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Effect of dye for dye-sensitized solar cell from gamma-irradiation

Hwa-Jung Kim, Ju-Woon Lee, Hae-Jun Park*

RT Practical Application Division
Advanced Radiation Technology Institute, Korea Atomic Energy Research Institute, Jeongeup 580-815, Republic of Korea.
**Corresponding author. Tel.: +82 63 570 3190; fax: +82 63 570 3195.*
E-mail address: hjpark@kaeri.re.kr

1. Introduction

Solar energy relevant issues are unequivocally some of the most urgent and popular research fields, among which the development of a dye-sensitized solar cell (DSSC) aimed at economic cost, high conversion efficiency, and long-term stability, seems to be promising.
However, most researches have focused on the cell performance of the DSSC such as the conversion efficiency and cell architecture. Herein, we tried a new alternative, concept toward dye-material by the interaction between the dye and gamma-irradiation. We also describe the preparation of dyes using gamma-irradiation and the results achieved. Specifically, commercialized dyes (N719, Z907) were investigated.

2. Methods and Results

In this section, dyes were prepared using various ranges of gamma-irradiation dose, the results of which are described shortly.

2.1 Preparation and property of dyes via the gamma-irradiation

Figure 1 shows the visible information of the prepared dyes using various ranges of gamma-irradiation treatment.
The dye solutions are representing differently using the following colors: non-irradiated (cont.) and 1Gy-irradiated dye solutions are similarly shown as red-pink colors. However, N719 and Z907 dye solutions are indicated to have considerably different color properties at an increased irradiation dose (10 kGy to 100 kGy).

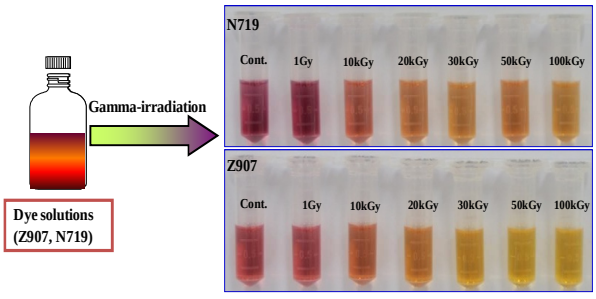

Fig. 1. Preparation and visible property of dye solutions by gamma-irradiation.

2.2 Optical property of prepared dye solutions

An optical analysis showed that newly formed dye solutions have a various adsorption peaks, as shown in Fig. 2 and Fig. 3. The clearly different optical spectrum properties were represented as changes and shifted peaks in the UV and visible wavelength fields. These interesting results were shown in dye solutions through gamma-irradiation treatment. Although the absorption peak shape of N719 and Z907 dyes are remarkably different, the results have not shown a direct effect on the DSSC efficiency. In UV and visible optical absorption spectra, it was indicated that the different created properties of dyes from gamma-irradiation do not correlate with the dye function for DSSC.

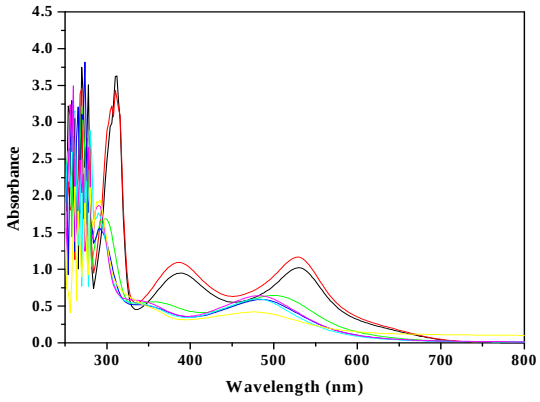

Fig. 2. Absorption spectrum changes of N719 dye solution by irradiation of various doses using a gamma-radiolysis technique. Non-irradiation (cont.; black), 1 Gy (red), 10 kGy (light green), 20 kGy (blue), 30 kGy (light blue), 50 kGy (magenta), and 100 kGy (yellow).

