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Application News

No.A473

Spectrophotometric Analysis

Evaluation of Light-Shielding Effect of Milk Cartons Using a UV-VIS-NIR Spectrophotometer

Foods that are on display in shops are exposed to various types of light, including ultraviolet, visible, and near-infrared light, all of which can pass through packaging materials and containers. Such exposure of these foods and beverages to light can cause protein oxidation, vitamin destruction, fading, and other adverse effects in the foods. Consequently, examination of the light-shielding effect (transmittance) of food containers is very important. Previously, transmittance in various types of PET bottles was measured in Application News No. A461. Those results indicated differences in transmittance among the bottles in the near-infrared and ultraviolet regions.
Here, we examined the transmission characteristics of paper-based milk cartons using the UV-3600 ultraviolet-visible-near-infrared spectrophotometer. The results of measurements conducted on the 3 types of milk cartons indicated differences in transmittance depending on the carton sample. Further, differences in transmittance were also found within each of the respective samples, depending on the measurement site. This paper introduces those results.

Total Light Transmittance Measurement of Milk Cartons

After mounting the integrating sphere accessory in the UV-3600, measurement of the total light transmittance was conducted for the three types of milk cartons, A, B, and C. Fig. 1 shows a diagram of the principle of total light transmittance measurement. First, baseline correction is conducted in the absence of a sample. Then, by conducting measurement with a sample mounted in the integrating sphere accessory, the total light transmittance consisting of the combined linear and diffuse transmittance can be obtained. Using this method makes it possible to capture all of the transmitted light including not only the linearly transmitted light, but the diffusely transmitted light as well. This total light transmittance measurement technique is often used when measuring the transmittance of samples having some degree of turbidity (cloudiness), such as films, plastics, and paper.
Here, the sample consisted of a milk carton that had been washed out with water, and then allowed to dry naturally. Three pieces, each a few centimeters in size, were cut from the same sample carton, and measurements were conducted at three differently colored sites on each sample. Fig. 2 shows a photograph of a milk carton sample mounted in the integrating sphere accessory, and Table 1 shows the analytical conditions used.

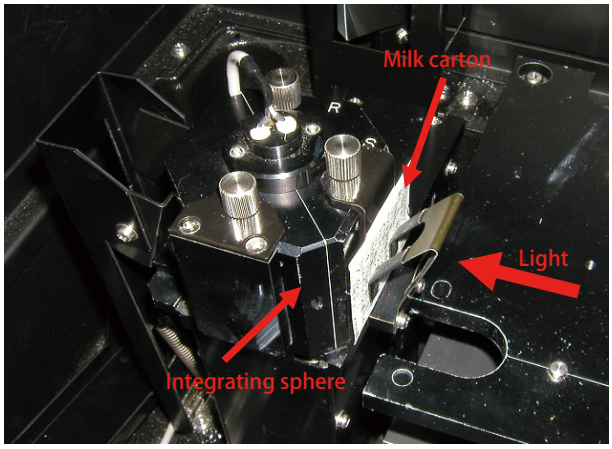

Fig. 2 Photograph of a Sample Set in an Integrating Sphere

Table 1 Analytical Conditions

Instruments	: UV-3600 UV-VIS-NIR spectrophotometer MPC-3100 large sample compartment (with built-in integrating sphere)
Measurement Wavelength Range	: 200 nm to 2300 nm
Scan Speed	: Medium
Sampling Pitch	: 1.0 nm
Measurement Value	: Transmittance
Slit Width	: (20) nm
Detector Switching Wavelength	: 870 nm

