UPDATE ON MEXIFIRE SYNTHETIC FIRE OPAL

Rajneesh Bhandari and Gagan Choudhary

As a result of changes in the manufacturing process, recent production of the synthetic fire opal marketed as "Mexifire" exhibits some new properties. While the earlier material could be identified on the basis of low RI and SG values, the new synthetics have values that are quite similar to—and partially overlap those of—natural fire opals. With the change in the manufacturing process, the water content has also changed, as reflected in the IR spectra.

In Choudhary and Bhandari (2008), we described a new synthetic fire opal marketed as "Mexifire." The article detailed the material's gemological properties, chemical composition, and infrared spectra, as well as provided a brief outline of the manufacturing process. Since November 2009, this process has been slightly modified. Water content is now controlled in such a manner that the refractive index and specific gravity values are much closer to those of natural fire opal. This article presents the properties of this new generation of Mexifire; the previous generation is no longer being produced, although some material undoubtedly remains in the marketplace.

Materials and Methods. We examined nine faceted ovals (3.40–4.40 ct; figure 1) representative of the new Mexifire production. Standard gemological tests were performed on all samples. Qualitative energy-dispersive X-ray fluorescence (EDXRF) chemical analyses of all samples were conducted using a PANalytical Minipal 2 instrument under two different conditions: Elements with a low atomic number (e.g., Si) were measured at 4 kV tube voltage and 0.850 mA tube current, while transition and heavier elements were measured at 15 kV and 0.016 mA. Spectroscopic measurements of all samples in the infrared range (6000–400 cm^{-1}) were performed with a Shimadzu IR Prestige 21 Fourier-transform infrared (FTIR) spectrometer, operating at room temperature with a diffuse-

Figure 1. These new samples of Mexifire synthetic fire opal (3.40–4.40 ct) were manufactured by a modified process and exhibit properties different from those recorded in the original production in 2008. Photo by G. Choudhary.

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TABLE 1. Properties of Mexifire synthetic opals (new and original products) and natural fire opals.

Properties	New Mexifire synthetic fire opal (this study)	Mexifire synthetic fire opal (Choudhary and Bhandari, 2008)	Natural fire opal
Color	Brownish orange to orangy brown	Brownish orange to orangy yellow	Brownish orange to orangy yellow
Color distribution	Typically even; on rotation, color appeared to concentrate in the center	Typically even	Often color zoned; flow-like or wavy pattern
Diaphaneity	Transparent under normal viewing conditions; translucent/turbid with fiber-optic light	Transparent under normal viewing conditions; translucent/turbid with fiber-optic light	Transparent to translucent
Quality of polish	Good	Good	Dull to good
Refractive index	1.470	1.380–1.405	1.440–1.460 (Simoni et al., 2010); 1.400–1.435 (Choudhary and Bhandari, 2008); and 1.435–1.455 (Webster, 1994)
Specific gravity	2.19	1.63–1.77	2.15–2.38 (Simoni et al., 2010); 1.92–2.06 (Choudhary and Bhandari, 2008); and 1.97–2.06 (Webster, 1994)
Polariscope reaction	Weak strain pattern; no snake-like bands observed	Strong strain pattern with snake-like bands	Weak strain pattern; no snake-like bands observed
Long- and short-wave UV fluorescence	Inert	Inert	Inert
Spectroscope	No features	No features	No features
Internal features	• Zoned turbidity • Scattered pinpoints	• Zoned turbidity • Scattered pinpoints • Whisker-like inclusion in one sample	Choudhary and Bhandari (2008): • Zoned turbidity • Scattered pyrite or some flake-like inclusions • Dendritic inclusions common • Flow patterns, cloudy zones, and fluid inclusions
EDXRF analysis	Si, Fe, and Ca	Si, Fe, and Ca	Si, Fe, and Ca (Choudhary and Bhandari, 2008); Al (Gaillou et al., 2008)
FTIR spectroscopy	Weak hump at ~5440 cm^{-1}; sharp peak with a shoulder at ~4520 cm^{-1}; absorption band in the 4000–3250 cm^{-1} region; weak shoulder at 2652 cm^{-1}; a sharp peak at 2262 cm^{-1} and complete absorption below 2100 cm^{-1}	Absorption band in the 5350–5000 cm^{-1} region; hump from 4600 to 4300 cm^{-1}; detector saturated below 4000 cm^{-1}	Absorption band in the 5350–5000 cm^{-1} region; hump from 4600 to 4300 cm^{-1} (absent from some stones); detector saturated below 4000 cm^{-1} (Choudhary and Bhandari, 2008)

