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Application News

UV-2600i / UV-3600i Plus / SolidSpec™-3700i UV-Vis Spectrophotometers

Evaluation of Transmittance of Ultraviolet Radiation (C Band) for Disinfection

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User Benefits

- Investigation of UV transmittance in the UV-C wavelength region (<280 nm) is useful in selecting suitable packaging materials for UV disinfection of viruses.
- Virus disinfection time can be estimated from the UV-C transmittance by using "Advanced formula" of the photometric function of LabSolutions™ UV-Vis.

■ Introduction

Ultraviolet (UV) radiation is classified as A band (315 to 400 nm), B band (280 to 315 nm), or C band (<280 nm) according to its wavelength. UV wavelengths of 254 nm or 222 nm, which are classified as the C band (UV-C), are used in disinfection of viruses by UV radiation. As advantages of UV disinfection, noncontact disinfection is possible, treatment of a waste solution is not necessary, and there is no risk of contamination by way of chemicals. On the other hand, it is necessary to pay attention to the following problems when using UV disinfection: the UV radiation emitted from the light source may be blocked by the light source encapsulant of the UV germicidal lamp or the packaging material of the disinfectant object, then the irradiation intensity may become weaker than expected. For this reason, the transmittance property in the UV-C band region is one important evaluation value for all materials related to UV disinfection.

In this article, the transmittance of general packaging materials in the UV-C band region was evaluated by using a Shimadzu UV-Vis spectrophotometer. In addition, this article also introduces a method for estimating the disinfection time for the novel coronavirus SARS-CoV-2 considering the transmittance of the packaging material by using the photometric function of LabSolutions UV-Vis.

■ Measurement Samples

The measurement samples prepared for this experiment were polyethylene (PE), polyethylene terephthalate (PET), and silicone, which are generally used in packaging materials. Two types of silicone with different transparencies in the visible light region were prepared. Fig. 1 shows the appearance of the measurement samples, and Table 1 gives the details of the measurement conditions.

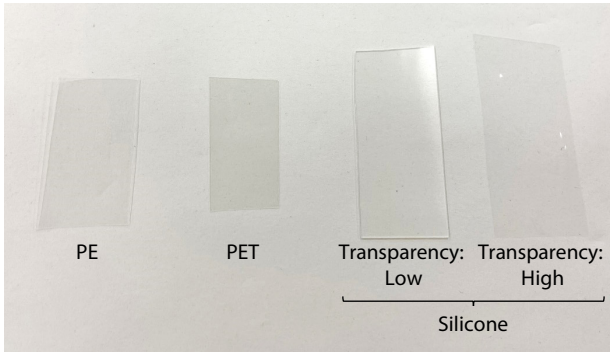


Fig. 1 Appearance of Packaging Materials Used in Measurement

Table 1 Measurement Conditions

Instruments	: UV-2600i, ISR-2600Plus
Measurement wavelength range	: 220 - 400 nm
Scan speed	: Low
Sampling pitch	: 1.0 nm
Slit width	: 5.0 nm

■ Transmission Spectra of Packaging Materials in UV Region

Fig. 2 shows the transmission spectra of the respective packaging materials.

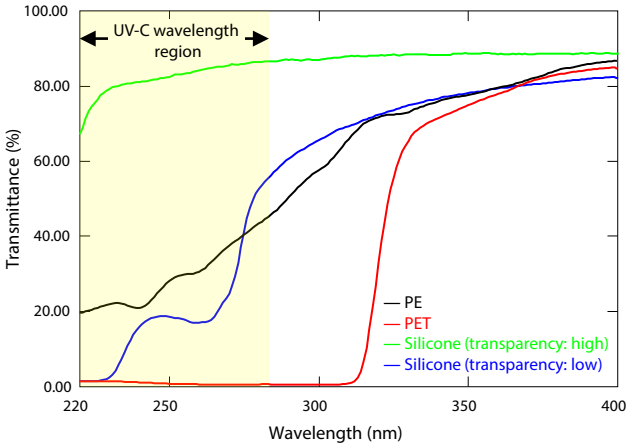


Fig. 2 Transmission Spectra of Packaging Materials

From Fig. 2, it can be understood that the transmittance of the PE, PET, and low-transparency silicone decreases in the wavelength region of 320 nm and lower, and transmittance is low in the UV-C region, at approximately 0 to 50 %. On the other hand, because high transmittance of 65 % or higher was confirmed with the high-transparency silicone, even in the UV-C region, the high-transparency silicone is expected to be the most suitable packaging material in cases where UV disinfection by UV-C is applied through the packaging material.

■ Estimation of Virus Disinfection Time

When using the photometric function of LabSolutions UV-Vis, it is possible to set an arbitrary calculation formula using a photometric value (Fig. 3), and the result obtained with the set formula can be displayed automatically.

