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Application News

High performance Liquid Chromatography No.L426

Analysis of Dye Degradation in Dye-Sensitized Solar Cell

Of the organic photovoltaic cells that have been under extensive development as next-generation solar cells, dye-sensitized solar cells are perhaps the closest to commercialization today. These types of solar cells are expected to be produced inexpensively. Commercialization will of course be contingent on sufficient photoelectric conversion efficiency, but equally important will be their endurance in withstanding degradation over time.
By using HPLC, it is possible to observe changes in these dyes over time. Here we introduce some analytical examples of the degradation of one such dye, referred to as N3 dye.

* We wish to express our appreciation for the N3 dye samples as well as cooperation provided under the FIRST program through the Segawa Laboratory at the University of Tokyo Research Center for Advanced Science and Technology.

■ Degradation of N3 Dye Due to Light Irradiation

Fig. 1 shows chromatograms of N3-4TBA aqueous solution prior to (a) and following (b) degradation due to irradiation, and Table 1 shows the analytical conditions used. The N3 dye peak appears at 4.64 minutes, but following irradiation processing, impurity peaks due to degradation are apparent at 1.92 minutes and 3.50 minutes. In addition, the impurity peak at 3.50 minutes was determined through LC-MS analysis to be from an isomer of the N3 dye. Fig. 1 (c) and (d) show the UV absorption spectra of the peak at 3.50 minutes (from isomer) and the peak at 4.64 minutes (from N3 dye), respectively, in the range 400 to 700 nm. Both of them show significant absorption in the vicinity of 530 nm.

