

## 단일분자형광 측정기술을 이용한 폴리스티렌/유리 계면의 분자수준 극성분포 연구

### Molecular Scale Polarity Distribution at the Interface of Polystyrene/Glass observed by Single Molecule Detection

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Since the first report on the single molecule fluorescence detection<sup>1</sup>, this technique has been continuously developed for better application in the study of physical properties of nanomaterials and observation of living systems. Single molecule detection (SMD) has several advantages over the ensemble measurement which observes the averaged optical informations over great numbers of object molecules. A major advantage is that SMD enables us to observe the individual molecular properties which are influenced by molecular scale environments (a few nm). As we can detect the fluorescence signal from a single molecule, it is possible to deduce a detailed distribution of molecular sub-population which varies with molecular conformation or nano-scale environment. Such a sub-population can not be obtained by ensemble measurement in which it is hidden under totally mingled information.

We have observed the fluorescence spectra of Nile Red (NR) molecules embedded in a polystyrene (PS) film prepared by spin coating of dye-polymer mixture solution on a silicon-oxide glass. A laser scanning microscope system which provides a detection sensitivity down to single molecule level was used to observe the ensemble and single molecule fluorescence spectra of NR. NR is a compound with its fluorescence property largely influenced by the polarity of the surrounding nanoenvironment<sup>2</sup>. NR molecules embedded in a PS film showed different fluorescence maxima depending on the concentration of polymer solution (1~100 mg/mL PS in toluene) used for spin coating (i.e. the thickness of the PS film) [Fig. 1(a)]. Since the fluorescence intensity was observed to be linearly dependent on the NR concentration in both relatively thick and thin PS films [Fig. 1(b)], the fluorescence spectra were considered to be originating from independent fluorophores instead of dimers or aggregates. The red shift of NR fluorescence might be attributable to the charges at the surface of silicon-oxide glass which provide a polar environment to NR molecules<sup>3</sup>. As the red shift was not observed on the surface of relatively thick PS film (100 mg/mL solution), charge distribution at the polymer surface was considered to be negligible. Using single molecule detection technique, distribution of spectral maximum of individual NR fluorescence in PS films with different thickness was observed and compared. The result was statistically assessed to deduce

information of molecular scale polarity distribution at the interface of PS/glass.

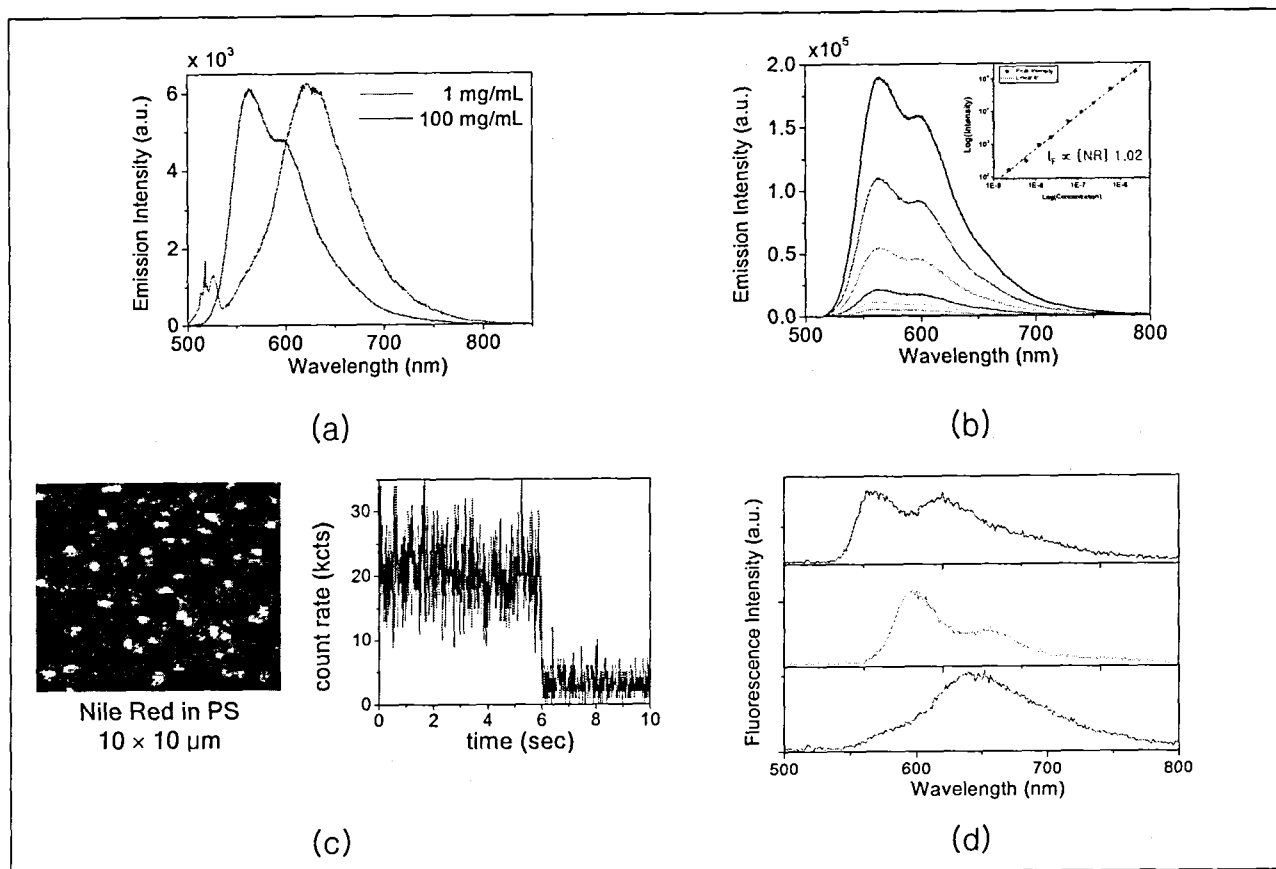


Figure 1. (a) Fluorescence spectra of NR embedded in PS films spin coated with solutions of different polymer concentration. (1 and 100 mg/mL PS in toluene) (b) Fluorescence spectra of NR embedded in PS films (10 mg/mL) as a function of NR concentration from  $2 \times 10^{-9}$  to  $2 \times 10^{-6}$  M. [Inset shows  $\log$ - $\log$  plot of peak intensity vs. embedded NR concentration.] (c) An image of single NR molecules embedded in a PS film. Yellow spots correspond to the fluorescence from single fluorophores. The discrete jump in the fluorescence intensity transient is an evidence of single molecule detection. (d) Examples of single NR fluorescence spectra in a PS film. Fluorescence maxima can be greatly influenced by the nanoenvironment of individual molecules.

1. N.J. Dovichi, J.C. Martin, J.H. Jett, and R.A. Keller, *Science* **219** 845-847 (1983).
2. Y. Hou, A. M. Bardo, C. Martinez, and D. A. Higgins, *J. Phys. Chem. B*, **104** 212-219 (2000).
3. M. Porti, M. Nafria, M.C. Blum, X. Aymerich, and S. Sadewasser, *Appl. Phys. Lett.* **81(19)** 3615-3617 (2002).

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