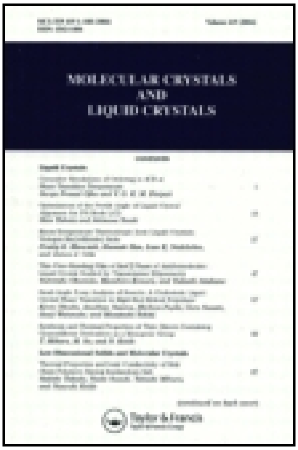

Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl20

Enhancement of Luminescence of Nematic Liquid Crystals Doped with Silver Nanoparticles

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Version of record first published: 05 Oct 2009

To cite this article: Shuan-Yu Huang, Chih-Chieh Peng, Li-Wei Tu & Chie-Tong Kuo (2009): Enhancement of Luminescence of Nematic Liquid Crystals Doped with Silver Nanoparticles, Molecular Crystals and Liquid Crystals, 507:1, 301-306

To link to this article: http://dx.doi.org/10.1080/15421400903054071

Mol. Cryst. Liq. Cryst., Vol. 507, pp. 301–306, 2009

ISSN: 1542-1406 print/1563-5287 online
DOI: 10.1080/15421400903054071

Enhancement of Luminescence of Nematic Liquid Crystals Doped with Silver Nanoparticles

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The photoluminescence of nematic liquid crystals doped with silver nanoparticles has been investigated. The peak intensity of photoluminescence varies with the concentration of doped silver nanoparticles. The peak intensity of photoluminescence shows the enhancement effect in the range of concentration from 0% ~ 1% and the quenching effect in the range of concentration from 1% ~ 4%. The photoluminescence can be enhanced around 55% for silver nanoparticles with 88 nm in diameter.

Keywords: nematic liquid crystal; photoluminescence; quenching effect; silver nanoparticles

PACS number(s): 42.70.-a; 78.55.-m

INTRODUCTION

The influence of nanoparticle on the optical phenomena has received much attention in the last decade [1–4]. An increase of luminescence intensity of dye molecules at the presence of metal nanoparticles has been observed in the early 80's [5–7]. Later, the enhancement and

The authors would like to thank the National Science Council of the Republic of China, Taiwan for financially supporting this research under contract No. NSC 96-2112-M-110-004.

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modification of the emission of dye molecules and trivalent rare-earth ions adsorbed onto rough metallic surfaces has been the subject of intense interest [8–11]. Noginov demonstrated that the efficiency of spontaneous and stimulated emission can be enhanced by adding the solution of aggregated silver nanoparticles to the solution of rhodamine 6 G dye [12]. More recently, Hung reported the observation of an enhanced optical diffraction in cholesteric liquid crystals due to the presence of silver nanoparticles [13].

In this work, we report the photoluminescence of nematic liquid crystals doped with silver nanoparticles. The dependence of photoluminescence on the concentration of silver nanoparticles has been performed. The enhancement of photoluminescence has been demonstrated by doping nematic liquid crystals with an appropriate concentration of silver nanoparticles.

EXPERIMENTAL

The material investigated was pentyl-cyanobiphenyl (5CB) liquid crystals doped with silver nanoparticles. The size of silver nanoparticles is approximately 88 nm in diameter and the weight concentration of silver nanoparticles ranges from $0 \sim 4.0\%$. The nematic liquid crystals doped with silver nanoparticles were capillarity injected into the sample cell, which was assembled from a pair of glass substrates coated with transparent indium tin oxide layers and spaced by a pair of 5.4-μm-thick Teflon sheets. The homogeneous planar alignment of the nematic liquid crystals was achieved by spin-coating a thin layer of polyimide on the inner surface of the front glass substrate, which was mechanically rubbed with a velvet cloth unidirectionally. The helium-cadmium laser with the wavelength of 325 nm was employed as the excitation beam operated at an approximate power of 1 mw. The polarization of the excitation beam was maintained parallel to the director of nematic liquid crystals. The spectra of photoluminescence were measured with Jobin-Yvon T64000 spectrofluorometer at room temperature, as shown in Figure 1.

RESULTS AND DISCUSSION

The photo-induced luminescence of nematic liquid crystals was performed under the excitation of helium-cadmium laser operated at 325 nm. The photoluminescence of pure nematic liquid crystals revealed a purple-blue image, as shown in Figure 2. The photoluminescence spectrum of nematic liquid crystals without doping nanoparticles was recorded from 350 nm to 500 nm. The peak position

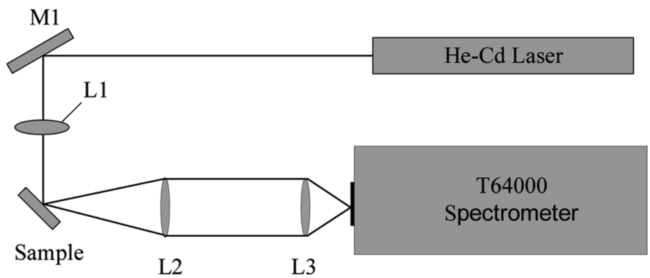

FIGURE 1 The experimental setup of the photo induced luminescence of nemalic liquid crystals measured with Jobin-Yvon T64000 spectrofluorometer.

