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Application News

UV-Vis Spectrophotometers

Differences in Turbidity Calibration Curves Depending on Models, Instruments, and Measurement Methods —Comparison of Transmission Turbidity and Integrating Sphere Turbidity—

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User Benefits

- Consistent turbidity evaluations can be achieved with different instruments by preparing different calibration curves for the respective models or instruments.
- Differences between transmission turbidity and integrating sphere turbidity can be evaluated by using the appropriate calibration curve for each measurement method.
- The appropriate measurement method can be selected for the given measurement objectives; for example, transmission turbidity could be selected for its simplicity or integrating sphere turbidity for its lower turbidity levels.

■ Introduction

Turbidity is a measure of the cloudiness of water, and turbidity standards[1] are specified for things like public drinking water and effluents.[2),3)] Turbidity can be caused by soil or other substances becoming suspended in water, chemical changes to dissolved substances in water, or other factors.[4)] Standard solutions for turbidity are typically prepared using kaolin clay, formazin, or polystyrene.

Turbidity can be measured by light transmission, integrating spheres, or other methods, but the resulting calibration curves will differ depending on the instrument model and measurement method used. So evaluating turbidity without considering these differences can be problematic.

This article describes the data obtained from preparing calibration curves based on transmission turbidity measured with a UV-1900i Plus UV-Vis spectrophotometer (Fig. 1a) and a UV-2600i Plus UV-Vis spectrophotometer (Fig. 1b) according to JIS K0102-1 testing methods for industrial wastewater. It also includes results from using an integrating sphere to measure integrating sphere turbidity.

(a) (b)



Fig. 1 UV-1900i Plus (a) and UV-2600i Plus (b) UV-Vis Spectrophotometers

■ Transmission Turbidity

Transmission turbidity is defined as the intensity of light that passes through a sample with a wavelength close to 660 nm. The turbidity measurement range differs depending on the type of standard solution used (kaolin or formazin) and the optical path length of the absorption cell (10 or 50 mm). For this article, a formazin standard solution and a cell with a 10 mm optical path length were used (with a measurement range of 20 to 400 degrees for formazin*1).

Measuring turbidity involved simply mixing the sample by shaking it, loading it into the absorption cell, and measuring the intensity level of the transmitted light, which had a wavelength close to 660 nm. The calibration curve, which was prepared in advance, expresses the degree of turbidity (for formazin) on the horizontal axis and the apparent absorbance level on the vertical axis. Note that the apparent absorbance value is different for each instrument. Each instrument has a different distance between the absorption cell and detector due to the different intensity of transmitted light resulting from the scattering in each standard solution.

Figs. 2 and 3 show the calibration curves measured with the same analysis conditions (Table 1) but with different models (UV-1900i Plus and UV-2600i Plus).

Table 1 Measurement Conditions

Wavelength:	660 nm
Slit Width:	1 nm
Integration Time:	1 sec.
Number of Repetitions:	5

*1 In addition to formazin (deg.), nephelometric turbidity units (NTU) are also sometimes used in drinking water test methods.[1)]

