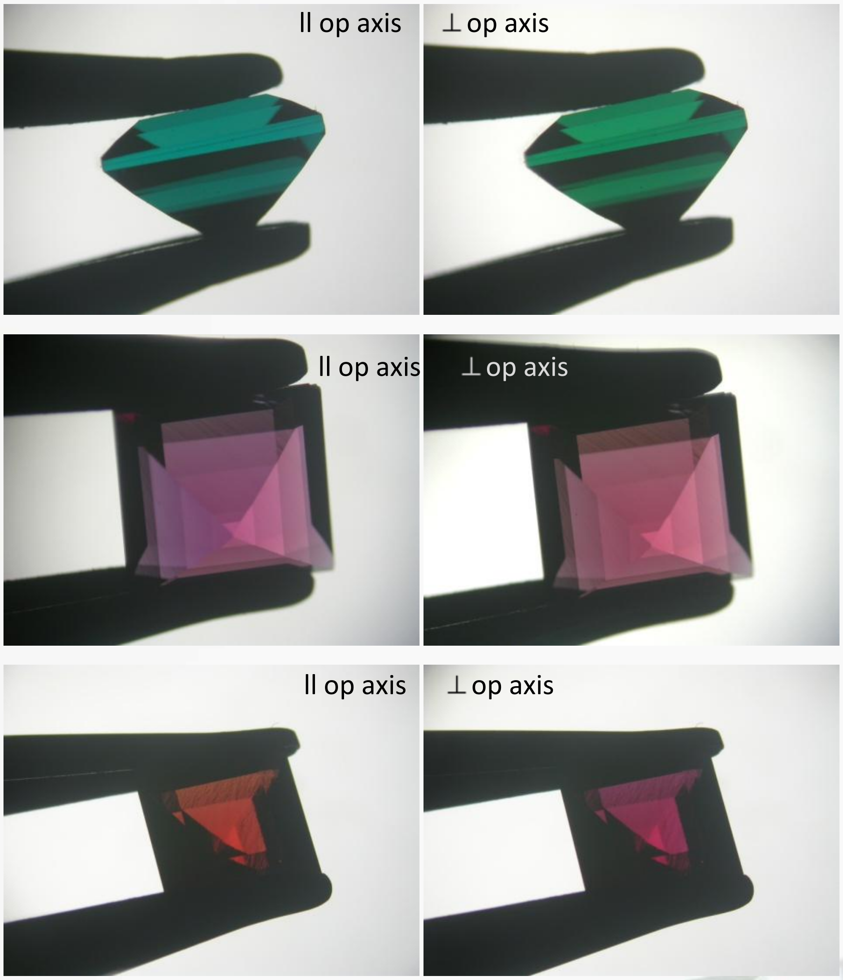


Figure 2: Pleochroic colours as seen in these synthetic beryls ranged from moderate to strong in intensity. Emerald displayed two principal colours as yellowish green ('parallel' optic axis –top, left) and bluish green ('perpendicular' to optic axis-top, right). Purple pink and orange red varieties displayed a strong degree of dichroism; the purple pink variety displayed orange pink ('parallel' optic axis-centre, left) and purplish pink ('perpendicular' to optic axis – centre, right) while orange red variety exhibited orange red ('parallel' optic axis – bottom, left) and purplish red ('perpendicular' to optic axis- bottom, right).

