Organic Thin-Film UV Detector

유기 박막 UV 감지기

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Introduction

Especially, the recent increasing of UV exposure by ozone depletion[1] on the earth surface becomes a severe problem. This enforces the improvement of new UV detection techniques from angles of manufacturing process, economical cost, and so on. With these backgrounds, in order to surmount general problems of conventional UV sensor based inorganic materials and also to design more effective UV sensitive sensor, we try to construct a novel UV sensor using molecular switching of photochromic dye (spirooxazine derivatives ; naphthoxazinespiroindoline, compound **1**) and thin film active waveguide structure.

Experimental

Spirooxazine, a well-known photochromic dye[2] as a UV sensitive photochromic molecule (absorbs visible light at λ_{max} = 587 nm, Fig. 1), has good solar-blind characteristics and these unique properties are useful to UV sensing molecular device. To make the waveguide type sensor, the core layer as a active UV sensing layer using photochromic dye dispersed in poly(methyl methacrylate) (PMMA, refractive index n = 1.492 at 633 nm) is located between air (n = 1.0) and substrate (n = 1.47) as a clad layer. The casting solution of PMMA, spiroxazine derivative, and toluene is coated on pyrex glass surface by spin coating method. Film thickness is about 1.0 ㎛ (SEM measurement).

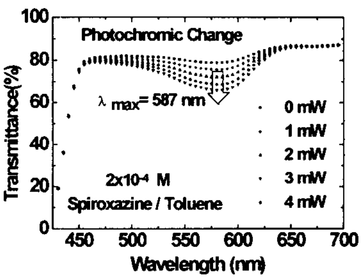

Fig. 1. Photochromic changes of **1** in visible region with increase of the irradiated UV intensity (solution)

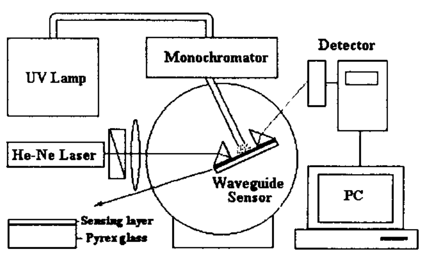

Fig. 2. Experimental setup diagram of the waveguide type UV sensing system.

Fig. 3. Photograph of output ; TE_0 mode

The UV sensing system with waveguide type sensor is constructed as follows (Fig. 2). In this system, the incident light to waveguide via prism from He-Ne Laser is absorbed in sensing layer through photochromic phenomena according to ring open of dye structure by UV absorption.

The out coupled beam by prism is appeared on screen as m-line (Fig. 3). The UV wavelength of light source (high pressure mercury lamp, Spot Cure SP3-250D) is fixed at 366 nm through monochromator

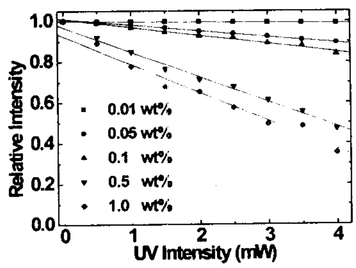

Fig. 4. Output intensity (at 633 nm) of the waveguide sensor according to varied UV intensity.

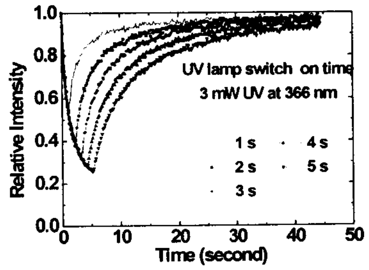

Fig. 5. Irradiation time responsibility of a waveguide type UV sensor.

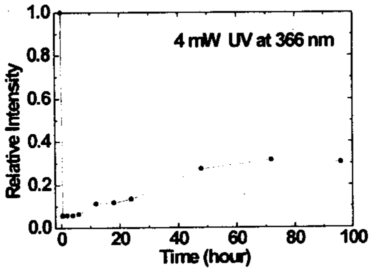

Fig. 6. Long time stability of a waveguide type UV sensor. Dye concentration of sensing membrane is 1.0 wt%.

and the intensity is calibrated with conventional UV power meter (USHIO 150).

To obtain more precise detecting characteristics of this waveguide type UV sensor, we investigate the output intensity of waveguide sensor by the change of dye concentration of PMMA matrix (0.01, 0.05, 0.1, 0.5, 1.0 wt%) and exposing UV intensity. The time dependance of waveguide sensor is measured by following method. The temporal response is checked out by UV lamp switch on time variation from 1 second to 5 seconds at fixed intensity of 3 mW. The long time stability is tested for 96 hours under continuous UV irradiation of 4 mW intensity.

Results and Discussion

The output intensity of the waveguide sensor is linearly decreasing according to the light at 633 nm by increasing UV irradiation time and also increasing dye concentration linearly as expected (Fig. 4). Figure 5 shows that as increasing UV irradiation time and intensity to this waveguide sensor, absorption at 633 nm is increasing. This resulted in decreasing output light intensity and increased reversible (relaxation) time to original output intensity. When the waveguide sensor is continuously irradiated by UV lamp for investigating long time stability, its response shows fairly good stability (Fig. 6) and this can be improved through more precise experimental conditions, photochromic dye design, choice of matrix, and etc. (now under studying). Although it is necessitated to study on more accurate quantification and miniaturization, we believe that these experimental results can be useful to design new UV type sensor and may be applicable to several areas.

References

1. D. -P. Häder, *J. Photochem. Photobiol. B : Biol.*, 35, 181 (1996).

2. C. B. McARDLE, *Applied Photochromic Polymer Systems*, Blackie & Son Ltd., New York (1992).