Asian Journal of Chemistry; Vol. 25, No. 10 (2013), 5631-5632

ASIAN JOURNAL OF CHEMISTRY

http://dx.doi.org/10.14233/ajchem.2013.OH41

Preparation of Polymethyl methalcrylate Rhodamine 6G and Its Optical Property†

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AJC-13284

Solid state Rhodamine 6G dye gain medium fabricated and discussed. Its optical properties are investigated for the all solid state tunable laser system in visible region. Among several methods of solidifying dye, the plastic method of using acrylic material of methymethalcrylate illustrated in detail that has never reported earlier. In optical inspection it showed a slightly distorted uniformity and bidirectional refractive indices. However, it has the good optical surface and there was not a serious scattering. Polymethyl methalcrylate Rhodamine 6G showed the nearly same absorption and fluorescence spectra compared to those of liquid state Rhodamine 6G.

Key Words: Polymethyl methacrylate, Rhodamine 6G, Optical property.

INTRODUCTION

The demand for the broader, sharper and faster laser light source in nearly every wavelength has increased in many applications such as medicine, communication, sensing, spectroscopy, biology and space technology. In most contactless inspection and evaluation, those laser light source has played an important role for more accurate and reliable results. Especially in visible region the dye laser is the most proper to cover from ultraviolet to near infrared region, though the development of laser diode is replacing a role of the dye laser in many wavelengths.

The solid dye has been attractive to many researchers. A dye cartridge for easy replacing proposed to make up for the photo-dissociation, but it could not be a complete solution. Moreover, the triplet-triplet absorption is another problem in realization of solid dye[1-3].

Among laser gain medium, the dye has a unique characteristics of broad absorption and fluorescence spectra, which is much profitable for fabrication of a fast and narrow band laser light source. Solid dye has many comparative advantages to liquid dye such as nontoxic, easy to handle and fabricate maintaining tunable property. Manufacturing of solid dye has studied by many researchers and three methods reported to date, which are the plastic method of using acrylic material[4,5], the colouring method of using pore glass[6,7] and the crystalline method of colouring with crystal growing direction[8,9]. The plastic method of using acrylic material has no limit in size and easy to cut and polish. In most case, the plastic method use monomer methylmethalcrylate for polymerization with dye. methyl methalcrylate has good physical, mechanical properties compared to other candidates. In a polymerization process, a bubble generation and a stickiness and gel remaining depends on the temperature treatment and complete removal of solvent that used to solve a dye. Though these complicated processes, the plastic method of using acrylic material such as polymethylmethalcrylate is the most easy to access for a solid dye.

EXPERIMENTAL

Preparation of solid state of Rh-6G: Table-1 shows the thermo-optical properties of several solid and liquid hosts for a dye laser material. As indicated in Table-1, polymethylmethalcrylate has a low thermo-diffractive index and thermal conductivity and a moderate density.

TABLE-1
THERMO-OPTICAL PROPERTIES OF SOLID AND LIQUID HOSTS[10,11]

Solvent/host	dn/dT ($\times 10^{-5}$/°C)	ρ (g/cc)	K (W/m·°C)
PMMA	8.5	1.19	0.207
Ethylene Glycol	26	1.113	
EtOH	26	0.789	
Silicate glass	0.3		1.30

Polymethyl methalcrylate is a most commonly used material for polymer matrix for solid state dye laser because it has a good optical transparency in spite of low damage threshold. Furthermore, the good efficiency, photo-stability, longevity have been enhanced by modification, such as pyrromethene dyes,

†Presented to the 6th China-Korea International Conference on Multi-functional Materials and Application, 22-24 November 2012, Daejeon, Korea

modified polymethyl methalcrylate (MPMMA), dye doped organically modified silicate (ORMOSIL) and 2-hydroxyethyl methacrylate (HEMA) + MMA = HEMMA, PHEMMA.

