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Application News

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Spectrophotometric Analysis

# Example of Measuring Weak Signals Produced by Luminous Paints

Everyday we encounter numerous examples of luminous phenomena all around us. These include products that emit light to keep us safe at night and others that employ illumination to provide enjoyment. Some of these products make use of fluorescence and phosphorescence.

This article introduces an example of measuring the weak signals produced by phosphorescent paint used on the dial and hands of wrist watches in addition to commercially available paints that utilize fluorescence and phosphorescence.

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## Phosphorescent Paint Used on Wrist Watches

With the highest sensitivity in its class, the RF-6000 spectrofluorophotometer is capable of detecting even barely perceptible weak fluorescence. The RF-6000 is also capable of measuring the spectra of phosphorescence, chemiluminescence, and bioluminescence because measurement is performed without irradiating samples with excitation light.

Tritium has been widely employed in phosphorescent paint used on the dial and hands of wrist watches. However, since tritium is a radioactive material, safer materials are now used for safety reasons. Three commercially available wrist watches manufactured in Japan (from two companies) and two manufactured outside Japan (from two companies) that produce visually perceptible phosphorescence were prepared for this example. Table 1 lists the measurement conditions and Fig. 1 shows the measurement results. The measurement results are shown normalized since the fluorescence intensity differs depending on the area of the phosphorescent paint and the sample placement.

**Table 1 Measurement Conditions**

| | |
|---|---|
| Instrument | : RF-6000 |
| Fluorescence wavelength range | : 350 to 800 nm |
| Data interval | : 1.0 nm |
| Scan speed | : 600 nm/min |
| Bandwidth | : Em 15.0 nm |
| Sensitivity | : High |

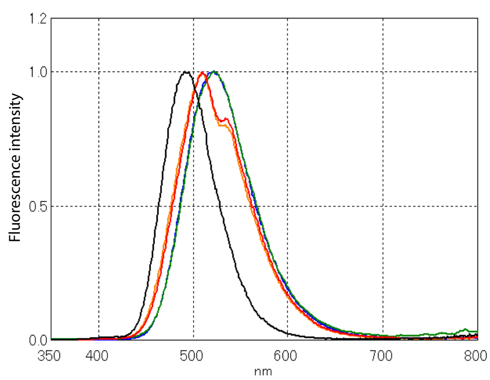


**Fig. 1 Black: Japanese Manufacturer 1, Red/Orange: Japanese Manufacturer 2 Blue: Overseas Manufacturer 1, Green: Overseas Manufacturer 2**

The same spectrum shape is apparent for the same manufacturer (red and orange lines in Fig. 1). From this we can infer that Japanese manufacturer 2 uses the same phosphorescent paint on different wrist watches. On the other hand, the spectra measured for Japanese manufacturer 1 and Japanese manufacturer 2 differ in shape (black and red lines in Fig. 1). From this we can conclude that each Japanese manufacturer uses a different phosphorescent paint. The spectra measured for the different watches manufactured outside Japan both have the same shape (blue and green lines in Fig. 1). These spectra differ in shape from the spectra of the Japanese manufacturers. Different phosphorescent paint is used by each manufacturer to give their wrist watches their own unique color.

## Fluorescent and Phosphorescent Paints

Fluorescence is the phenomenon where a substance emits light upon irradiation with light and phosphorescence is the phenomenon where a substance will continue to emit light after irradiation with light. The difference between the two is the duration (lifetime) of light emission. Note that for phosphorescence, light emission also occurs from the point of light irradiation.

Fig. 2 shows samples of paper coated with commercially available fluorescent paint and phosphorescent paint. Fig. 3 to Fig. 5 show the spectra (fluorescence spectra) of the fluorescent paint and phosphorescent paint measured while being irradiated with light and under the conditions listed in Table 2, and the spectra (phosphorescence spectra) of the phosphorescent paint measured without light irradiation and under the conditions listed in Table 3. The fluorescence intensities are shown normalized to facilitate comparison of the spectrum shapes.

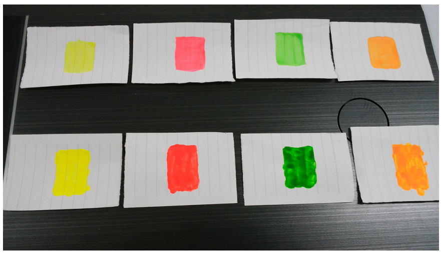

**Fig. 2 Samples Top Row: Phosphorescent Paint, Bottom Row: Fluorescent Paint**

**Table 2 Measurement Conditions**

| | |
|---|---|
| Instrument | : RF-6000 |
| Accessories | : Solid (powder) sample holder, long-pass filter L42 |
| Excitation wavelength | : 300 nm |
| Fluorescence wavelength range | : 450 to 800 nm |
| Data interval | : 1.0 nm |
| Scan speed | : 600 nm/min |
| Bandwidth | : Ex 3.0 nm/Em 5.0 nm |
| Sensitivity | : Low |

**Table 3 Measurement Conditions**

| | |
|---|---|
| Instrument | : RF-6000 |
| Fluorescence wavelength range | : 450 to 800 nm |
| Data interval | : 1.0 nm |
| Scan speed | : 600 nm/min |
| Bandwidth | : Em 15.0 nm |
| Sensitivity | : Low |