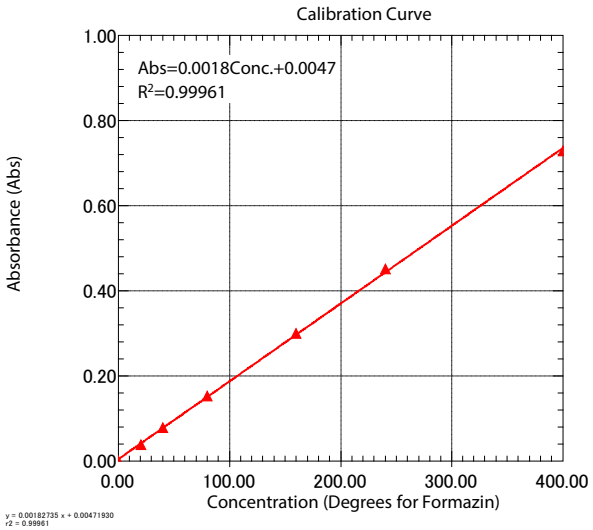

Fig. 2 Calibration Curve Obtained with UV-1900i Plus Model

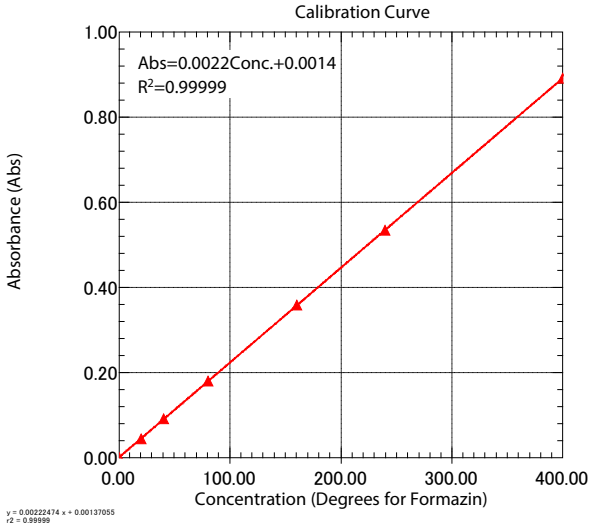

Fig. 3 Calibration Curve Obtained with UV-2600i Plus Model

Figs. 2 and 3 show that the calibration curve slope differs depending on the instrument model. (The absorbance spectra for standard samples are shown in Fig. 4 for reference.)

Table 2 shows measurements of river water taken after a typhoon. The absorbance is different for each instrument, but the turbidity values from the calibration curves are approximately the same. This demonstrates the need to prepare a separate calibration curve for each instrument.

Table 2 Apparent Absorbance and Turbidity of River Water (After a Typhoon)

	UV-1900i Plus Abs/Turbidity	UV-2600i Plus Abs/Turbidity
First Measurement	0.086/44.4	0.098/43.2
Second Measurement	0.082/42.3	0.101/44.7
Third Measurement	0.084/43.2	0.100/44.5

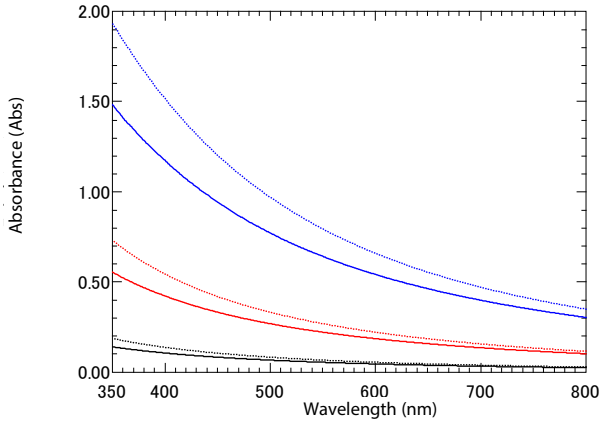

Fig. 4 Formazin Spectra (Black: 20 Deg.; Red: 80 Deg.; Blue: 240 Deg.)
Solid Lines: UV-1900i Plus; Dotted Lines: UV-2600iPlus

■ Integrating Sphere Turbidity

Integrating sphere turbidity is the ratio between the intensity of light scattered by particles in water and the intensity of light transmitted through water. The turbidity measurement range also differs for integrating sphere turbidity depending on the type of standard solution and the optical path length of the absorption cell, where lower turbidity levels are generally measured compared to transmission turbidity. For this article, a formazin standard solution and a cell with a 10 mm optical path length were used (with a measurement range of 5 to 100 degrees for formazin).

To perform measurements, an absorption cell filled with water is placed into the integrating sphere; the zero point is reset; and the standard white plate is removed to confirm that the %T value is zero.*2 A sample that has been thoroughly mixed by shaking is placed in the absorption cell and measured (with a total transmission intensity of T_t). Then the standard white plate is removed, and the sample is measured (with a scattered light intensity of T_d). The two measurement values are used to calculate equation (1) and plot the calibration curve.

$$Calculated\ Value = \left(\frac{T_d}{T_t}\right) \times 100 \qquad (1)$$

For this article, the UV-2600i Plus paired with the ISR-2600Plus was used to measure samples. The setting conditions are shown in Table 3, and the reference spectra are shown in Fig. 5. Since JIS K0102-1 does not specify a wavelength for the integrating sphere turbidity in equation (1), the same 660 nm wavelength as that used for transmission turbidity was used to prepare the calibration curve in Fig. 6. To plot the curve, the 660 nm transmission was substituted into equation (1), and the results were entered using the setting "Enter photometric values manually" in the quantitative analysis mode.