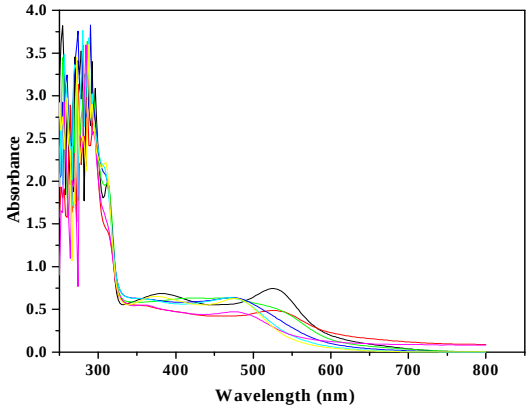

Fig. 3. Absorption spectrum changes of N719 dye solution by irradiation of various dose in gamma-radiolysis technique. Non-irradiation (cont.; black), 1 Gy (red), 10 kGy (light green), 20 kGy (blue), 30 kGy (light blue), 50 kGy (magenta), and 100 kGy (yellow).

2.3 Application for DSSC analysis

The photovoltaic properties of gamma-irradiated dye solutions in a DSSC analysis are showed in Table 1 (N719) and Table 2 (Z907). In general, the DSSC efficiency of dyes (N719, Z907) in application to DSSC has decreased in accordance to the rise in gamma-irradiation dose. A Comparison of the I-V characteristics of a prepared cell using gamma-irradiated dye with and without irradiation revealed that J_{sc} of the cell is decreased, while no large changes occurred for an open-circuit voltage (V_{oc}, N719; 0.73 to 0.23, Z907; 0.71 to 0.35) against the degree of change in the value of J_{sc}. However, patterns from the changed values of N719 and Z907 were not similarly shown.

Table 1. *I-V* performances parameters of DSSC with gamma-irradiated N719 dye solutions

Dose of irradiation	V_{oc} (mV)	J_{sc} (mA/cm^2)	FF (%)	η (%)
Control	0.69	14.21	67.53	6.48
1 Gy	0.70	14.26	72.66	7.26
10 kGy	0.29	0.28	41.70	0.03
20 kGy	0.26	0.23	40.16	0.02
30 kGy	0.20	0.12	34.22	0.01
50 kGy	0.24	0.13	41.31	0.01
100 kGy	0.23	0.12	39.72	0.01

Table 2. *I-V* Performance parameters of DSSC with gamma-irradiated Z907 dye solutions

Dose of irradiation	V_{oc} (mV)	J_{sc} (mA/cm^2)	FF (%)	η (%)
Control	0.69	12.76	72.15	6.29
1 Gy	0.70	13.43	72.97	6.82
10 kGy	0.50	0.01	59.41	0.002
20 kGy	0.47	0.01	58.05	0.002
30 kGy	0.51	1.34	58.44	0.40
50 kGy	0.46	0.60	46.51	0.13
100 kGy	0.35	0.45	38.18	0.06

3. Conclusions

Commercialized dyes were prepared from gamma-irradiation with doses of various ranges. The dyes showed various color characteristics according to the irradiation dose. Based on the optical property of the dyes, interesting structural characteristics were shown. The results might indicate that the dye structure was partially destructed and newly created from the gamma-irradiation. Although the DSSC efficiency of the dyes in a photovoltaic analysis, very interesting results were clearly suggested from the reaction between the dyes and gamma-irradiation. This suggests that further studies be conducted to investigate the dyes-molecular destruction and a new design induced by gamma-irradiation. Therefore, it can be applicable to needed for customized products including DSSC material, etc. It can be used effectively in various industrial fields and is applicable to diverse systems.

REFERENCES

[1] S. K. Lee, E. G. Jeong, J. S. Im, and Y.-S. Lee, Electrochemical Characterization of Hybrid Semiconductor-Based Dye-Sensitized Solar Cells, Korean Chem. Eng. Res., Vol. 49, p. 175, 2011.
[2] N Sekar and Vishal Y Gehlot, Metal Complex Dyes for Dye-Sensitized Solar Cells: Recent Development, Resonance, September 2010.
[3] D.-Y. Chen, K.-Y. Cheng, M.-L. Ho, I.-C. Wu, M.-W. Chung, H. S. Fu, and P.-T. Chou, A new recognition concept using dye sensitized solar cell configuration, Chem. Commun., Vol. 47, p. 985, 2011.
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