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The Nondestructive Identification of Ivory-Like Seal Materials

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ABSTRACT: As nondestructive identification techniques, optical microscopic observation, microscopic fluorescence spectroscopy, and specific gravity measurement were applied to examine evidentiary ivory-like seal materials. The cross-hatching pattern, which is known to be characteristic on the cross section of genuine elephant ivory, could be observed on each evidentiary ivory-like seal material, and the evidentiary seal materials were concluded to be made of soft-type African elephant ivory on the correlation of microscopic fluorescence intensity and specific gravity. This technique is novel and useful in inferring the source of African elephant ivory.

KEYWORDS: forensic science, criminalistics, ivory, seal material, nondestructive analysis, microscopic fluorescence spectroscopy, specific gravity

In Japan, seal impressions have been traditionally used as certification means for public or private documents, and seal materials such as ivory, stone, horn, wood, and plastic have been used. African elephant ivory is the most supreme and expensive seal material. On the other hand, the trade of elephant ivory and its products are prohibited now under the control of the Convention on International Trade in Endangered Species (CITES). Recently, a Japanese Yakuza terrified a man into buying many ivory-like seal materials, and such evidentiary materials had to be examined nondestructively whether genuine ivory or not. In this report, the ivory-like evidentiary seal materials were examined using optical microscopic observation, microscopic fluorescence spectroscopy, and specific gravity measurement and were compared with authentic African ivory seal materials.

Experimental

Materials

Three samples (A, B, and C) were selected randomly as representative samples among ivory-like evidentiary seal materials because each evidentiary material was nearly the same in appearance and of weight. Twenty standard African elephant ivory seal materials consisting of ten hard-type ivories and ten soft-type ivories were presented by Mr. Kageo Takaichi (Chairman of Japan General Merchandise Importer's Association, Ivory Division). In Japan, "Hard" types of ivory are defined as tusks originating from elephants in the forest of western Africa, whereas "Soft" types are defined as tusks originating from elephants in eastern and southern Africa (1). Asian elephant ivory could not be obtained due to the decline of the Asian elephants.

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Methods

Optical Microscopic Observation

A Nikon SMZ-U model equipped with 10 × eyepiece lens and 1× objective lens was used for observation on the cross section of samples.

Microscopic Fluorescence Spectroscopy

Microscopic fluorescence spectra were measured by Nanometrics NANO 100 UV equipped with a photomultiplier detector under the conditions of a 2-nm resolution and a violet excitation method (excitation filter: 405 nm, dichroic mirror: 430 nm, barrier filter: 435 nm). A standard soft-type African ivory material was adopted as a temporary standard for this measurement.

Specific Gravity Measurement

The well-known Archimedes principal method was applied for the measurement of specific gravity of each sample. The method was performed by replacing sample volume with water using a specific gravity bottle, and specific gravity values were calculated on the weights of sample in the air and in the water.

Results and Discussion

Optical Microscopic Observation

The cross-hatching pattern, that is, Schreger pattern (2,3) could be observed on the cross section of both standard African ivory seal materials and evidentiary seal materials. Representatively, a cross section profile of an ivory-like evidentiary sample A is shown in Fig. 1. For reference, the typical Schreger pattern of a soft-type African native ivory is shown in Fig. 2. The two patterns closely resemble each other. These Schreger angles were obtuse. It is well known that such patterns are inherent in genuine elephant ivory (2,3). The results of optical microscopic observation on the cross section of each ivory-like evidentiary sample suggest that these evidentiary samples might be made of genuine elephant ivory material.

Microscopic Fluorescence Spectroscopy and Specific Gravity Measurement

Three microscopic fluorescence spectra of a representative ivory-like evidentiary sample C, a hard-type African ivory seal

