THE CHROMIUM CONTENT OF LECHLEITNER SYNTHETIC EMERALD OVERGROWTH

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The refractive indices of the synthetic overgrowth on the beryl seeds of Lechleitner synthetic emeralds show a linear correlation with the chromium content of the coating. In a sample with refractive indices of n_o=1.580, n_e=1.572, a Cr_2O_3 content of 3.99% was found; a stone with n_o=1.610, n_e=1.601 contained 10.01% Cr_2O_3. Very broad, faint shadow edges on the refractometer in one sample were caused by an inhomogeneous distribution of Cr_2O_3—between 7.64% and 13.20%—in the synthetic emerald overgrowth. From these experiments, it is evident that the higher the chromium content in the overgrowth, the darker the coating (and, therefore, the overall appearance of the stone) will be.

Figure 1. Two Lechleitner synthetic emeralds. The larger stone weighs approximately 2.5 cts. The smaller stone is cut in cross-section to reveal the deep green overgrowth. Photo by Tino Hammid, Gem Media.

The synthetic emerald first produced by J. Lechleitner of Innsbruck, Austria, in 1959 consists of colorless or light pink natural beryl that is coated on all facets with a thin layer of synthetic emerald (figure 1). Details of the experimental conditions used to grow a layer of synthetic emerald approximately 0.5 mm thick on the beryl seeds have not been published, but inclusions in the overgrowth indicate that a hydrothermal method is probable. After the stones have been coated, they are repolished for greater brilliance.

Several studies on the optical properties of Lechleitner synthetic emerald have been published; the data are summarized in table 1. It is presumed that the variations in the refractive indices reported in these different studies are due to the variable chromium content in the synthetic emerald substance that forms an overgrowth on the natural seed (Flanigen et al., 1965). Until now, however, no analytic investigations of the chromium content in the overgrowth have been published. In general, the refractive indices of the synthetic emeralds produced by Lechleitner are higher than those of other synthetic emeralds. In some instances, they are also higher than those of natural emeralds, which usually contain less than one percent Cr_2O_3. Therefore, one would expect the Lechleitner synthetic emeralds to contain more chromium substituting for Al^{3+} in the beryl lattice than is observed in natural stones.

In addition, while testing a parcel of Lechleitner synthetic emeralds on the refractometer, one of the authors observed several distinct shadow edges for both refractive indices n_o and n_e, a phenomenon that has already been described for heat-treated tourmalines (Mitchell, 1967; Schiffmann, 1972; Bank, 1975). Other Lechleitner synthetic emeralds, in spite of their well-polished tables, showed only faint and broad shadow edges for n_o and n_e; this implies that both refractive indices may vary over a considerable range as measured in the table of a single stone. We think that this situation is caused by a variation in the chemical composition, especially the chromium content, of the overgrowth on the table. The aim of this investigation was to clarify these observations.

DETAILS OF THE EXPERIMENT

For the investigation, seven Lechleitner synthetic emeralds were selected from a total of 270 sam-

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TABLE 1. Studies on the optical properties of Lechleitner synthetic emeralds.

Study	Optical properties n_o	n_e	Birefringence
Schlossmacher, 1960	1.581	1.575	0.006
Holmes and Crowningshield, 1960	1.581	1.575	0.006
Gübelin, 1961	1.578–1.590	1.571–1.583	0.007
Flanigen et al., 1965	1.582–1.597	1.577–1.587	0.005–0.010
Bank, 1976	1.583–1.605	1.577–1.599	0.005–0.009
Bank and Zwetkoff, 1979	1.578–1.598	1.570–1.591	0.007–0.008

ples on the basis of sharp refractive index shadows in the range of n_o=1.571, n_e=1.566 and n_o=1.610, n_e=1.601. One additional sample showed only faint broad shadow edges on the refractometer. For each stone, the synthetic emerald overgrowth on the table of a natural beryl seed (figure 2) was analyzed for chromium using an electron microprobe. Table 2 presents the optical data and chromium content for each stone. The samples were also tested for the presence of other elements with an atomic number greater than 11 that are not essential constituents of beryl. An absorption spectrum was recorded for the Lechleitner synthetic emerald with the highest refractive indices and chromium content. We then used a diamond hardness point to remove a small amount of the overgrowth from the table of this sample to produce an X-ray powder diffraction pattern.