Table 3 Measurement Conditions

Wavelength:	350 to 800 nm
Data Interval:	1.0 nm
Slit Width:	5 nm
Type of Photometric Value:	Transmittance

*2 The %T value may not be zero in some cases. In this article, measurement values were used for calculations at a concentration of 0 degrees.

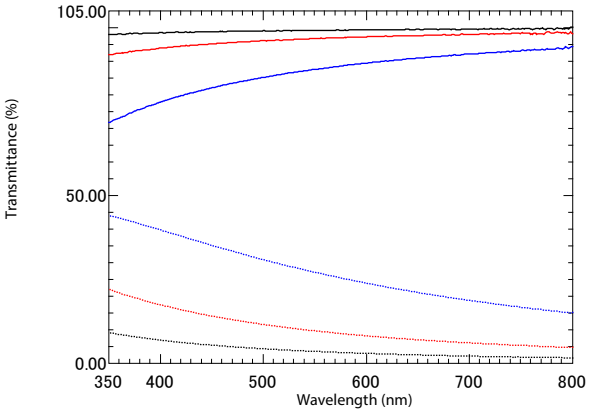

Fig. 5 Formazin Spectra (Black: 5 Deg.; Red: 20 Deg.; Blue: 80 Deg.)
Solid Lines: Intensity of Total Transmitted Light (T_t);
Dotted Lines: Intensity of Scattered Light (T_d)

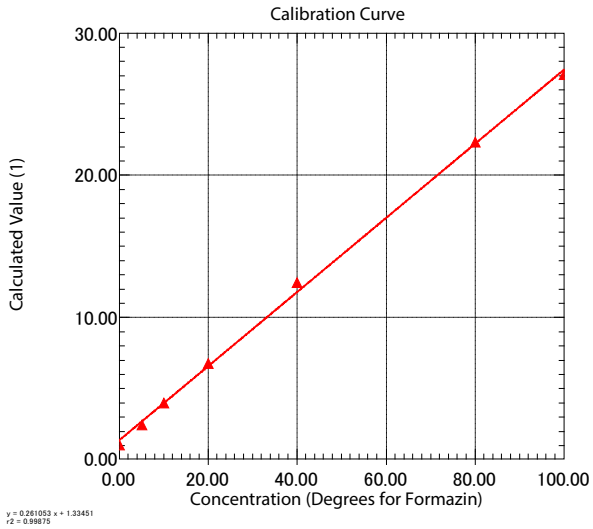

Fig. 6 Calibration Curve for Integrating Sphere Turbidity

Fig. 5 shows that if turbidity is low, the total transmission intensity near 660 nm is about 100 %T and the scattered light intensity is about 0 %T. So as turbidity increases, the total transmission intensity decreases and scattered light intensity increases. The calibration curve in Fig. 6 has a correlation coefficient of 0.99875.

The measurements of river water after a typhoon based on integrating sphere turbidity are shown in Table 4. The results are approximately the same as the transmission turbidity results in Table 2.

Table 4 Integrating Sphere Turbidity of River Water after a Typhoon

	Calculated Value / $(T_d/T_t) \times 100$	Integrating Sphere Turbidity / Deg. (Formazin)
First Measurement	13.59	46.9
Second Measurement	12.72	43.6
Third Measurement	13.79	47.7

■ Conclusion

This article describes measuring turbidity using different models, instruments, and measurement methods.

When transmission turbidity was measured with two different models (UV-1900i Plus and UV-2600i Plus systems), the calibration curves had different slopes. But similar turbidity values were obtained when calibration curves that were appropriate for each model were prepared. This article also confirmed that calibration curves created based on transmission turbidity will have different slopes and properties. However, similar turbidity values were obtained by using calibration curves that were appropriate for the respective measurement methods. The results show that it is important to select an appropriate measurement method and calibration curve based on the targeted turbidity because the turbidity range and calibration curve properties will differ depending on differences in the measurement method.

References

1) 2020 Drinking Water Testing Methods—II General Physics and Chemistry—Inorganic Substances Edition, Japan Water Works Association
2) ISO 7027-1 Water quality-Determination of turbidity
3) JIS K 0102-1 Testing methods for industrial wastewater—Part 1: Test methods for general physics and chemistries.
4) Ministry of the Environment, Water Quality Standards—Criteria and Criteria Values (52 Criteria) 000219145.pdf (refer to 2026-06-16)

Related Application News Articles

1. Measuring Turbidity in Accordance with JIS K 0101 Testing Methods for Industrial Water, Application News No. A449

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