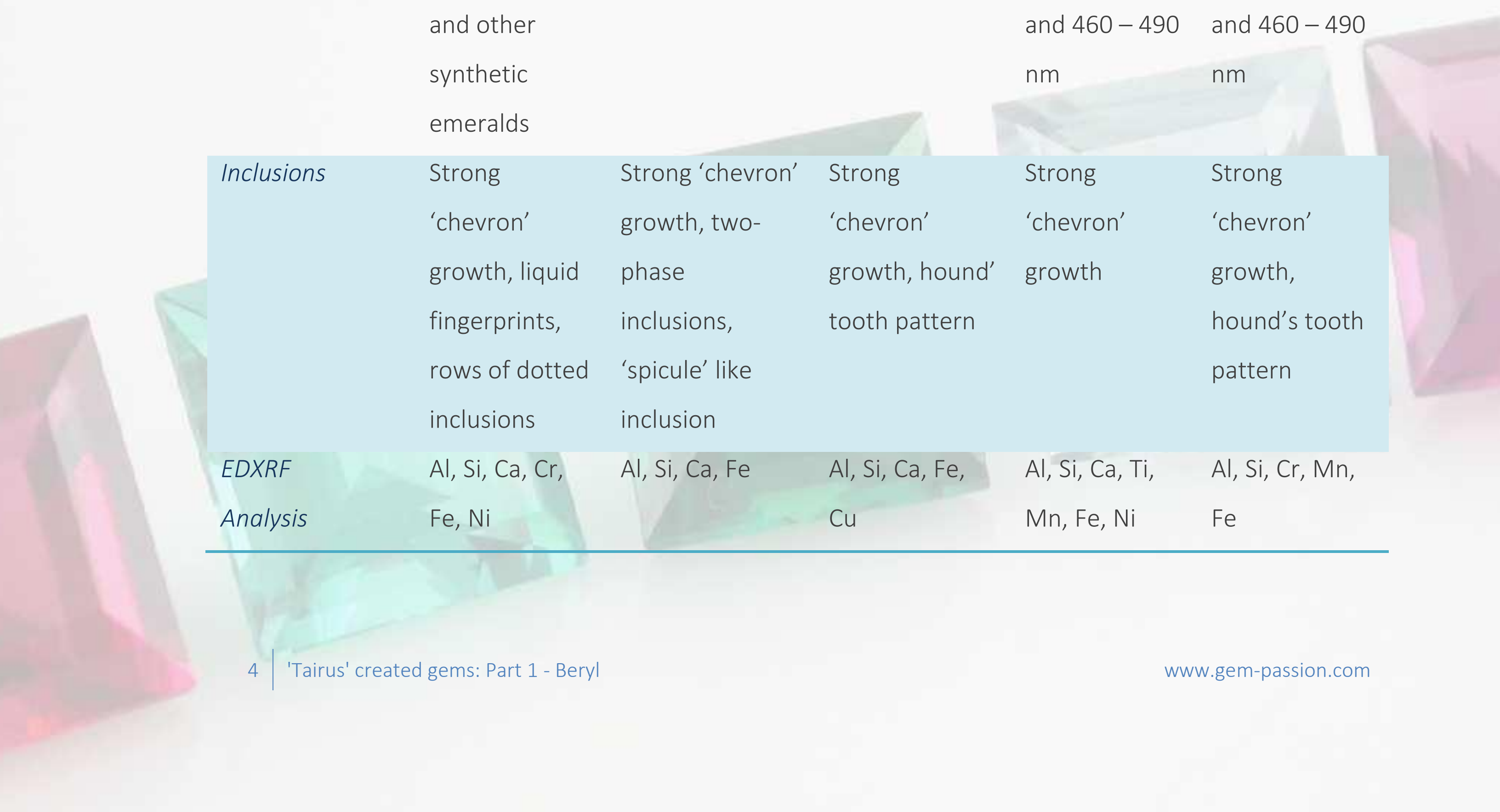
Absorption Spectrum: The spectrum varied as per the colour variety; emerald showed a typical chromium spectrum while the 'paraíba' colour displayed a strong band at around 430 nm. Purple pink and orange red varieties exhibited strong bands at 460 to 490 and 550 to 600 nm.

UV fluorescence: All samples were inert to long wave as well as short wave UV light.

Chelsea Filter Reaction: Emerald revealed a red glow while all other varieties were either inert or did not displayed any reaction.

Table 1: Properties of ‘Tairus’ created Beryl

Property	Emerald (bluish green)	Aquamarine (light blue)	‘Paraiba’ (greenish blue)	Purple Pink	Orange Red
RI	1.590 – 1.598	1.582 – 1.590	1.590 – 1.600	1.585 – 1.592	1.583 – 1.591
Birefringence	0.008	0.008	0.010	0.007	0.008
SG	2.69	2.70	2.76	2.70	2.69
UV Fluorescence	Inert	Inert	Inert	Inert	Inert
CF Reaction	Red	Inert (weak greenish)	No reaction	No reaction	No reaction
Pleochroism	Moderate; yellowish green (along optic axis) and bluish green (⊥ to optic axis)	Weak; shades of blue	Moderate; greenish blue (along optic axis) and blue (⊥ to optic axis)	Strong; orange pink (along optic axis) and purplish pink (⊥ to optic axis)	Strong: orange red (along optic axis) and purplish red (⊥ to optic axis)
Absorption Spectrum	Typical chromium as seen in natural and other synthetic emeralds	None	Strong band at around 430 nm	Strong bands at 550 – 600 nm and 460 – 490 nm	Strong bands at 550 – 600 nm and 460 – 490 nm
Inclusions	Strong ‘chevron’ growth, liquid fingerprints, rows of dotted inclusions	Strong ‘chevron’ growth, two-phase inclusions, ‘spicule’ like inclusion	Strong ‘chevron’ growth, hound’ tooth pattern	Strong ‘chevron’ growth	Strong ‘chevron’ growth, hound’s tooth pattern
EDXRF Analysis	Al, Si, Ca, Cr, Fe, Ni	Al, Si, Ca, Fe	Al, Si, Ca, Fe, Cu	Al, Si, Ca, Ti, Mn, Fe, Ni	Al, Si, Cr, Mn, Fe