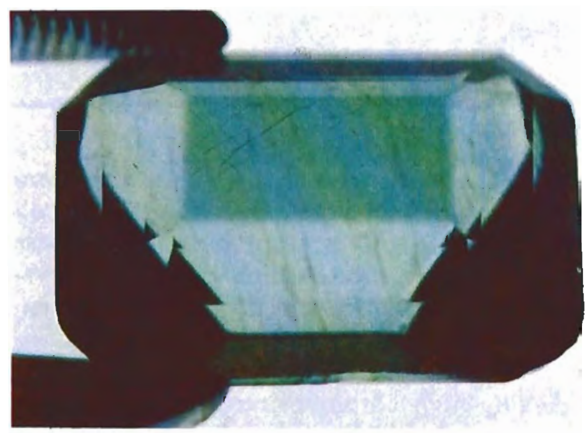

Figure 2. Lechleitner synthetic emerald viewed through the pavillion to reveal the chromium-rich overgrowth on the table facet. Photo by Tino Hammid, Gem Media.

RESULTS

The absorption spectrum of sample 7 corresponds to the spectra of natural emeralds from different localities. The X-ray powder diffraction pattern of sample 7 is identical to that of patterns for both natural and synthetic emeralds and for other beryls. These two tests showed that the green substance on the table facet consists of beryl in which Cr^{3+} replaces Al^{3+} in the crystal structure. Therefore, the substance is emerald. These data confirm the results of Holmes and Crowningshield (1960), Gübelin (1961), and Flanigen et al. (1965). The microprobe investigation of sample 8 revealed a strongly inhomogeneous distribution of chromium on the table facet. This variation in Cr_2O_3 content between 7.64% and 13.20% explains the variation in the refractive indices of the Lechleitner synthetic emerald and the resulting broad, faint shadow edges observed for this sample on the refractometer.

No chromium was detected on the table of sample 1. The green color apparently resulted from the synthetic emerald substance coating the bottom facets. The refractive indices measured on the table of sample 1 were the same as those of the colorless beryl seed (n_o=1.571, n_e=1.566). It appears that the overgrowth was removed when the table was repolished at the conclusion of the treatment process. On the bottom facets, values of n_o=1.590, n_e=1.582 were obtained, which are comparable to the data for other Lechleitner synthetic emeralds.

Unfortunately, we do not know the precise experimental conditions under which a crystalline phase with beryl structure that contains up to 13.20% Cr_2O_3 replacing Al_2O_3 in the beryl lattice is formed.

CONCLUSIONS

It is evident from these experiments that the intense green of the Lechleitner synthetic emerald

TABLE 2. Refractive indices and chromium content of Lechleitner synthetic emeralds.

Sample	Refractive index n_o	n_e	Mean	Cr_2O_3 (in weight %)
1	1.571	1.566	1.5685	—
2	1.580	1.572	1.576	3.99
3	1.582	1.575	1.5785	4.25
4	1.586	1.580	1.583	5.76
5	1.590	1.583	1.5865	6.09
6	1.600	1.590	1.595	7.55
7	1.610	1.601	1.6055	10.01
8	Broad shadow edges for n_o and n_e			Scanning profile across the table: 7.64, 8.23, 9.12, 10.09, 9.87, 11.28, 12.92, 13.18, 13.20, 12.25, 11.62, 10.82

is the result of the extremely high chromium content in the synthetic emerald that coats the colorless beryl seeds. By minimizing the thickness of the overgrowth and the time required for crystallization, the producers of the Lechleitner synthetic emeralds can offer these stones at a reasonable price. A totally synthetic piece with a comparable high chromium content would certainly be too dark for jewelry and, therefore, unusable. The chromium content of Linde synthetic emeralds, for example, ranges from 0.3% to 1.2% and leads to refractive indices of n_o=1.571–1.578, n_e=1.566–1.572 (Flanigen et al., 1965). The greater variation in the optical data for natural emeralds is due to the fact that the refractive indices are determined not only by the chromium content of the individual stone (which has been reported as high as 2.00%; Feklichev, 1963), but also by the percentages of other foreign admixtures, e.g., iron or alkali oxides, present in each.

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