Rhodamine 6G Confined in Polymeric Nanoparticles as Active Media of Tunable Lasers

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Fluorescent dyes are usually applied in signalling, imaging and sensing different process of interest or molecular events. To this aim, the fluorophore should be stable in different environments, small enough to ensure a good compatibility with the biochemical systems and highly fluorescence. However, sometimes the fluorophores are affected by the surrounding environment properties. For example, extreme acid or basic conditions could damage the dye causing a loss of the sensing ability of the dye. In other cases, the environment might induce interactions between dye molecules causing the aggregation and hence the quenching of the fluorescence signal.[1]

One way to circumvent this problem is to encapsulate the fluorescence label into a nano-sized organic or inorganic particle. Thus, the dye is protected against external factors increasing its photo and thermal stability. That is why we decide to encapsulate Rhodamine 6G (Rh6G) laser dye into latex polymeric nanoparticles. The obtained dye-doped materials are small enough and show a random distribution in solution. Consequently the transparency is not affected and these systems could be applied as the active media of tunable lasers. Even more, the lasing action of rhodamine 6G is enhanced in the latex framework by the non-resonant feedback of the emission by multiple scattering.[2] The dye doped latex nanoparticles act as scattering centers, which, instead of being detrimental for the laser action, improve the lasing efficiency of the dye.

In the present work, we have studied in detail the photophysical and lasing properties of aqueous suspensions of Rh6G encapsulated in latex nanoparticles.[3] The influence of the dye concentration, composition of the latex and morphology of the polymeric nanoparticle have been taking into account looking for the best conditions to optimized the optical properties of these systems. This is possible since the size, polarity and viscoelasticity of the surrounding environment of the dye can be controlled by carefully changing the latex composition.

The small size of the latex nanoparticles makes possible to obtain stable aqueous suspensions. Dye aggregation is one of the mayor drawbacks of tunable dye lasers. Their inactive absorption and their fluorescence quenching effect drastically decrease the lasing efficiency. Instead, Rh6G has tendency to self-associate in concentrated media, which are required for the lasing action. However, this problem is overcome with the dye encapsulation. No sign of aggregation has been observed up to dye concentrations around 10^{-2} M inside the latex, obtaining highly fluorescence emissions and hence improved lasing signals.

While the latex polymeric composition has minor effect onto the photophysical properties of Rh6G the size of the nanoparticle is a key factor. For small enough particles (diameter lower than 70 nm) the fluorescent efficiency is unaltered. Due to the incoherent random lasing, the weak scattering of the emission elongates the light path inside the gain media providing extra feedback and improving the lasing efficiency of Rh6G with regard to liquid solutions. However, for big nanoparticles the fluorescence is quenched and no lasing emission is detected. In these conditions the scatter effect is so high that increases the losses in the resonator cavity.

Summarizing, the encapsulation of Rh6G in latex nanoparticle lads to a highly fluorescent system, even at high concentrations, and ameliorates the lasing properties of the dye due to the weak scatter of the light, which provide an extra non-resonant feedback of the emission. Besides, the dye is protected against photobleaching. However, big nanoparticles damage the fluorescence and laser emission owing to the too high light scattering probability.

References

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Figures

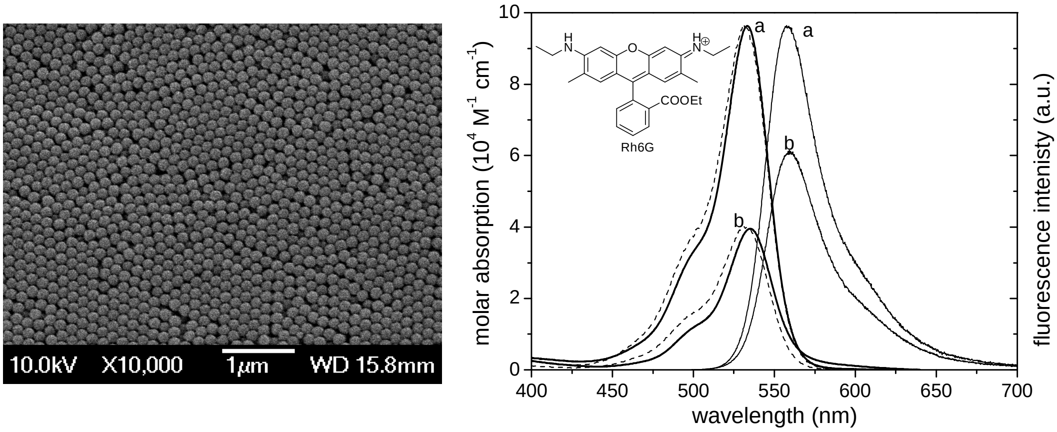

Figure 1. *Scanning Electron Microscopic (SEM) image of the latex nanoparticles and absorption, excitation (dashed) and fluorescence spectra of rhodamine 6G (Rh6G) inside small (a, diameter 20nm) and big (b, diameter 166 nm) polymeric nanoparticles.*