Solar radiation film

OptoLeaf

Instruction Manual

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Contents

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＜Introduction: Usage notes＞

Thank you very much for purchasing our Solar radiation film, OptoLeaf. This system is product to measure the amount of solar radiation based on the degree of color fading of a colored film. Before use of this system, please read this manual carefully and handle this system appropriately to make this system function properly.

Make sure to note the following points in order to use this product safely:

Usage notes

This product does not contain harmful regulated substances under RoHS 2 Directive, but please do not lick or put it in your mouth.

When discarding

When disposing of this product, please do not leave as it is, please treat according to the local government's ordinance as "plastic garbage".
We appreciate your cooperation in protecting the environment.
This product is a plastic film containing Triacetylcellulose as the main component.
Triacetylcellulose: Used as a base material for textiles, motion picture films, and recording tapes.

Caution

Failure to observe the following may cause performance deterioration.

Storage method

Keep this product away from direct sunlight, high temperatures, and humid environments.

＜Summary＞

OptoLeaf is a film to measure the integrated amount of solar radiation and integrated amount of light quanta. The coloring matter of the film is faded by solar radiation, and the color fade rate is converted to the integrated amount of solar radiation and integrated amount of light quanta with use of a calibration curve.

OptoLeaf enables measurements that have been difficult with a conventional pyranometer.

OptoLeaf is a film, which means small and light, and therefore, it can be placed anywhere. Because OptoLeaf can be prepared in large numbers by cutting it, it is suited for measuring at many places at the same time. There are three types of OptoLeaf available, which have different fading speeds and fading periods, you can choose OptoLeaf depending on your measurement environment or measurement period.

＜Principle＞

OptoLeaf is a colored film that is a highly transparent film impregnated with a coloring matter. The integrated amount of solar radiation is obtained by using the gradual fading of the coloring matter caused by exposure to solar radiation. Conversion to the integrated amount of solar radiation can be simply obtained by using the calibration curve graphically indicating the relationship between the color fade rate that shows the fading level and values indicated by a conventional pyranometer. The color fade rate of the film can be calculated from values of absorbance before and after exposure with use of a spectrophotometer. The calibration curve with a light quantum meter allows the integrated amount of light quanta to be measured, too.

＜Features＞

- Small and light because it is a film
- Placeable anywhere (measureable even in the water)
- Convenient for multipoint measurements at the same time for it can be prepared in large numbers
- Amount of light quanta as well as amount of solar radiation is measurable
- Required size of film is obtained by cutting, so it is low cost per piece

＜Example of use＞

- Measurement of solar radiation amount at plantations of vegetable and fruit or forests
- Measurement of solar radiation at plant leaf surfaces
- Measurement of solar radiation in greenhouse or the like (a calibration curve in greenhouse required)
- Measurement of solar radiation at the surface or shadow of buildings
- Measurement of solar radiation on the surface of human bodies
- Measurement of water turbidity based on amount of solar radiation in water

＜How to use OptoLeaf＞

1. Type selection

Select an OptoLeaf type to be used depending on your operating environment (site, ambient temperature, etc.) and measurement period.

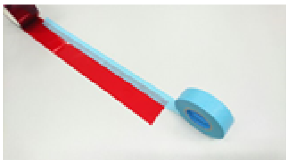
2. Cut

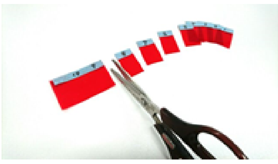
(1) Cut OptoLeaf to a suitable size for measurements.

(2) A length of 20 mm is necessary for D-Meter, OptoLeaf measuring instrument used later.
(35 mm x 20 mm) (W x L)

In the case of preparing many OptoLeaf pieces, marking on OptoLeaf pieces beforehand is useful.

- Sticking tape on the edge of OptoLeaf as a mark before cutting helps recognize the front and back sides of OptoLeaf at measurements. The inner side of the OptoLeaf roll is the exposure surface (solar radiation side).
- Writing a number or the like is useful for arrangement after measurements.





When OptoLeaf is not used, keep it in a dark place at room temperature.

3. Measurement of initial absorbance

(1) Measure the initial absorbance (before exposure) that is a reference.

Measure all the initial values of all pieces of OptoLeaf to be used.
(Because the initial values of plural OptoLeaf pieces with the same specifications may differ depending on color irregularities.)

(2) Absorbances shall be measured with D-Meter, the OptoLeaf measuring instrument (a spectrophotometer can be also used).

Refer to the instruction manual of D-Meter for how to use D-Meter, the OptoLeaf measuring instrument.

OptoLeaf measuring instrument, D-Meter
This device is an instrument to measure the absorbance of OptoLeaf.
This instrument is suitable for use in fieldwork because it is compact, light, and convenient to carry.
Simplified operations of the instrument are convenient for measurements in large quantities with OptoLeaf.
This instrument is used to calculate the color fade rate of OptoLeaf from the values before and after exposure.
(This instrument itself cannot obtain the color fade rate.)