reflectance accessory in transmittance mode. We used a standard resolution of 4 cm^{-1} and recorded 50 scans per sample. In addition to the nine faceted samples, two slices (one from the previous production and one from the new production) with parallel surfaces were prepared for FTIR analysis; both measured 10.06 × 8.06 × 4.75 mm.

Results and Discussion. *Physical and Optical Properties.* The physical and optical characteristics of the new Mexifire synthetic fire opals are given in table 1, together with the Mexifire properties reported in Choudhary and Bhandari (2008) and those of natural fire opal. Most of the samples we examined for the current study were brownish orange; only one was orangy brown (again, see figure 1). The samples exhibited even coloration and good transparency under normal lighting conditions, but (as with the earlier product) they appeared slightly turbid when viewed with a fiber-optic light (figure 2). When the specimens were rotated and viewed from different directions, the color appeared to be concentrated toward the center.

The most significant development with these products was the fact they had higher RI and SG values than the Mexifire synthetics studied previously. All the new samples yielded consistent RI and SG readings of 1.470 and 2.19, respectively, which are closer to those of their natural counterparts (again, see table 1). Simoni et al. (2010) reported RI values for natural fire opal from Bemia, Madagascar, of 1.440–1.460 and SG values of 2.15–2.38. The SG values of these new Mexifire synthetics clearly overlap those of the fire opals from Madagascar, though the RI values, while close to natural fire opals, are sufficiently higher to allow

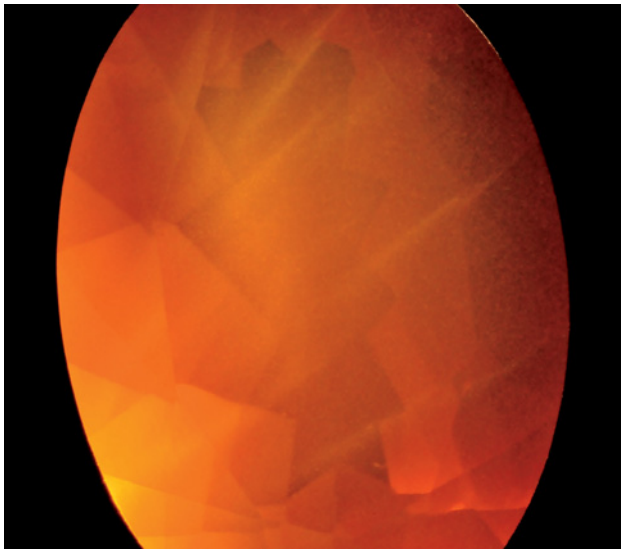

Figure 2. The turbid zones observed in almost every Mexifire sample remain an identifying criterion. Photomicrograph by G. Choudhary, fiber-optic illumination; magnified 15×.

a clear distinction. However, because there are minute variations in the calibration of refractometers of different makes and models, one must be very careful when using RI to separate natural from synthetic fire opals.

Microscopic Features. In addition to the zoned turbidity, these samples displayed fine pinpoints scattered throughout (figure 3), like the earlier product (Choudhary and Bhandari, 2008). These pinpoints were clearly seen with fiber-optic illumination, but they were only weakly visible with darkfield illumination. We could not resolve the exact nature of the pinpoints with the instruments we used. Although similarly scattered flake-like inclusions have been seen previously in natural opals, and Gübelin and Koivula (2005) mentioned tiny grains of pyrite scattered throughout one stone, we did not find any reports of such "pinpoint" inclusions in natural opal.