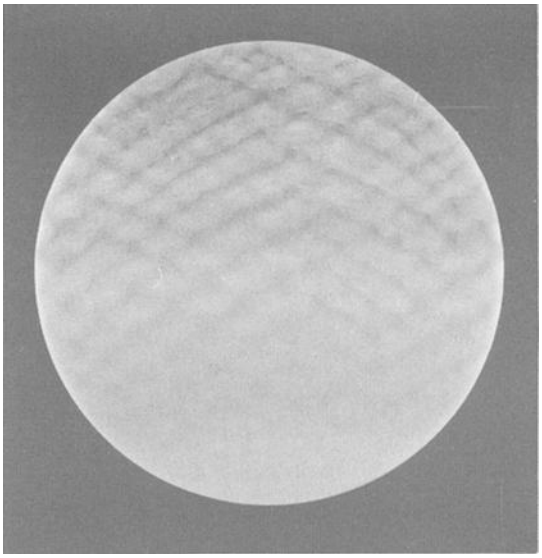

FIG. 1—*A cross section of an evidentiary sample A.*

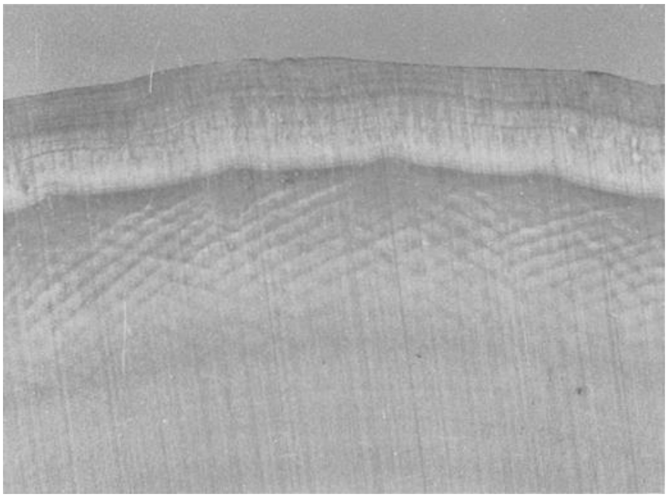

FIG. 2—*A cross section of a soft-type African native ivory.*

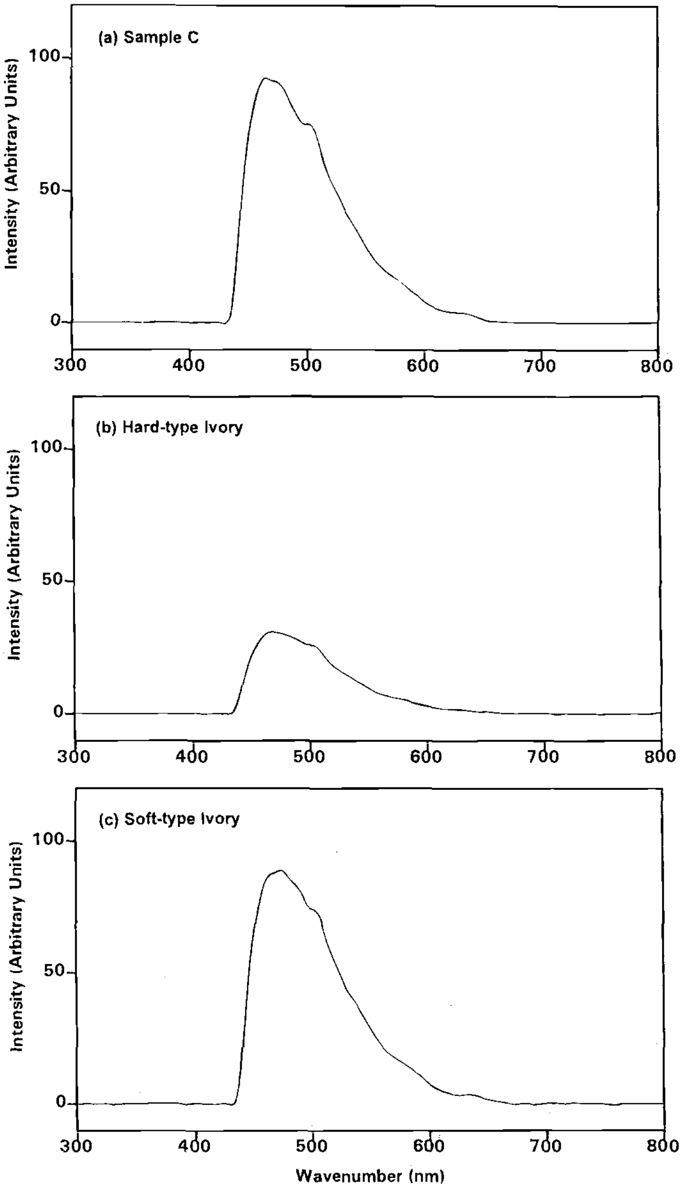

FIG. 3—*Microscopic fluorescence spectra: (a) An evidentiary sample C; (b) a hard-type African ivory seal material; (c) a soft-type African ivory seal material.*