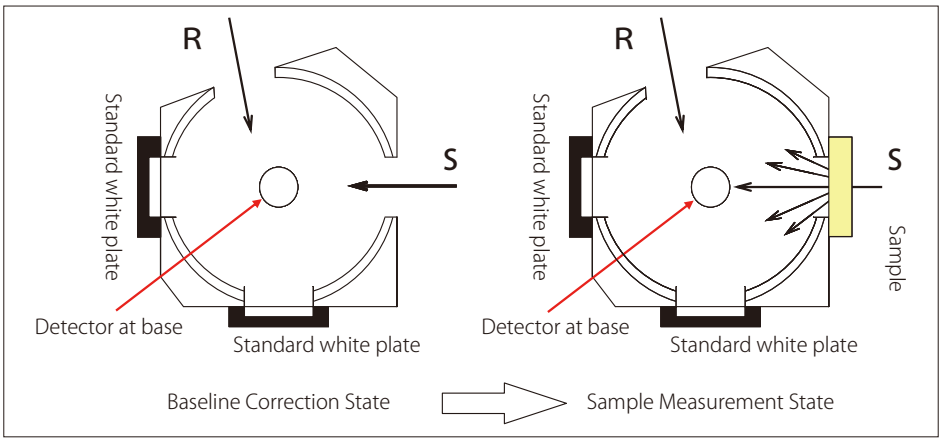

Fig. 1 Total Light Transmittance Measurement

Results

The measurement results for each of the milk cartons A to C are shown in Figures 3 to 5. The differences in print color are reflected in the transmittance spectra obtained from measurement at three sites in the same sample, respectively, in Fig. 3 and Fig. 4. For example, in milk carton B of Fig. 4, measurements were conducted at sites that were printed with reddish, whitish, and mixed black and white colors, respectively. The measurement results are shown using a red, blue and black trace, respectively, for each of the spectra. The shape of the red-trace spectrum is different from that of the others, but this is thought to be due to absorption of green light and blue light in the region of 400 to 600 nm, causing a decrease in transmitted light in that region. Further, comparing this to the green- and black-trace spectra, the black trace shows lower transmittance. At the site printed with the mixed black and white color system corresponding to the black-trace spectrum, it is believed that the overall low transmittance is due to the ease with which a black surface absorbs light.
From the results of Figures 3 and 4, it is clear that even in the same milk carton, the transmittance varies depending on the printed color at the measurement site. As for the data associated with milk carton C shown in Fig. 5, the transmittance for all three color regions was about 0 %. This was undoubtedly due to the aluminum film affixed to the inner surface of milk carton C, preventing the transmission of nearly all light, from the ultraviolet to near-infrared region.

