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Ni-bearing Synthetic Sapphires Showing Irreversible Photochromism

In July 2025, the Stuller Gemological Laboratory received a parcel of calibrated synthetic sapphires ranging from 1 to 9 mm that were labelled by the colours ‘aqua-blue’ (consisting of pale violetish blue to moderate blue gems) and ‘green’ (pale bluish green). They underwent routine analysis, as well as additional testing for photochromism, as per the recent report by Estrella and Smith (2025).

When some representative samples were exposed to 254 nm short-wave UV radiation, they showed a noticeable change in colouration after <1 minute of exposure. After five minutes, the pale violetish blue ones changed to yellow, the moderate blue samples changed to greenish yellow and the pale bluish green specimens turned greenish yellow (Figure 34). We attempted to reverse these colour alterations by exposing the affected samples to a powerful incandescent light source for four hours, but no changes in

their colour were seen. Future tests will examine their responses to gentle heating, although no restoration of the original colouration was noted upon heating by Estrella and Smith (2025).

UV-Vis spectra were obtained from each sample before and after exposure to short-wave UV radiation using a Magilabs GemmoSphere spectrometer (e.g. Figure 35). In their initial state, all three colour types displayed a wide absorption band centred around 605 nm and a 697 nm emission line. In addition, a very small 435 nm absorption feature was present in the violetish blue and blue samples. Following exposure to short-wave UV radiation, a slight decrease in the 605 nm band was observed, accompanied by a significant increase in absorption in the 400–500 nm range. Additionally, the 697 nm emission feature was somewhat diminished.

The 605 nm band has previously been reported



Figure 34: Representative synthetic sapphires from a parcel recently examined by the authors show the changes in colour before (left side) and after (right side) exposure to short-wave UV: (a) pale violetish blue to yellow (6 × 6 mm), (b) moderate blue to greenish yellow (5 × 5 mm) and (c) pale bluish green to greenish yellow (5 mm in diameter). Composite photos by Daniel Maldonado, Stuller Inc.

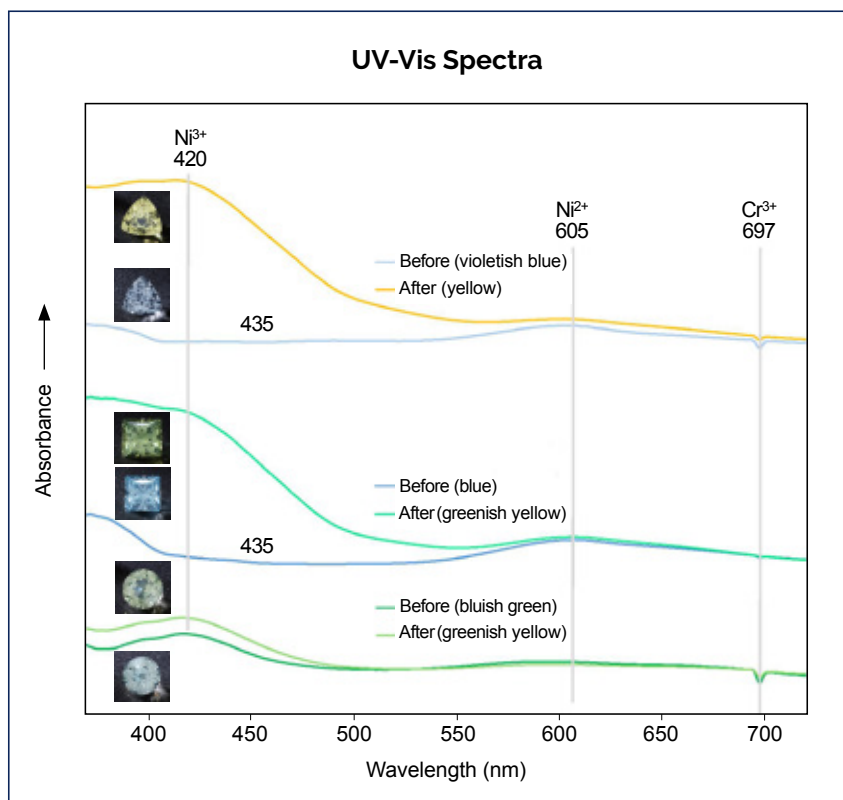


Figure 35: These UV-Vis absorption spectra were collected from three of the synthetic sapphires before and after exposure to short-wave UV radiation. After exposure, the Ni^{3+} absorption at 400 to 500 nm increases, especially for the samples that were blue before exposure. In addition, the Cr^{3+} emission at 697 nm decreases somewhat. The spectra are offset vertically for clarity.

as a superposition of Ni^{2+} (580–620 nm) and Cr^{3+} (510–620 nm) in synthetic Ni^{2+} -doped hydrothermal synthetic sapphires (Thomas *et al.* 1997), while the 697 nm feature has been attributed to Cr^{3+} . The 400–500 nm absorption that was intensified after exposure to short-wave UV has previously been attributed to transitions associated with both Ni^{3+} and trapped hole centres (Emmett *et al.* 2023).

PL measurements taken before and after short-wave UV exposure revealed a decrease in the intensity of an emission band at 500 nm in all samples. This PL emission has been attributed to an oxygen-vacancy trapped hole centre, also known as the F_2 centre (Ananchenko *et al.* 2018).

EDXRF chemical analysis with a Shimadzu EDX-8000 unit indicated traces of Ni, Ti, V, Fe and Cr in all samples. In addition, an in-house-built deep-UV imaging system clearly showed the presence of curved growth lines, indicating a flame-fusion process for these synthetic sapphires.