Microscopic features: The inclusion study in most of the cases distinguishes a natural stone from the synthetic counterparts as was also in this case. The range of inclusions observed in this particular set of stones includes:

'Chevron' growth features and hound's tooth: The wavy growth features known as 'chevron' (figure 3.a) typically associated with synthetic hydrothermal stones were present in all specimens; in some varieties the effect was visible even with naked eyes. These have been described as irregularly changing subgrain boundaries between sub-individuals crystals (Schmetzer, 1990). In 'paraiba' and 'orange red' varieties 'hound's tooth' (figure 3.b) effect was also observed in the direction perpendicular to the chevron growth.

Rows of fine dotted inclusions: Fine rows of dotted inclusions (figure 3.b) were also observed in the emerald, following the direction of chevron growth. This gave appearance of fine / broken needles.

Liquid fingerprints: The emerald variety also displayed fine liquid fingerprints (again, figure 3.b) which were also oriented along the direction of 'chevron' growth. However, the size of fingerprints was relatively smaller as compared to previously seen in stones created by the hydrothermal process; in addition many also displayed angular edges.

Two-phase inclusions: Aquamarine specimen had a cluster of tiny two-phase inclusions with irregular boundaries (figure 3.c); one individual triangular/ conical phase inclusion (figure 3.d) was also present giving impression of a 'spicule'. However, 'head' of this spicule like inclusion was not visible.

EDXRF Analysis: Qualitative elemental analysis performed on all five samples revealed the presence of Al and Si as the major elements as expected for Beryl. Various trace elements detected include Cr, Fe, Cu, Mn, Ti, Ca, and Ni. The manufacturer claims that the orange red and purple pink colours are produced by adding Co impurity; however, in our analysis no distinct peak for Co was detected. The paraíba colour displayed Cu and Fe peaks, which appeared to be the cause of colour and responsible for unusually higher values of RI and SG. These elements have also been reported as the colour-causing impurities in synthetic blue beryls (Schmetzer et al., 2006).

