UPDATE ON THE IDENTIFICATION OF TREATED "GOLDEN" SOUTH SEA CULTURED PEARLS

By Shane Elen

Most of the "golden" South Sea cultured pearls in a single strand were found to exhibit unusual brownish orange fluorescence to long-wave UV radiation and atypical absorption features at 405 nm and 558 nm. On the basis of these features and visual examination, 33 of the 35 cultured pearls were identified as color treated. This study demonstrates how atypical absorption features, particularly in the blue region of the spectrum, can be used to positively identify color treatment, even in the presence of the 330–385 nm UV absorption feature characteristic of natural-color "golden" pearls from the *Pinctada maxima* mollusk.

The identification of treated "golden" South Sea cultured pearls has relied primarily on observations made with the gemological microscope. Unusual fluorescence to long-wave ultraviolet radiation often has been used as supporting evidence. When present, color concentrations in nacre defects or around drill holes can be used to positively identify treated color. Ongoing investigation at GIA Research has shown that some types of color treatment might be identified by the presence of atypical absorption features in the visible region of the reflectance spectrum.

The present study centers on the examination of a strand of 35 "golden" South Sea cultured pearls (11–14 mm in diameter) that were submitted to the GIA Gem Trade Laboratory for an identification report earlier this year. The pearls exhibited quite uniform yellow coloration (figure 1), but standard gemological testing revealed evidence of treatment. In keeping with our pearl research program, these cultured pearls were examined further in an attempt to determine the identifying characteristics of this treatment method. Particular attention was paid to spectra in the UV-visible range.

BACKGROUND

Recently, UV-Vis reflectance spectroscopy was used to help distinguish natural-color "golden" cultured pearls from those reportedly treated using heat (Elen, 2001). The application of this "heat" treatment method to undrilled pearls was unlike the more common dyeing method encountered by gemologists, which typically is applied after drilling, often resulting in a characteristic concentration of color in the drill hole. Evidence of the "heat" treatment method in undrilled pearls occasionally could be detected by observing an unusual color concentration in surface defects, or was indicated by the atypical fluorescence.

However, testing of known natural-color samples has revealed that both yellow shell nacre and natural-color "golden" cultured pearls from the *Pinctada maxima* mollusk exhibit broad absorption from 330 to 460 nm (Elen, 2001). This absorption was found to consist of two features, one in the UV region from 330 to 385 nm and a weaker one in the blue region of the visible spectrum from 385 to 460 nm. Closer examination of these features showed absorption maxima between 350 and 365 nm and from 420 to 435 nm. The strength of both these absorption features increased with increasing saturation of the yel-

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Figure 1. This strand of loosely strung, predominantly treated-color "golden" South Sea cultured pearls (11 to 14 mm in diameter) was characterized in this study. Photo by Maha Tannous.

low color (figure 2). It was concluded that the absence of the UV absorption feature in "golden" cultured pearls indicated treated color, regardless of the treatment method used. However, given that numerous chemicals and dyes are available to produce yellow coloration (see Green, 1990), it also was noted that the presence of the absorption features in the UV and blue regions of the spectrum could not be used with certainty to indicate natural color. This article demonstrates how atypical absorption features in these regions extend the application of UV-Vis spectroscopy for the identification of treated "golden" South Sea cultured pearls.

MATERIALS AND METHODS

All 35 cultured pearls in the strand were examined with a standard gemological microscope equipped with fiber-optic lighting. Although it is difficult to inspect the drill holes of a knotted strand of cultured pearls for evidence of color concentrations, this particular strand was strung temporarily, so relatively few (four) of the cultured pearls were knotted tightly in place. Therefore, the others could be separated easily for inspection of the drill holes.

The fluorescence reaction was tested in a darkened room using a UVP model B100 AP long-wave UV lamp. UV-Vis reflectance spectra were obtained for all 35 samples with a Hitachi 4001 UV-Vis spectrophotometer. Energy-dispersive X-ray fluorescence (EDXRF) analysis was performed with a Thermo Noran Spectrace 5000 EDXRF spectrometer for four samples chosen on the basis of their reaction to long-wave UV: two that exhibited strong brownish orange fluorescence and two that displayed greenish yellow fluorescence.

RESULTS

Visual Appearance. All 35 cultured pearls in the strand were yellow with uniform color distribution and exhibited a good color match to one another (again, see figure 1).