Previous research has demonstrated that gamma-ray irradiation of Ni^{2+} -doped pale greenish blue synthetic sapphires induced a similar yellow colouration by promoting the conversion of Ni^{2+} to Ni^{3+} (Thomas *et al.* 1997). In addition, a mechanism involving Ni^{2+} donating an electron to a nearby oxygen-vacancy-related defect has been observed in flame-fusion synthetic sapphires grown in a reducing atmosphere (Kawaminami *et al.* 2018).

The authors believe the colour alterations after short-wave UV exposure follow similar mechanisms to those described in the reports mentioned above, evident by the increasing contribution of Ni^{3+} , as well as the resulting yellow contribution to the hue. The decrease in the 500 nm PL emission and the detection of traces of Ni by EDXRF analysis provide further support for defect-related changes involving Ni and F_2 centres. The decrease in Cr^{3+} emission after UV exposure suggests another, unknown quenching mechanism.

The apparently irreversible change in colour shown by these synthetic sapphires raises important concerns regarding the stability, treatment disclosure and long-term appearance of such materials in the gem trade. Gemmologists and appraisers should keep this irreversible photochromism in mind when looking for curved banding with short-wave UV radiation or checking the UV fluorescence of stones mounted in jewellery. In addition, the possibility exists that further testing could reveal a more gradual rate of colour change in such synthetic sapphires under standard conditions of wear such as long-term exposure to sunlight.

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TREATMENTS

Tsavorite Showing Evidence of Heat Treatment

In July 2025, GemRight Gemology, a gemmological laboratory in Singapore, received three loose faceted green gemstones for evaluation (Figure 36). Standard gemmological testing identified them as tsavorite, with RI values of 1.742, 1.745 and 1.756 obtained

for the three stones. Hydrostatic SG values were 3.60, 3.62 and 3.65, consistent with grossular (cf. Manson & Stockton 1982). Examination with a polariscope showed that all three samples were singly refractive, with anomalous double refraction seen as snake-like shadows that moved as the stones were rotated.

Microscopic examination revealed inclusions consistent with a natural origin, including negative crystals and ‘fingerprints’. However, the fingerprints in all three samples showed an altered appearance, with coarse, whitish solid-appearing inclusions resembling those seen in flux-healed corundum (Figure 37). All three samples also displayed multiple glassy, discoid tension fractures with melted frosty-looking crystals of various sizes at their centres (Figures 37a and 38), reminiscent of the inclusion scene in typical heat-treated corundum.

Given that tsavorite forms under high temperatures and pressures in metamorphic environments

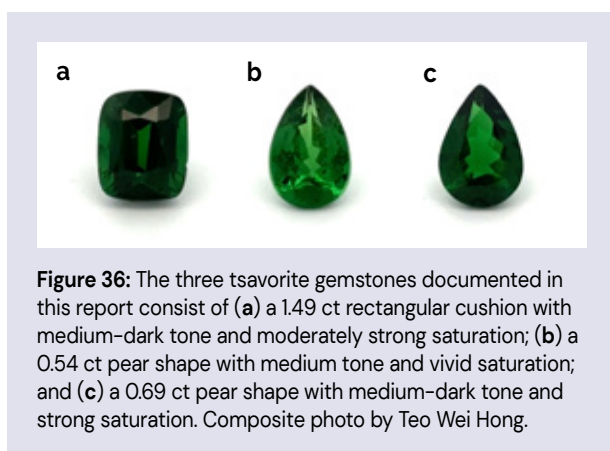


Figure 36: The three tsavorite gemstones documented in this report consist of (a) a 1.49 ct rectangular cushion with medium-dark tone and moderately strong saturation; (b) a 0.54 ct pear shape with medium tone and vivid saturation; and (c) a 0.69 ct pear shape with medium-dark tone and strong saturation. Composite photo by Teo Wei Hong.

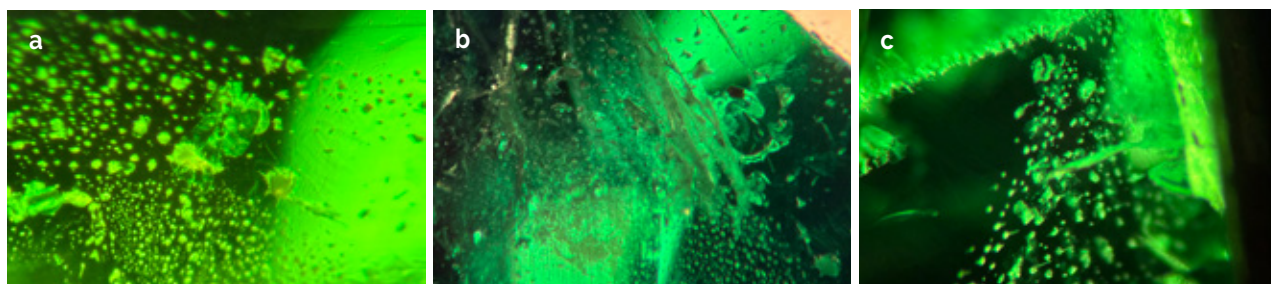


Figure 37: (a) The tsavorite in Figure 36a contains an altered ‘fingerprint’ with whitish, coarse solid inclusions and a discoid-like fracture. (b) An altered inclusion scene also occurs in the tsavorite in Figure 36b. (c) An altered fingerprint containing discoid fractures is present in the tsavorite in Figure 36c. The whitish, solid-appearing inclusions in these images are much different than the fingerprints typically seen in tsavorite, which consist of intact two-phase liquid–gas inclusions. Photomicrographs by Teo Wei Hong; magnified (a) 60×, (b) 70× and (c) 40×.