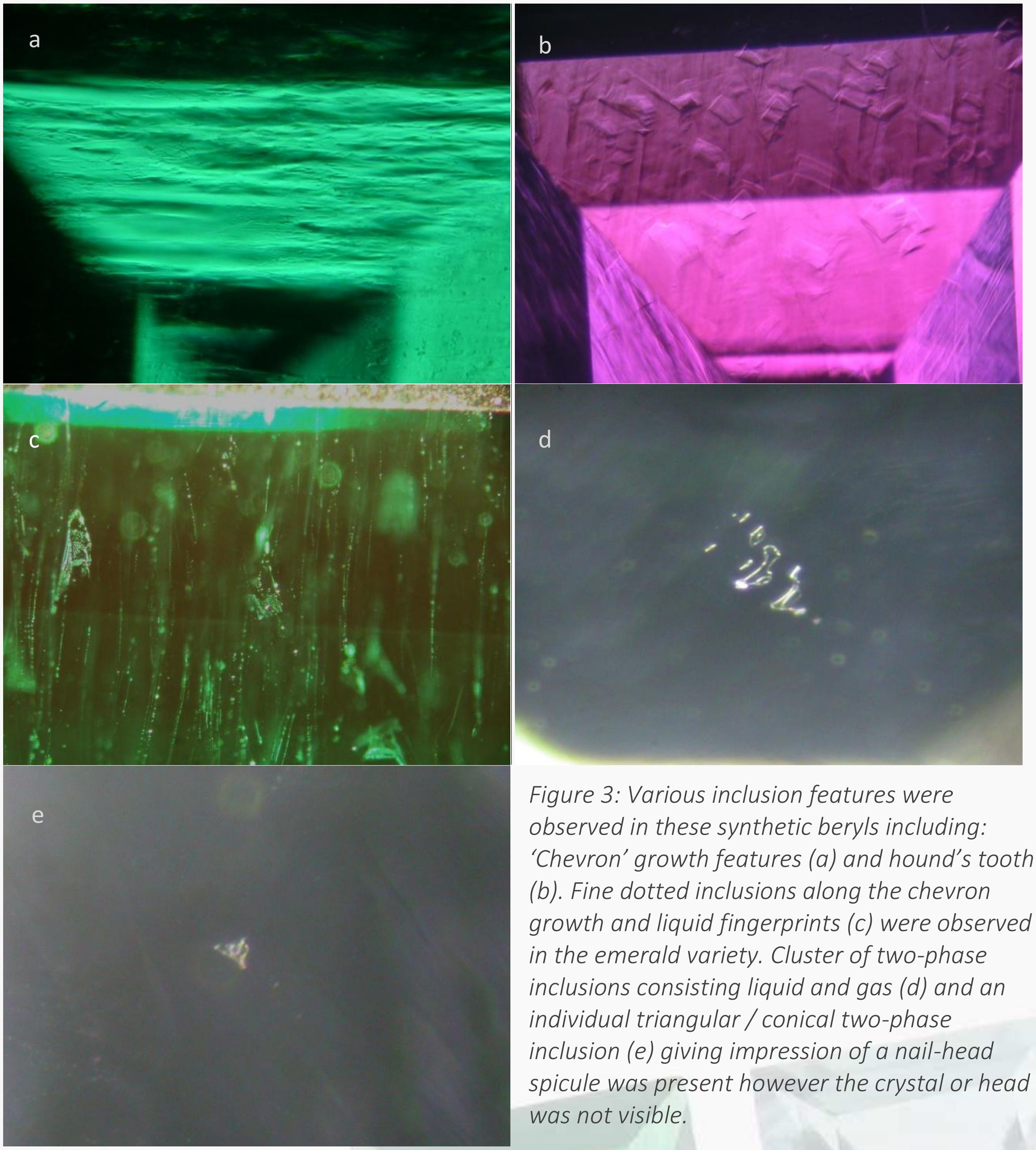


Figure 3: Various inclusion features were observed in these synthetic beryls including: 'Chevron' growth features (a) and hound's tooth (b). Fine dotted inclusions along the chevron growth and liquid fingerprints (c) were observed in the emerald variety. Cluster of two-phase inclusions consisting liquid and gas (d) and an individual triangular / conical two-phase inclusion (e) giving impression of a nail-head spicule was present however the crystal or head was not visible.

FTIR Analysis: FTIR absorption spectra (figure 4) exhibited a general absorption till 2200 cm^{-1}, an absorption band ranging from 3400 to 4000 cm^{-1} and a sharp but small peak at around 5266 cm^{-1} accompanied by two smaller peaks on the either sides. This pattern of peaks in the region 5500 to 5000 cm^{-1} is often encountered in synthetic hydrothermal emeralds. Some natural emeralds have also displayed a similar feature and hence not conclusive enough to differentiate these two. However, the shape of the peaks gives an indication regarding the origin. The distinguishing features were observed in the region around 2300 and 4100 cm^{-1}.

Natural emerald displayed strong peaks at around 2358 / 2340 cm^{-1}, while this was either missing or present as weak peak. Synthetic emerald displayed a hump at around 4055 cm^{-1}, which was missing in natural counterparts, but also affected by the noise present in the spectra. These features are also described by Koivula et al (1996).