material, and a soft-type African ivory seal material are shown in Fig. 3. The spectrum of the evidentiary sample C closely resembles that of the soft-type African ivory seal material, on the other hand, the fluorescence intensity of the hard-type ivory is far weaker than that of the soft-type ivory, although three spectra have common maximal peaks near 468 nm.

In Table 1, the maximal fluorescence intensity values of hard- and soft-type African ivory seal materials and three ivory-like evidentiary samples are summarized. Apparently at a glance on Table 1, the fluorescence intensity values of soft-type African ivory seal materials are far higher than those of hard-type ivory. The fluorescence intensity values of three evidentiary samples are consistent with those of soft-type ivory. The specific gravity values of hard- and soft-type African ivory seal materials and three ivory-like evidentiary samples are also summarized in Table 1.

In Fig. 4, the maximal fluorescence intensity values are plotted against the specific gravity values. Figure 4 shows the correlation of maximal fluorescence intensity and specific gravity. As shown in Fig. 4, all hard-type African ivory seal materials show lower fluorescence intensity values than those of soft-type ivory, whereas specific gravity values of hard-type ivory are larger than soft-type ivory. The three evidentiary samples show nearly the same fluorescence intensity values and specific gravity values characteristic of soft-type ivory. According to this correlation, it is possible to discriminate easily between hard-type African ivory materials and soft-type ivory, and the three evidentiary samples A, B, and C can be classified into the soft-type African ivory seal material.

Conclusions

The nondestructive identification and discrimination of ivory-like seal materials could be successfully carried out by using optical microscopic observation, microscopic fluorescence spectroscopy, and specific gravity measurement. As a result, the evidentiary ivory-like seal materials were concluded to be made of genuine soft-type African elephant ivory.

TABLE 1—*The maximal fluorescence intensity values and specific gravity values of African ivory seal materials.*

Seal Material	Intensity	Specific Gravity
Hard-type Ivory		
1	37	1.85
2	40	1.82
3	31	1.84
4	47	1.82
5	42	1.79
6	37	1.83
7	40	1.79
8	47	1.81
9	25	1.83
10	45	1.83
Soft-type Ivory		
1	95	1.66
2	84	1.73
3	118	1.71
4	75	1.71
5	89	1.69
6	78	1.75
7	96	1.77
8	98	1.76
9	94	1.75
10	85	1.71
Evidentiary Sample		
A	88	1.72
B	104	1.74
C	114	1.72

Acknowledgments

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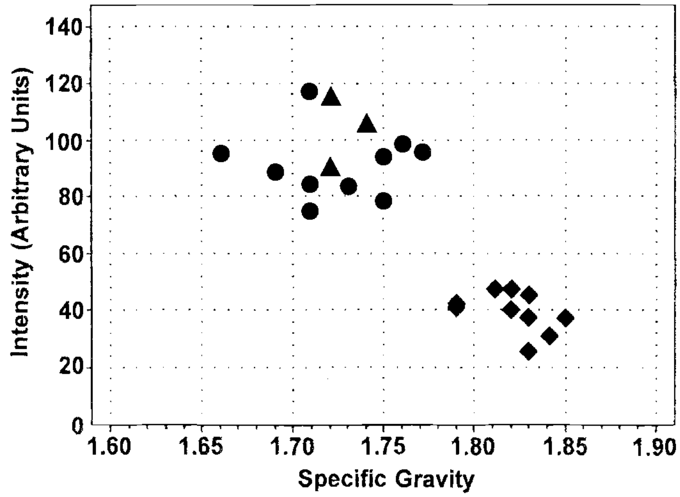

FIG. 4—*The correlation of maximal fluorescence intensity and specific gravity: Evidentiary sample (▲); hard-type African ivory seal material (◆); soft-type African ivory seal material (●).*

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