When absorbance is measured with spectrophotometer
Mount OptoLeaf on the holder portion of a spectrophotometer in an upright position.
(Mounting should be performed so that light strikes in a straight line)
In some cases, OptoLeaf must be cut in accordance with the holder portion size.
Because the maximum absorbance wavelengths of light vary with types of OptoLeaf, measure absorbances after setting to the maximum absorbance wavelengths of each OptoLeaf piece (see reference material).

(3) Record measured values.

Use them in the color fade rate calculation together with measured OptoLeaf values after exposure.

4. Placement at measurement point

(1) Confirm the exposure surface of OptoLeaf before placement.

OptoLeaf has front and back surfaces. The inner side of a roll is the exposure surface.
Please use it by setting the exposure side to the solar radiation side.
(If it is used with the reverse surface, correct measurements cannot be performed due to value errors.)

Exposure surface
＝Solar radiation side

(2) Place the OptoLeaf whose initial absorbance has been confirmed at the point where you would like to measure solar radiation.

Use adhesive tape, a clip, pin, or the like without overlapping the point where solar radiation is measured to secure the OptoLeaf piece.

(3) Leave the OptoLeaf for a certain period of time for the exposure.

(4) Decide on the collection time (depending on ambient temperature, weather, and more).

5. Collection

(1) Check the exposure state at the measurement point.

Finish the OptoLeaf exposure so that the absorbance is not less than 0.6.
If the absorbance is less than 0.6, correct measurements cannot be performed.
(A standard initial value at the time of manufacturing: 2.0±0.2)
The instrument, D-Meter, is useful for checking the exposure state at the site.

Be aware that the measurement accuracy is reduced if exposure is insufficient or too great.
Obtain the integrated amount of solar radiation within the range of the OptoLeaf color fade curve (calibration curve).

(2) Collect the OptoLeaf pieces after exposure.

When the absorbances are not immediately measured, keep the collected OptoLeaf pieces away from light.

6. Measurement of absorbance after exposure

(1) Measure the absorbance of OptoLeaf pieces after exposure.

(2) Perform the same operation as the measurement of initial absorbance.

7. Calculation of color fade rate

Use the following formula to calculate the color fade rate from the initial absorbance, D0, and absorbance after exposure, D.

Fading rate (%) R-3D : $\mathrm{Log}_{10}(D／D0 \times 100)$
Y-1W : $D／D_0 \times 100$
O-1D : $D／D_0 \times 100$ range: 30% to 90%

D_0 = absorbance at the beginning (before exposure)
D = absorbance after exposure

The absorbance values before and after exposure are necessary.

8. Conversion to integrated amount of solar radiation

(1) Use the “OptoLeaf color fade curve (calibration curve)” to convert the OptoLeaf color fade rate to the integrated amount of solar radiation [MJ/m^2].

(2) Use OptoLeaf type-specific “OptoLeaf color fade curve (calibration curve)”.

(3) Select a calibration curve to be used based on the ambient temperature in the exposure period of OptoLeaf.

☞ The color matter fading of OptoLeaf is also affected by the temperature (ambient temperature) of OptoLeaf.

☞ **OptoLeaf color fade curve (calibration curve)**
The color fade rate of OptoLeaf is converted to the integrated amount of solar radiation with use of the OptoLeaf color fade curve (calibration curve). The OptoLeaf color fade curve (calibration curve) shows the correlation “between the amount of OptoLeaf color fade and the value of the pyranometer”.

☞ The provided OptoLeaf color fade curves (calibration curves) are based on the actually measured values in Tokyo and Chiba prefectures. Therefore, in some areas, there may be errors between the provided data and actual amount of solar radiation. If higher accuracy is required, it is recommended to create calibration curves at the point of use.

OptoLeaf color fade curve (calibration curve)
The curve is used to convert the OptoLeaf color fade rate to the integrated amount of solar radiation [MJ/m^2]. The curve graphically shows the relationship between the OptoLeaf color fade rate and the measured values with a pyranometer in an ambient-temperature-specific manner. The provided data is the actual measured values in Tokyo and Chiba prefectures. The integrated amount of light quanta [mol/m^2] can also be measured by using calibration curves with a light quantum meter.

Used pyranometer: Neo-pyranometer, MS-42 (EKO Instruments),
measurable length: 300 to 2800 nm
O-1D: Neo-pyranometer, MS-131WP (EKO Instruments),

Used light quantum meter: Memory sensor, MES-101 (KI Holdings Co., Ltd.)