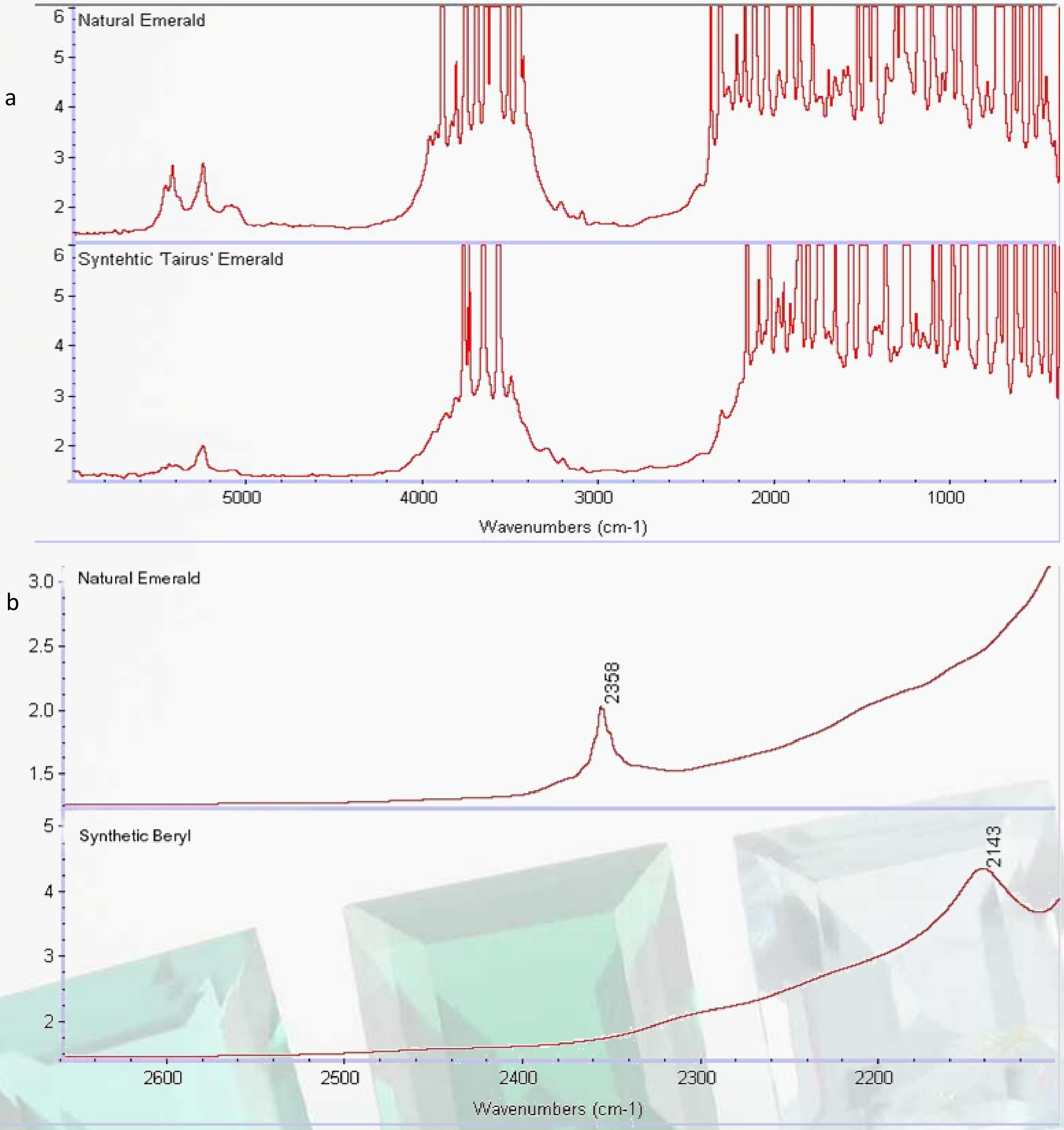


Figure 4: IR spectrum in the region 400 to 6000 cm^{-1} did not reveal significant differences (a) and hence proved to be inconclusive. The distinguishing features were observed in the region around 2300 and 4100 cm^{-1}. Natural emerald displayed strong peaks at around 2358 / 2340 cm^{-1}, while this was either missing or present as weak peak in synthetic counterparts. Synthetic emerald displayed a hump at around 4055 cm^{-1}, which was missing in natural counterparts, but also affected by the noise present in the spectra.

Conclusions

Although synthetic beryls (especially emerald) are known for decades in the trade, these colours were new in our experience, especially the paraíba one. Their standard gemmological properties, such as RI and SG overlap with those of natural counterparts. Microscopic features, such as, ‘chevron’ growth can readily identify this material as synthetic which is visible even with unaided eyes, however, there might be cases when the internal features may not identify the material; in such cases, FTIR and EDXRF analysis may be needed to conclude the stones as synthetic. Now, more care has to be taken when dealing with beryls, as synthetic counterparts for various colours are much easily available.

References

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