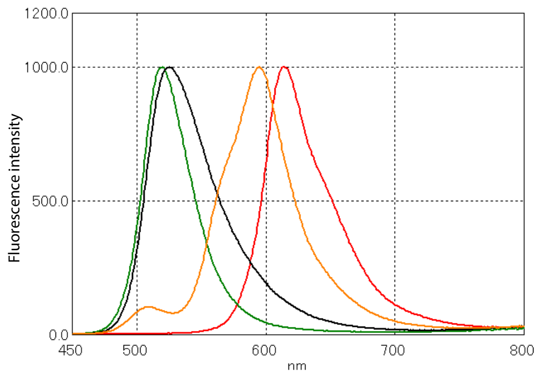


**Fig. 3 Fluorescence Spectra of Fluorescent Paints**
**Black: Yellow, Red: Red, Green: Green, Orange: Orange**

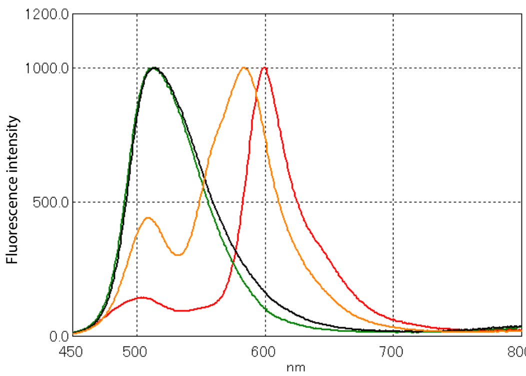


**Fig. 4 Fluorescence Spectra of Phosphorescent Paints**
**Black: Yellow, Red: Red, Green: Green, Orange: Orange**

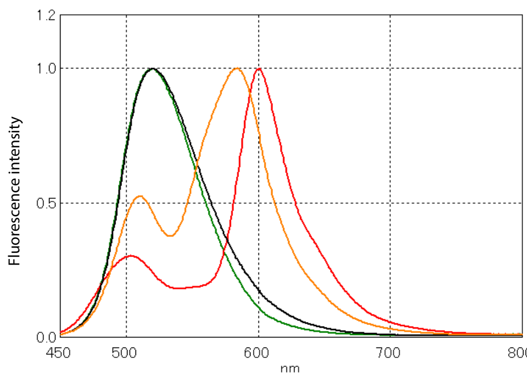


**Fig. 5 Phosphorescence Spectra of Phosphorescent Paints**
**Black: Yellow, Red: Red, Green: Green, Orange: Orange**

Fig. 3 shows that different spectra were obtained for each color of fluorescent paint.

Fig. 4 shows that fluorescence spectra were obtained even for the phosphorescent paints. A peak near 600 nm and a peak near 510 nm were obtained in the fluorescence spectra of the orange and red phosphorescent paint.

Fig. 5 shows that the phosphorescence spectra of the phosphorescent paints have the same shape as the fluorescence spectra. In the phosphorescence spectra, the ratios of intensity of the peaks near 600 nm and 510 nm for orange and red are different to those in the fluorescence spectra. We suspect that the difference in the sample placement, shown in Fig. 6, caused the decrease in the peaks near 510 nm due to the samples absorbing their own fluorescence (self-absorption) during fluorescence spectrum measurement. For the fluorescent paints, the decrease in peaks near 510 nm is also suspected to result from the same self-absorption due to the thickness of the samples, which is evident in Fig. 2.

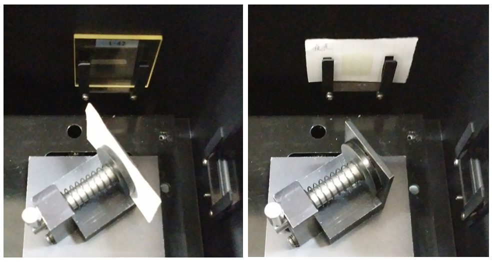

**Fig. 6 Left: Sample Placement**
**for Fluorescence Spectrum Measurement**
**Right: Sample Placement**
**for Phosphorescence Spectrum Measurement**

Since phosphorescence is the light emission that occurs due to the transition from the triplet state, which is lower in energy than the singlet state, to the ground state, the wavelengths of the peaks in the phosphorescence spectra are slightly longer than those of the fluorescence spectra, as shown in Fig. 7.

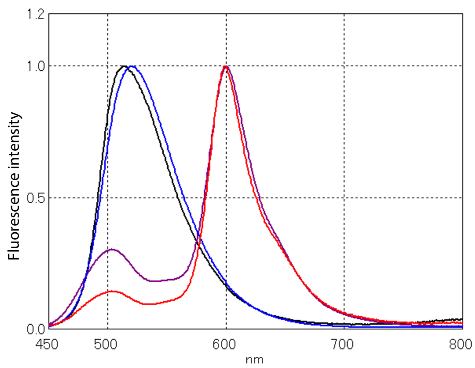


**Fig. 7 Yellow Phosphorescent Paint**
**Black: Fluorescence Spectrum, Blue: Phosphorescence Spectrum**
**Red Phosphorescent Paint**
**Red: Fluorescence Spectrum, Purple: Phosphorescence Spectrum**

## Conclusion

The RF-6000 spectrofluorophotometer, with the highest sensitivity in its class, allows detection of even weak signals, such as those produced by phosphorescence.
In the phosphorescence spectrum measurement of the wrist watches, we observed differences in the spectrum shapes, from which we can infer that each manufacturer uses different phosphorescent paint.
In the measurement of the fluorescent and phosphorescent paints, we found that each paint color has a different spectrum shape. Also, in the case of the phosphorescent paints, we confirmed that the shape of the fluorescence spectra when irradiated with light was the same as that of the phosphorescence spectra without irradiation.

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