Previous research [1] has discussed estimation of the time required for disinfection of various viruses. Since that research showed the lethal doses of UV irradiation Q (mJ/cm^2) required for disinfection of each virus, it is considered possible to estimate the time necessary to disinfect the target virus by the following Eq. (1) if the transmittance T (%) of the packaging material at a predetermined wavelength (nm) and the UV illuminance E (mW/cm^2) without intervening packaging material are known.

$$t = \frac{Q}{E \cdot T} \qquad (1)$$

t: time (s), Q: lethal dose (dose of UV irradiation required for disinfection)(mJ/cm^2),
E: UV illuminance without intervening packaging material(mW/cm^2),
T: transmittance of packaging material(%)

In this experiment, the time(s) required for disinfection of 99.9 % and 99.99 % of SARS-CoV-2 was estimated. The wavelength used was 254 nm, and the value of UV illuminance E without intervening packaging material was assumed to be 2 mW/cm^2, which is equivalent to the illuminance of a general UV irradiation LED.

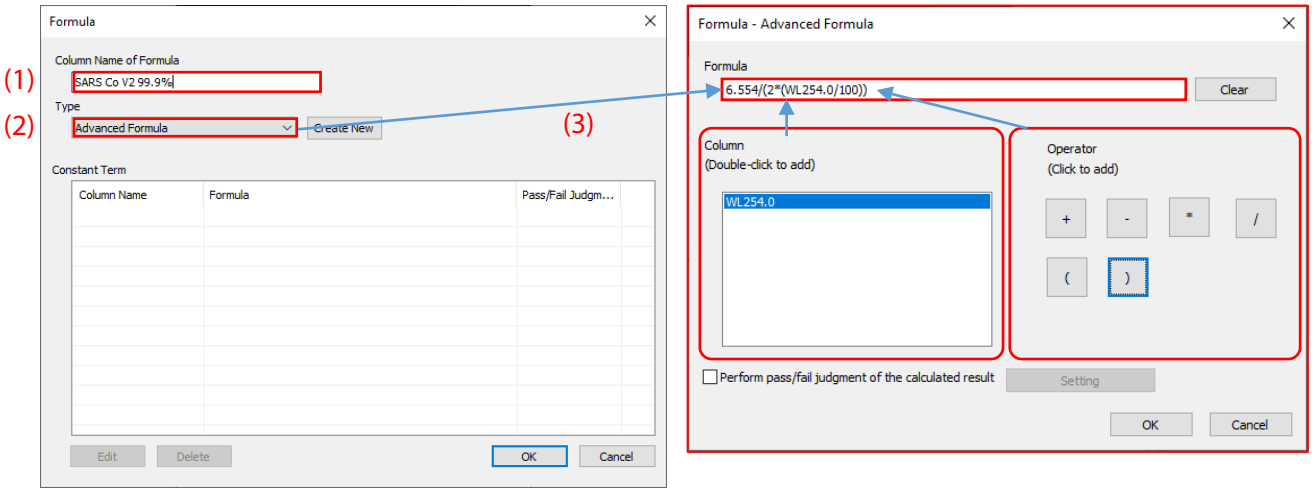
As the lethal dose Q of UV irradiation required for disinfection, the values presented in the previous research were used (6.556 mJ/cm^2 for 99.9 % disinfection and 31.880 mJ/cm^2 for 99.99 % disinfection).

Table 2 shows the estimated time necessary for 99.9 % and 99.99 % disinfection of SARS-CoV-2. The result for the high-transparency silicone was similar to that for "Air," which assumes a condition without intervening packaging material. In contrast, a remarkably long time was required for disinfection with PET, which had the lowest transmittance at 254 nm. Thus, among the samples measured here, it can be judged that PET is the least suitable packaging material for products when UV disinfection is to be applied. However, it should be noted that the time actually required for disinfection of viruses will differ depending on the surrounding environment.

■ Conclusion

The transmittance of C band ultraviolet radiation (UV-C), which is used in disinfection, was evaluated by using a UV-2600i UV-Vis spectrophotometer. It was also possible to estimate a more practical evaluation value from the photometric value by using the photometric function of LabSolutions UV-Vis.

<Reference>
(1) Sabino C.P., Sellera F.P., Sales-Medina D.F., Machado R.R.G., Durigon E.L., Freitas-Junior L.H., Ribeiro M.S. UV-C (254 nm) lethal doses for SARS-CoV-2, *Photodiagn. Photodyn. Ther.* 2020; 32: 101995.



(1) Input the column name of the formula.
(2) Select "Advanced Formula" from Types, and click "Create New."
(3) Directly input the numerical value and add the photometric value (WL254.0) from the column and an operator to set the target formula.

Fig. 3 Setting Screen of Time (s) Necessary for Disinfection of SARS-CoV-2 Using Photometric Function

Table 2 Results of Estimation of Time (s) Necessary for Disinfection

Packaging material	Time required for 99.9 % disinfection of SARS-CoV-2 (s)	Time required for 99.99 % disinfection of SARS-CoV-2 (s)
PE	11.05	53.74
PET	487.07	2368.50
High-transparency silicone	3.94	19.18
Low-transparency silicone	18.24	88.68
Air	3.28	15.94

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