Nonlinear response of photothermal and optical absorption for erythrosine B dye in epoxy resin

T. Toyoda, K. Fukao, T. Shigenari

► To cite this version:

T. Toyoda, K. Fukao, T. Shigenari. Nonlinear response of photothermal and optical absorption for erythrosine B dye in epoxy resin. Journal de Physique IV Proceedings, 1994, 04 (C7), pp.C7-357-C7-360. 10.1051/jp4:1994783 . jpa-00253313

HAL Id: jpa-00253313

<https://hal.science/jpa-00253313>

Submitted on 1 Jan 1994

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Nonlinear response of photothermal and optical absorption for erythrosine B dye in epoxy resin

T. Toyoda, K. Fukao and T. Shigenari

*Department of Applied Physics and Chemistry, The University of Electro-Communications,
1-5-1 Chofugaoka, Chofu, Tokyo 182, Japan*

Abstract: Photothermal measurement using thermistor is applied to study the heat generation by nonradiative processes in erythrosine B dye in epoxy resin. It shows that the incident light intensity dependence of heat generation using an Ar ion laser is nonlinear and corresponds to that for the transmission of erythrosine B in epoxy resin. The increase of the signal intensity of the heat generation is different from that of total rate of optical energy absorption.

1. INTRODUCTION

Erythrosine B is xanthene dye which is same class as rhodamine 6G (R6G) and is used as material for sensitizer. R6G is the most widely used and investigated dye for many applications. Its optical properties are of particular interest. R6G forms solid solutions in non-polar plastic materials and inorganic glasses[1,2]. On the other hand, erythrosine B is considered as one of the candidates for low power phase conjugation by degenerate four-wave mixing recently[3,4]. Erythrosine B is of interest in that a long lifetime of the triplet state (of the order of milliseconds) and a strong absorption at wavelength of an Ar ion laser enable us to generate the cw conjugate wave. Generation of a phase conjugate wave by degenerate four-wave mixing is attractive for applications to real-time holography, turbulence correction, and improvement of high-power laser-beam quality. Although several investigations have been carried out on the optical absorption and photoluminescence, and nonlinear properties of erythrosine B in non-polar plastic materials[5], there are few investigations on the heat generation by nonradiative processes except the thermal-lens measurements[6,7]. We present here the experimental results of the incident light intensity dependence of the direct detection

of heat generation for erythrosine B using an Ar ion laser and a simple photothermal spectroscopy apparatus [8] together with those of optical transmission and reflectance. It is worthwhile to investigate the direct detection of temperature changes resulting from nonradiative processes following light energy absorption. The direct temperature measurements allow a more flexible sample cell arrangement than photoacoustic cell and is suitable for short time irradiation of light.

2. EXPERIMENTAL

Optically homogeneous films of epoxy resin having erythrosine B dye concentration of 10^{-4} to 10^{-1} mol/l were made with the thickness of about 100 μm . For photothermal signal (PTS) measurements, we employed a thermistor as a sensor for temperature measurements proposed by Brilmeyer et al [8-11]. In order to eliminate the effect of temperature changes of surrounding air, a differential thermistor arrangement was used to compensate for changes in ambient temperature. The thermistor has a nominal resistance of 12 k Ω and a sensitivity of 480 Ω/K at 20°C. The light source was an Ar ion laser beam with a wavelength of 514.5 nm in which HOMO-LUMO transition was shown in erythrosine B dye. The transmission and reflectance measurements were carried out by conventional methods. In order to avoid irreversible bleaching, irradiation time is restricted to 0.2 seconds.

3. RESULTS AND DISCUSSION

Fig.1 shows the incident light intensity dependence of the transmittance of erythrosine B dye in epoxy resin for three different concentrations. They display increasing transmittances up to a final value, which is below unity. The measured saturation intensity (onset of saturation) is 2.0 W/cm^2 for three different concentrations. This value is close to that reported by Silberberg and Bar-Joseph [3]. Fig.2 shows the incident light intensity dependence of the reflectance of erythrosine B dye in epoxy resin for three different concentrations. They show no light intensity dependence for

Fig.1. Light intensity dependence of the transmission for erythrosine B dye in epoxy resin.

Fig. 2. Light intensity dependence of the reflectance for erythrosine B dye in epoxy resin.

Fig. 3. Total rate of optical energy absorption, $1-T-R$, for erythrosine B dye in epoxy resin.

Fig. 4. Light intensity dependence of the PTS for erythrosine B dye in epoxy resin.

Fig. 5. Light intensity dependence of the ratio, $PTS/(1-T-R)$, for erythrosine B dye in epoxy resin.

three different concentrations and show constant values within the experimental accuracy. Fig. 3 shows the total rate of optical energy absorption, $1-T-R$ (T : transmission; R : reflectance). $1-T-R$ for three different

ent concentrations show decreasing against the increase of light intensity. Fig.4 shows the incident light intensity dependence of heat generation (PTS) for erythrosine B dye in epoxy resin for three different concentrations. The heat generations show nonlinear dependence in which signal saturation occurs as the pump laser intensity is sufficiently high. This saturation mode results from the interaction between optical and thermal processes in the sample. In order to compare the increases and changes of both the heat generation (PTS) and total rate of optical energy absorption (1-T-R), PTS signals were divided by 1-T-R (PTS/(1-T-R)). Fig.5 shows the incident light intensity dependence of the PTS/(1-T-R) for erythrosine B dye in epoxy resin for three different concentrations. The heat generation by nonradiative processes for erythrosine B dye in epoxy resin increases in spite of the decrease of the total rate of optical energy absorption relative to increase of light intensity. This fact might be related to the nature of thermal conversion efficiency in nonlinear region of erythrosine B dye in epoxy resin. In the future, a comparison between heat generation and rate equation analysis in nonlinear region are desirable for useful information on the nature of nonradiative processes of erythrosine B dye in epoxy resin.

REFERENCES

- [1] Reisfeld R., Zusman R., Cohen Y. and Eyal M., Chem.Phys.Lett. **147** (1988) 142-147.
- [2] Narang U., Bright F.V. and Prasad P.N., Appl.Spectrosc. **47** (1993) 229-234.
- [3] Silverberg Y. and Bar-Joseph I., Opt.Comm. **39** (1981) 265-268.
- [4] Miyanaga S., Yamabayashi T. and Fujiwara H., Opt.Lett. **13** (1988) 1044-1046.
- [5] Atvarz T.D.Z., Bortolato C.A. and Dibbern-Brunelli D., J.Photochem. Photobiol.A: Chem. **68** (1992) 41-50.
- [6] Chartier A., Georges J. and Mermet J.M., Chem.Phys.Lett. **171** (1990) 347-352.
- [7] Chartier A., Georges J. and Mermet J.M., Spectrochimica Acta **46A** (1990) 1737-1742.
- [8] Brilmyer G.H., Fujishima A., Santhanam K.S.V. and Bard A.J., Anal. Chem. **49** (1977) 2057-2062.
- [9] Fujishima A., Masuda H. and Honda K., Anal.Chem. **52** (1980) 682-685.
- [10] Brilmyer G.H. and Bard A.J., Anal.Chem. **52** (1980) 685-691.
- [11] Fijishima A., Maeda Y. and Honda K., Bull.Chem.Soc.Jpn. **53** (1980) 2735-2741.