For those cultured pearls that were loose on the strand, microscopic examination with fiber-optic lighting revealed an unusual color distribution within the drill holes of the vast majority of the samples (figure 3). The color appeared to be more saturated at the surface of the nacre and to decrease in intensity with depth into the drill hole.

In reflected light, faint color concentrations were noted in small surface defects on several of the cultured pearls, and these were accompanied by a "blotchy" appearance of the color when observed in transmitted light. Two of the cultured pearls revealed an orange residue around their drill holes, and another revealed an orange residue concentrated in a large pit adjacent to the drill hole.

Fluorescence and UV-Vis Reflectance Spectra. Twenty-seven of the 35 cultured pearls revealed brownish orange fluorescence to long-wave UV radiation. All of these samples also showed a distinct absorption feature at 405 nm and a weaker one at 558 nm (figure 4). The strength of the absorption at 558 nm appeared proportional to the absorption at 405 nm. Six other samples showed greenish orangy yellow fluorescence and revealed only a weak 405 nm absorption feature. The remaining two samples exhibited greenish yellow fluorescence and absorption in the blue region centered at 430 nm (figure 4), which are both characteristic of "golden" cultured pearls from *P. maxima*. No color concentrations were evident in the drill holes of these two samples.

All 35 samples exhibited absorption between 355 and 365 nm in the UV region of the spectrum; in all but 10 of the samples, the UV absorption was stronger than the absorption in the blue region. Of the exceptions, six exhibited strong brownish orange fluorescence and the remaining four fluoresced brownish orange with moderate intensity. In addition, six other samples showed noticeably patchy fluorescence in which different areas exhibited distinct regions of greenish orangy yellow and brownish orange fluorescence.

EDXRF Chemical Analysis. EDXRF analysis revealed the presence of calcium, strontium, and sulfur in all four samples tested.

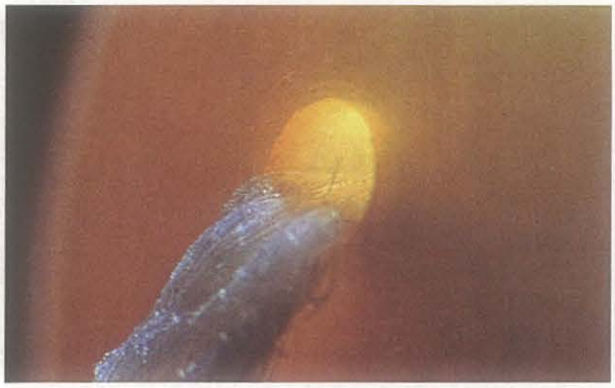


Figure 3. In many of the cultured pearls, the color appeared to be concentrated near the surface when viewed down the drill hole. Such concentrations of color in pearls are good indicators of treatment. Photomicrograph by John Koivula; magnified 5×.

DISCUSSION

In our experience, the relatively saturated color at the surface of the nacre, which gradually became lighter as one looked deeper into the drill hole, suggests that the cultured pearls exhibiting this feature were color treated prior to drilling. Had color treatment been applied after drilling, it most likely would appear to color the nacre uniformly within the drill hole, or to be concentrated at the conchiolin layer between the nucleus and the nacre (Gauthier and Lasnier, 1990).

Although the observation of both a color concentration inside the drill hole and unusual fluorescence often can indicate color treatment, detection requires both experience and the appropriate lighting environment (such as the proper orientation of the fiber-optic light for examination of the drill hole, and a dark room for fluorescence testing). In some cases, these observations can be quite difficult to interpret and are thus subjective criteria. In other cases, such as cultured pearls that are undrilled, post mounted, or tightly strung, it may not be possible to inspect inside the drill hole. In all these situations, UV-Vis reflectance spectroscopy is especially important because it provides objective data in the form of a spectrum. Often, color treatment can be identified conclusively only by com-

Figure 2. These reflectance spectra of six light yellow to orangy yellow cultured pearls from the P. maxima *oyster show absorption features that are characteristic of natural color. These features are located in the UV region between 350 and 365 nm, and in the blue region from 420 to 435 nm. Adapted from Elen (2001).*