The synthesis of solid dye is able to be done using sol-gel glass host or composite host. Perylene red, which has the peak wavelength of 604 nm, is the most stable for solid dye fabrication. It showed an increased photostability of 80 ± 15 GJ/mol after polymerized with polymethylmethalcrylate. The polymerizing process of laser grade dye with polymethyl-meth-alcrylate composite host hardly report as a paper. The data of perylene red and perylene orange were from the polymerized composite host. The wavelength of perylene red was 604 nm, but those of perylene orange and Rhodamine 6G were under 600 nm.

The solidifying process began from the preparation of polymethylmethalcrylate. The refinery process of methylmethalcrylate as a host material is as following. A NaOH solvent was prepared with the distilled water and a H_3PO_4 solvent also done like the NaOH solvent. The same volumic NaOH solvent and methyl methalcrylate were mixed and stirred. The next step was the separation of methylmethalcrylate by using a seperatory funnel. The separation step of methyl methalcrylate was repeated several times. The secondary refinery process of methylmethalcrylate was done with H_3PO_4 solvent. In actual mixing process, the mixed solution of distilled water and H_3PO_4 should be stirred till H_3PO_4 solve completely.

Fig. 1. Picture of solid dyes

The process of mixing and shaking was performed and left till the separation of salt and distilled water finish by precipitation. This secondary refinery process also repeated several times to get a pure refined methylmethalcrylate.

The next step is drying. Then, a low temperature treatment process was done in 3-11 ºC for a day. A dryer separation performed after a low temperature treatment. The last step was the dye mixing and polymerization. A hardened plastic dye cut and optical polished by using a diamond cutter and a jigged polishing machine. The polymerized polymethyl methalcrylate dye was a comparatively soft synthetic resin.

RESULTS AND DISCUSSION

Optical property of polymethyl methalcrylate Rh-6G: The prepared solid dyes were investigated its optical properties. Firstly, the uniformity of dye molecules in polymethyl methalcrylate resin need to be tested. The beam of a He-Ne laser focused with a lens of 200 mm focal length. The position of a solid dye moved from 50 mm to 200 mm from the lens. The transmitted images of beam profiles shrank and a little distorted with the solid dye approaching to the focal point. Fig. 2 is the comparison of liquid dye and solid dye in absorption and fluorescence spectra. The absorption spectra were investigated with a spectrophotometer and the fluorescent spectra were measured with a spectrometer and a second harmonic generation of Nd : YAG laser. The dashed lines are of liquid Rh-6G dye and the solid lines are of polymethylmethalcrylate Rh-6G. There was not a meaningful difference in the peak wavelengths of absorption and fluorescence spectra between liquid and solid states of Rh-6G.

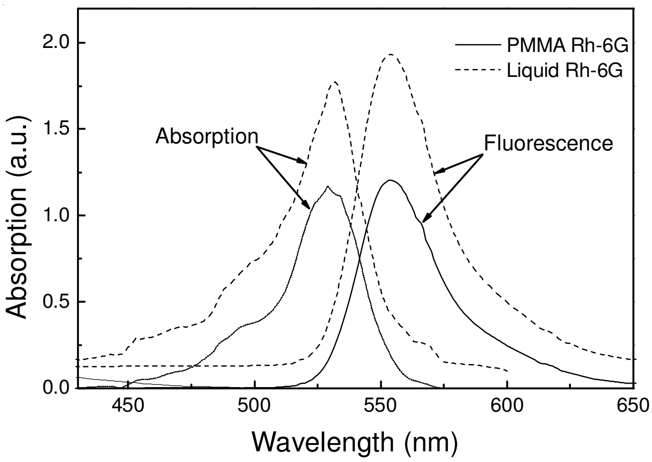

Fig. 2. Absorption and fluorescence spectra of liquid and solid Rh-6G

The solidifying laser gain material is a trend for more practical applications in science and industry. In this paper, the solidifying dye solution discussed that has many advantages of broad absorption and emission bands. The investigated optical properties are moderate for laser application. The solidifying technology of dye solution is much valuable for the laser application of visible region including ultraviolet and near infrared. Additive study is necessary for more improved solid dye solution.

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