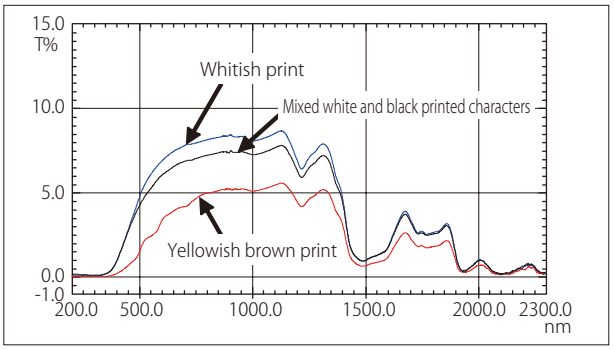

Fig. 3 Transmittance Spectra of Three Positions in Sample A

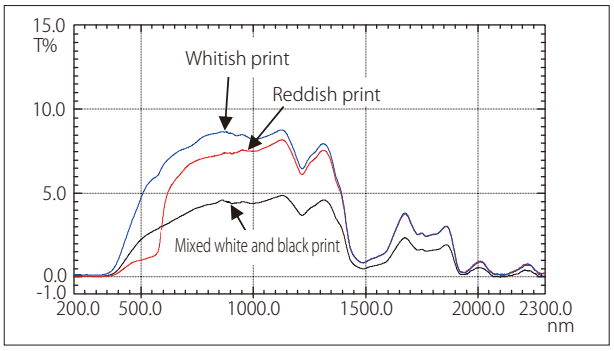

Fig. 4 Transmittance Spectra of Three Positions in Sample B

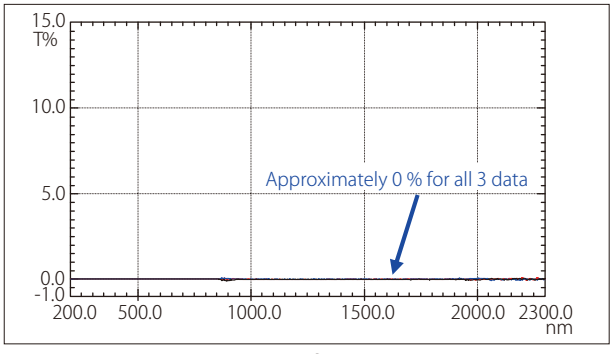

Fig. 5 Transmittance Spectra of Three Positions in Sample C

Comparison of Milk Carton and PET Bottle

We compared the transmittance spectra of the PET bottles measured previously in Application News No. A461 with those of the milk cartons measured here. The results are shown in Fig. 6. The blue-trace spectrum of Fig. 3 represents that of the milk carton, and the PET bottle spectrum is that of sample A in the above-mentioned Application News.
From Fig. 6, it is clear that the transmittance in the milk carton is very low over the entire measurement range as compared with that of the PET bottles. The ultraviolet region from 200 to 380 nm is shown in Fig. 7. While transmission of ultraviolet radiation occurs above 320 nm in the case of the PET bottle, almost no ultraviolet radiation is transmitted with the milk carton. Thus, it is clear that the light-shielding effect of the paper-based container is superior to that of the PET bottle.

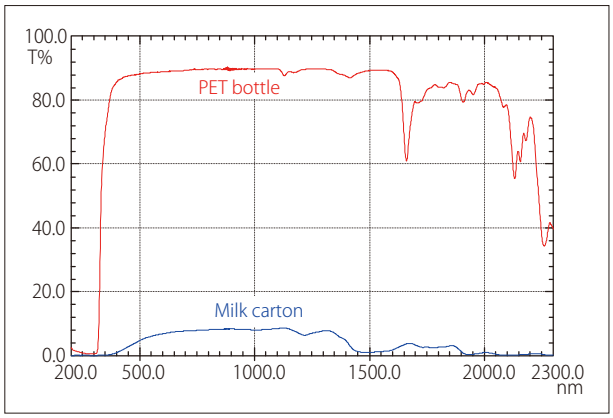

Fig. 6 Transmittance Spectra of PET Bottle and Milk Carton

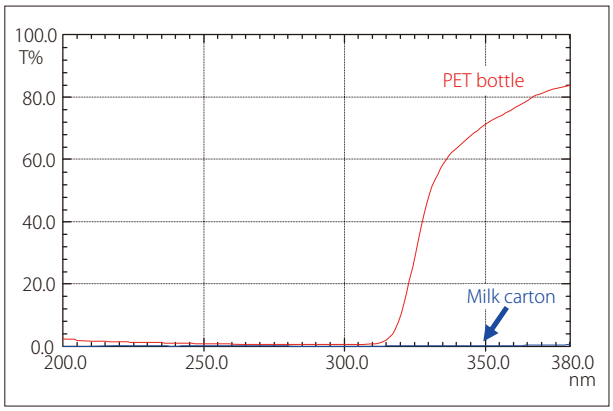

Fig. 7 Expanded Spectra of Fig. 6 (Ultraviolet Region)

Conclusion

The results of measurement of the three types of milk cartons conducted here indicated that the light transmission characteristics vary depending on the milk carton. Even measurements taken using the same milk carton showed differences in transmittance depending on the printed color. This suggests that light-shielding performance can be changed through the selective use of the colors printed on the carton. Also, affixing aluminum film to the inner surface achieves nearly complete shielding in the ultraviolet to near-infrared regions. Such use of aluminum film could be an effective means of protecting foods that are especially susceptible to light. It was also found that the light-shielding effect of milk cartons is higher than that of PET bottles. From these results, it is believed that transmittance measurement using a spectrophotometer is effective for assessment of light shielding in food containers.

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