of photoluminescence was located at around 389 nm. In order to investigate the behavior of nanoparticles in the photoluminescence of nematic liquid crystals, the dependence of photoluminescence on the concentration of silver nanoparticles was performed. The photoluminescence spectra of nematic liquid crystals doping with various concentrations of silver nanoparticles were recorded for the particle size of 88 nm in diameter, as shown in Figure 3. The photoluminescence spectra of nematic liquid crystals in the presence of silver nanoparticles have the same profile as the spectrum of pure nematic liquid crystals. The peak intensity of photoluminescence as a function of concentration is shown in Figure 4. The peak intensity of photoluminescence increases with the increasing concentration of silver nanoparticles in the range of concentration from 0% ~ 1%. The peak

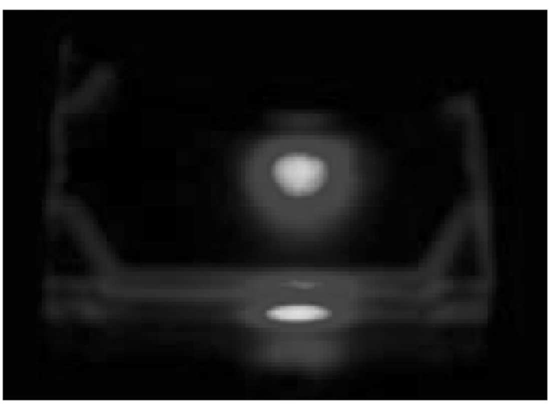

FIGURE 2 The image of purple-blue luminescence from nemalic liquid crystals under the excitation of 325 nm.

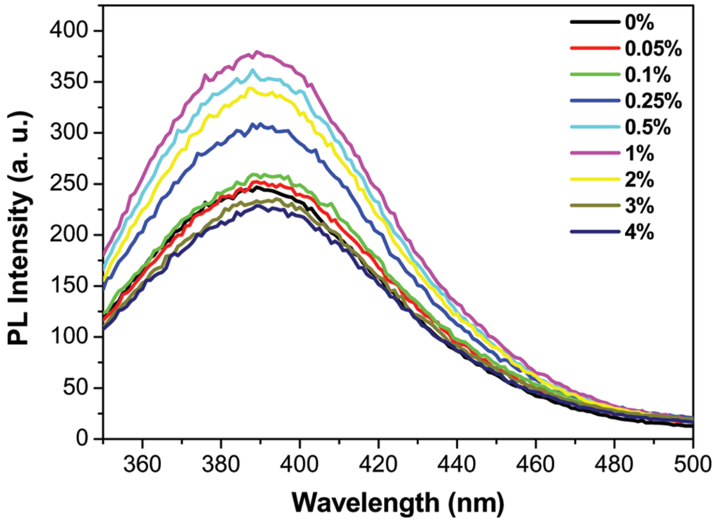

FIGURE 3 The photoluminescence spectra of nemalic liquid crystals doped with various concentrations of silver nanoparticles (88 nm in diameter) with the director parallel to the polarization of excitation beam.

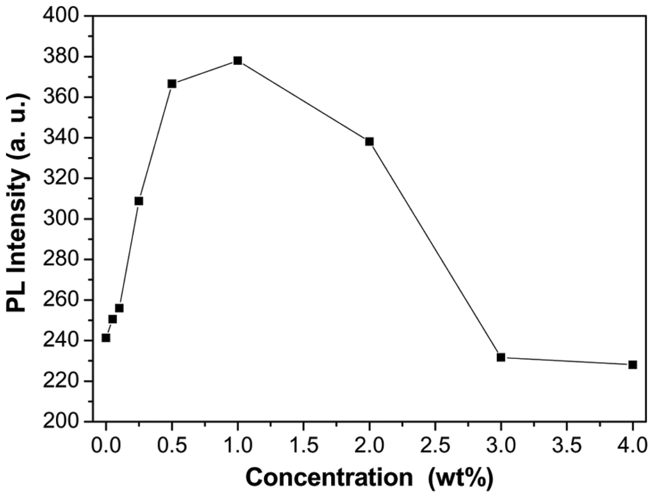

FIGURE 4 The peak intensity of photoluminescence as a function of concentrations of silver nanoparticles.

intensity of photoluminescence reaches the maximum at the concentration of 1% and shows the enhancement of intensity around 55%. The peak intensity of photoluminescence decreases with the further increasing concentration of silver nanoparticles in the range of concentration from 1% ~ 4%.

The enhancement of the peak intensity of photoluminescence is attributed to the effect of local surface plasmon resonance in the range of concentration from 0% ~ 1%. The local surface plasmon resonance effect of silver nanoparticles in the host of nematic liquid crystals becomes more obviously as the concentration of silver nanoparticles increases in this range of concentration. The decay of the peak intensity of the photoluminescence is attributed to the effect of energy transfer between nematic liquid crystals and doped silver nanoparticles in the range of concentration from 1% ~ 4%. The partial energy of nematic liquid crystals transferring to the silver nanoparticles results in the reduction of photoluminescence intensity. The rate of energy transfer becomes higher as the concentration of silver nanoparticles increases in this range of concentration. Thus, the peak intensity of photoluminescence decreases with the increasing concentration of silver nanoparticles in the range of concentration from 1% ~ 4%.

CONCLUSIONS

We have demonstrated that the photoluminescence of nematic liquid crystals can be enhanced by doping an appropriate amount of silver nanoparticles. The photoluminescence depends on the concentration of doped silver nanoparticles. The peak intensity of photoluminescence increases with the increasing concentration of silver nanoparticles up to certain concentration, and then decreases as the concentration increasing further.

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