EDXRF Analysis. As was reported for the earlier material in Choudhary and Bhandari (2008), only Si, Fe, and Ca were detected in the new Mexifire synthetic fire opals. There were no additional elements. Gaillou et al. (2008) reported Al as a major impurity in natural opals; however, we did not detect any Al in the natural samples we studied for the previous article or received for identification at the laboratory over the years. In our samples, we recorded the same results for both the natural and the synthetic opals.

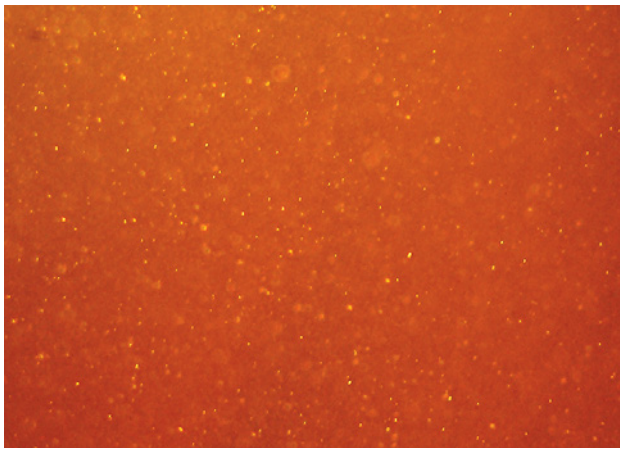

Figure 3. The exact nature of the scattered pinpoints in the Mexifire material could not be resolved at 80× magnification. Photomicrograph by G. Choudhary, fiber-optic illumination.

FTIR Analysis. The IR spectra of the new Mexifire product were quite different from those of either natural fire opal (studied in the previous article or at the Gem Testing Laboratory in Jaipur) or the earlier synthetic product. All nine samples displayed a weak hump at ~5440 cm^{-1}, a sharp peak with a shoulder ~4520 cm^{-1}, an absorption band in the 4000–3250 cm^{-1} region, a weak feature at 2652 cm^{-1}, and complete absorption of wavelengths below 2400 cm^{-1}.

The earlier version of Mexifire had an absorption band in the 5350–5000 cm^{-1} region; this feature also consisted of a series of sharp peaks, depending on the transmission. A hump was observed in the 4600–4300 cm^{-1} range, often with small peaks (a feature absent in some natural opals, including fire opal). The detector was saturated by strong absorption below ~4000 cm^{-1}. The absorption at ~5440 cm^{-1} in the new Mexifire product is attributed to O-H stretching/vibration, the peak at ~4520 cm^{-1} is due to a combination of O-H stretching and Si-O-H bending, and the absorption band in the 4000–3250 cm^{-1} region is due to the presence of O-H groups (Yamagishi et al., 1997).

These differences in the IR spectra reflect the lower water content of the new type of Mexifire opal. Although some of the differences could also have been due to variations in sample thickness (i.e., thicker samples would have greater absorbance and vice versa), the fact that the samples previously studied were smaller (0.23–3.50 ct) than those in the present study (3.40–4.40 ct) negates this possibility. To confirm this, we cut slices of equal thickness (4.75 mm) from one piece each of old and new Mexifire opal and polished two parallel faces; the IR spectra of