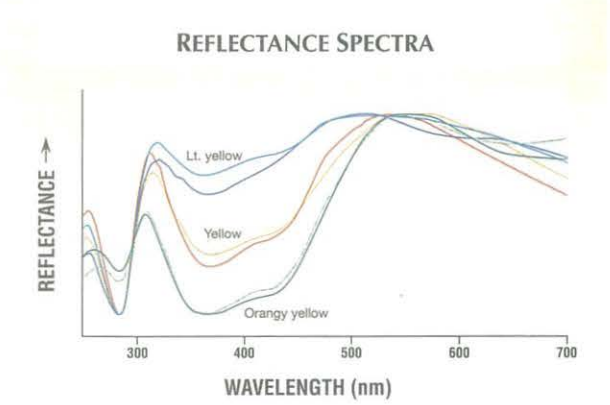
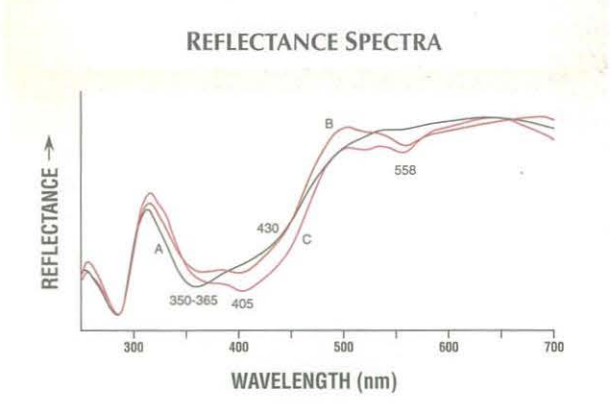


Figure 4. These reflectance spectra represent the three types of "golden" cultured pearls on the strand examined: (A) untreated, with typical greenish yellow fluorescence; (B) treated, with slightly brownish orange fluorescence; and (C) treated, with strong brownish orange fluorescence.



paring the data from a variety of these tests.

For all the cultured pearls in the strand examined for this study, the absorption from 355 to 365 nm was similar to that observed in the UV region of natural-color "golden" cultured pearls (Elen, 2001). However, 10 of the samples exhibited stronger absorption in the blue than in the UV region, which is not characteristic of natural yellow color in *P. maxima* (again, see figure 3). In these 10 samples, the brownish orange fluorescence was generally quite strong. However, there was not a consistent correlation between the strength of the 405 nm absorption and the intensity of the brownish orange fluorescence. Nevertheless, all 33 samples that showed either the unusual brownish orange or greenish orangy yellow fluorescence also had an absorption feature at 405 nm. This, in conjunction with the color concentration, indicates that this particular color treatment uses a chemical or dye in which absorption in the blue region at 405 nm is responsible for the yellow coloration. Absorption at 405 nm and 558 nm, and the brownish orange fluorescence, are not characteristic of natural-color "golden" cultured pearls from the gold-lipped oyster *P. maxima* (Elen, 2001).

Different yellow dyes and chemicals may have distinctly different absorption features in the blue region of the visible spectrum (e.g., Thiazol Yellow G and Mordant Yellow 12 [Green, 1990]). They also may exhibit additional absorption features in the UV as well as other regions of the spectrum (Green, 1990). When present, these absorption features can be used to identify color treatment.

No difference was observed in the EDXRF analyses for the treated samples compared to those of natural-color cultured pearls tested previously (see Elen, 2001). Organic compounds cannot be detected by this technique, and sodium (a relatively light element) can only be detected when present in high concentration; no sodium was detected in the four samples analyzed. This suggests that the treatment involved the use of organic chemicals or dyes, or inorganic chemicals composed of light elements such as sodium salts.

CONCLUSION

All but two of the cultured pearls tested in this study were found to have been color treated prior to drilling. However, the treatment process used for these pearls appears to be different from the "heat" treatment method reported in an earlier study (see Elen, 2001). Evidence of treatment consisted of a surface color concentration noted in the drill hole, color concentrations in nacre defects, unusual brownish orange fluorescence to long-wave UV radiation, and the presence of atypical (for natural-color "golden" cultured pearls) absorption features at 405 and 558 nm in the UV-Vis reflectance spectrum.

In the absence of conclusive visual indicators, a variety of treatment methods for producing "golden" color in South Sea cultured pearls may be detected by atypical absorption features in the visible region of their reflectance spectrum. When several cultured pearls on a strand exhibit matching absorption features, particularly in the blue region of the spectrum, and these are not typical of natural-color "golden" cultured pearls, then treatment is indicated for those samples. However, as more data are obtained on natural-color "golden" cultured pearls, it is likely that we will see an occasional anomalous absorption feature. Therefore, the detection of unusual absorption features in a single cultured pearl should be evaluated with caution.

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