Measurement place: Solar radiation amount R-3D, Chiba-shi
Solar radiation amount, Y-1W, Chiba-shi
Solar radiation amount, O-1D, Katsushika-ku, Tokyo
Light quanta amount, R-3D, Katsushika-ku, Tokyo
Light quanta amount, Y-1W, Katsushika-ku, Tokyo
Light quanta amount, O-1D, Katsushika-ku, Tokyo

Others: OptoLeaf placed horizontally to the ground

<**Data**>

OptoLeaf 35 mm x 10 m (W x L/roll)

Product No. (color/period)	Type
R-3D (Red-3Days)	**Standard type** **Measurement period as a guideline: 3 to 7 days** This type is most often used for the research of agricultural products and gardening. Long-term measurement can be performed if it is used by replacing with a new one.
Y-1W (Yellow-1Week)	**Long-term measurement type** **Measurement period as a guideline: 1 to 3 weeks** This type is a relatively slow color fade type. This type is useful for measuring at places where OptoLeaf collection is not easy such as measurements in distant mountain areas.
O-1D (Orange-1Day)	**Short-term measurement type** **Measurement period as a guideline: 1 to 3 days** This type is sensitive to color fading. This type is suitable for a place where the amount of solar radiation is low or a place (or time) where (when) color fading is too slow because of low ambient temperatures.

Measurement period (period required for color fading)

Product No. (color/period)	Summer/fair weather	Summer/cloudy weather, Winter/fair weather	Winter/fair weather
R-3D (Red-3Days)	1 to 3 days	2 to 5 days	4 to 8 days
Y-1W (Yellow-1Week)	3 to 7 days	5 to 14 days	1 to 3 weeks
O-1D (Orange-1Day)	0.5 to 1 day	1 to 2 days	2 to 4 days

* The periods described above are guidelines. Adjustment is necessary depending on measurement conditions.

Fading rate formula

Product No.	Max absorbance wavelength	Fading rate formula Fading rate (%)
R-3D	521nm	$\log_{10}(D/D_0 \times 100)$
Y-1W	468nm	$D/D_0 \times 100$
O-1D	492nm	$D/D_0 \times 100$ Range: 30 - 90%

D_0 = absorbance at the beginning (before exposure)
D = absorbance after exposure

＜How to create color fade curve (calibration curve)＞

(1) Record values of every OptoLeaf color fade step.
(The more the values are recorded, the more correct the graph becomes)

(2) For value record, use both the D-Meter (or a spectrophotometer) and a pyranometer.

1) D-Meter (or spectrophotometer): Absorbance (required for color fade rate calculation)
2) Pyranometer: Integrated amount of solar radiation

(3) The color fade rate of OptoLeaf is obtained from the values (absorbances) indicated by D-Meter (a spectrophotometer). The color fade rate is calculated from absorbances before and after exposure.

(Refer to how to use OptoLeaf for the calculation formula for the color fade rate)

(4) Link between the color fade rates and integrated amounts of solar radiation with lines to complete the correlation diagram.

1) Color fade rate: Value calculated from absorbances before and after exposure
2) Integrated amount of solar radiation: Value measured with pyranometer
* Use of a light quantum meter instead of a pyranometer can create the color fade curve (calibration curve) of the light quanta amount.

＜Example: Creation of R-3D color fade curve＞

For example, suppose color fading is examined at intervals of half a day for three days.

(1) Prepare six pieces of OptoLeaf. (3 days x 2 times = 6 pieces of OptoLeaf)
- Record the initial values before exposure in advance (for six pieces of OptoLeaf)

(2) Start exposure of 6 pieces at the same place at the same time.
- Start a measurement at the same place at the same time with the pyranometer (light quantum meter).

(3) Collect exposed OptoLeaf pieces every half a day (for example, at 12:00 and 18:00).
- Record the values of integrated amount of solar radiation indicated with the pyranometer at the same time.
- There is another way to continue exposure and measurements at the places without OptoLeaf collection.

(4) Measure the absorbances of the collected OptoLeaf pieces with the OptoLeaf measuring instrument or spectrophotometer.
- The color fade rate is calculated from the measured value mentioned above and the measured value of the absorbance before exposure.
See “How to use OptoLeaf.”

(5) Make a graph of the values of OptoLeaf color fade rates (six points) **and the values of the pyranometer** (six points)**.**

【Cautions】

- Place OptoLeaf horizontally to let the sun strike it.
- The more measurement points that exist, the higher the accuracy that can be achieved.
- Measure the initial values of all the OptoLeaf pieces to be used.
  (Because the initial values of plural OptoLeaf pieces with the same specifications may differ depending on color irregularities.)
- The color matter fading of OptoLeaf is also affected by the temperature (ambient temperature) of OptoLeaf.
  Temperature-specific (ambient-temperature-specific) calibration curves need to be created.
- Determine the ambient temperature of the calibration curve based on the actual measured temperature and the records of the Meteorological Agency.

For inquiries about unclear points or consultation, contact us as follows:

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