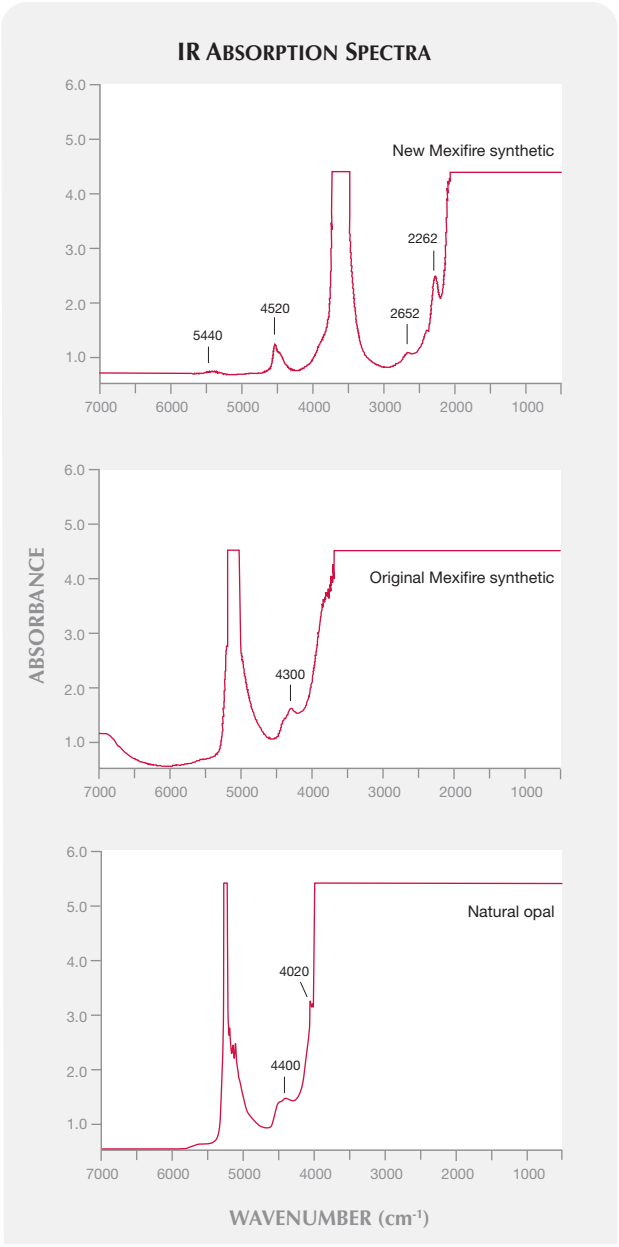

Figure 4. This IR spectrum of a slice of the new Mexifire synthetic opal (top; 4.75 mm thick) is quite different from that of a slice from the previous generation (center; 4.75 mm) and from natural fire opals (bottom; 0.6–4.0 ct) studied by the authors in the past.

both slices were similar to the spectra described above for faceted samples (figure 4). However, for the slice of new Mexifire synthetic opal, a sharp peak at 2262 cm^{-1} was resolved and the area of complete absorption was reduced to 2100 cm^{-1}. The other features and peaks remained unchanged between the slice and faceted samples of the new product.

It should be noted, though, that some natural opals from Ethiopia show absorption features similar to those seen in this new Mexifire product (E. Gaillou, pers. comm., 2010). Therefore, it does not appear that IR spectra provide a conclusive means of differentiating these new Mexifire opals from natural opal.

Conclusions. The higher RI and SG values of these new Mexifire synthetic fire opals will make their identification more difficult. The microscopic features are unchanged, however, and the fine pinpoints scattered throughout remain helpful in identifying the synthetic product. IR spectra, when used carefully, can offer some identification criteria, although similar absorption features have been seen in some natural opals from Ethiopia. The changes in the RI and SG values correlate with changes seen in the IR spectra as a result of a lower water content. Since the water content in these synthetics can be controlled, we anticipate additional changes in the properties of future product. Work is ongoing to further characterize this material.

ABOUT THE AUTHORS

Mr. Bhandari is a chemical engineer and owner of Rhea Industries (Jaipur, India), the manufacturer of Mexifire. Mr. Choudhary (gtl@gjepcindia.com) is deputy director of the Gem Testing Laboratory in Jaipur.

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