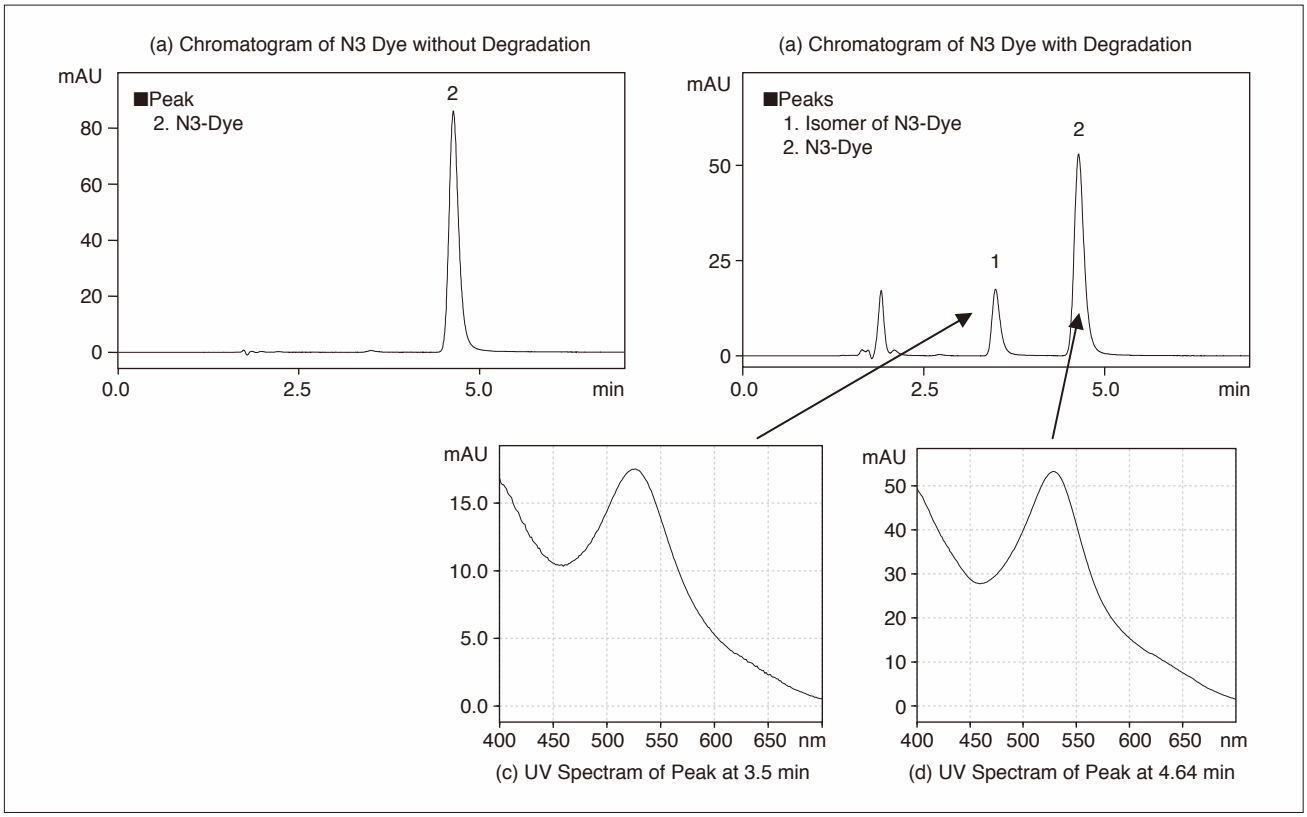


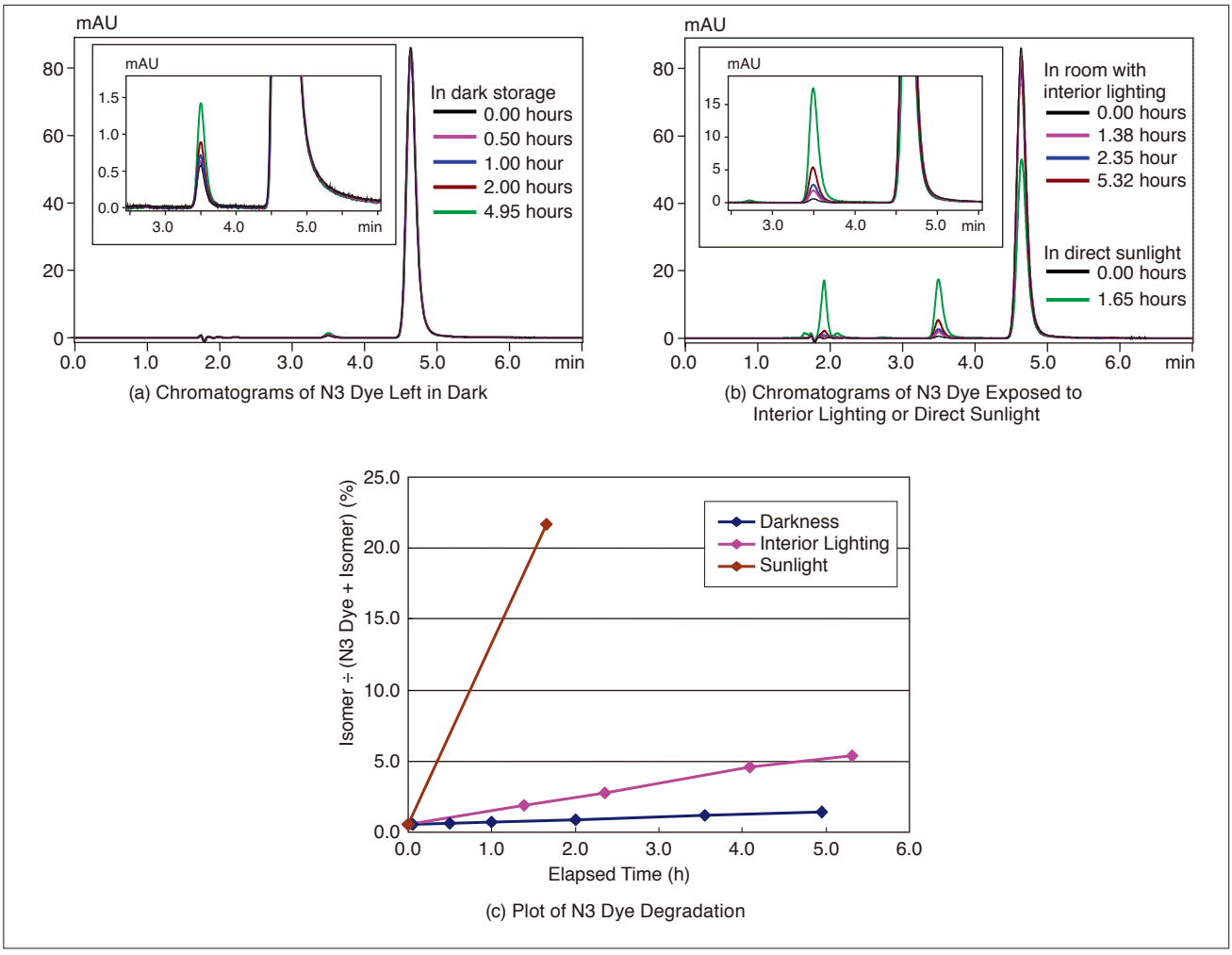
Fig. 1 Degradation of N3 Dye

Table 1 Analytical Conditions

Column	: Synergi Polar-RP (150 mm L. × 4.6 mm I.D., 4 µm)	Injection Volume	: 1 µL
Mobile Phase	: A : 1 % Formic acid in Water, B : Acetonitrile A / B = 65 / 35 (v/v)	Detection	: SPD-M20A 530 nm (Slit Width : 1.2 nm)
Flow Rate	: 1.0 mL/min	UV Cell	: Conventional Cell
Column Temp.	: 30 °C	Sample	: 1 mg/mL N3-4TBA in water

■ Degradation Analysis of N3 Dye

N3 dye is degraded due to irradiation, resulting in the formation of different types of impurities. Samples of 1 mg/mL N3-4TBA aqueous solution were transferred to glass vials, which were placed respectively in (1) a dark location (0-5.32 hr), (2) in a room with interior lighting (0-5.32 hr), and (3) under direct sunlight (0-1.65 hr). The samples were then analyzed using the conditions of Table 1. The chromatograms of the samples treated under the various lighting conditions are shown in Fig. 2 (a) and (b). The degradation state of the N3 dye in the various solutions is represented as an index based on the ratio of N3 dye to its isomer. Fig. 2 (c) shows a graph which plots the changes in the different samples with respect to time. N3 dye degradation was observed to progress not only in the room-lit environment, but to a slight degree in the dark as well. In other words, this suggests that dye degradation occurs during preparation of the dye in research and development as well as when the solar cell itself is being produced. Moreover, dye degradation progressed rapidly in direct sunlight.



(a) Chromatograms of N3 Dye Left in Dark

(b) Chromatograms of N3 Dye Exposed to Interior Lighting or Direct Sunlight

(c) Plot of N3 Dye Degradation

Fig. 2 Time-Dependent Degradation of N3 Dye

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