

Fast Responsive Photochromic Materials

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Abstract

During the last decades photochromic compounds have been proposed for a number of applications in optics, electronics, computing and materials science.^[1] Among them, the manufacturing of photoprotective coatings (e.g. for ophthalmic lenses and smart windows) is currently their main commercial use.^[2] For this application, photochromic compounds must fulfill several requirements: (i) to display light-induced conversion from a colorless to a colored state, (ii) to revert back thermally to the initial situation in absence of irradiation (T-type photochromicity^[1]), and (iii) to present fast color darkening and fading kinetics. Although a number of T-type organic photochromes displaying such properties have been developed, to achieve high switching speeds in solid materials still remains a challenge.^[3] This is due to the effect of the supporting matrix where these compounds are loaded, which imposes steric restrictions to the significant molecular motions typically involved in the interconversion between the two states of the photochromes.^[1a,3] As a result, the thermal back-reaction rate of these compounds is largely slowed down with respect to solution, thus affecting the performance or even preventing the application of the final photochromic materials.

In an attempt to overcome this drawback, herein we report on a novel, straightforward and universal methodology to attain high photochromic switching speeds in rigid matrices. Our approach consists in photochrome encapsulation into liquid-filled solid-shell hollow capsules, thus obtaining a solid material with solution-like photochromic behavior that will be preserved even when subsequently embedded into rigid hosts. Moreover, our strategy does not require synthetic modification of commercially available photochromes, while it also tackles other severe problems encountered when directly dispersing photochromic molecules within solid matrices, such as dye aggregation and migration.

With this aim, we have synthesized polyamide capsules containing photochromic solutions by interfacial polymerization in oil-in-water emulsions.^[4] In particular, the polycondensation of terephthaloyl chloride with diethylenetriamine was carried out, which led to the formation of polymeric shells around the microsized droplets of the organic solvent phase where the photochromes of interest had been previously dissolved. Measurements of the thermal color fading kinetics of the resulting capsules showed monoexponential decays and rapid decoloration rates that resemble those obtained for the same photochromic compounds in solution, and are at least ten-fold faster than those measured for rigid polymer thin films and solid particles. In addition, by properly selecting the nature of the liquid core, the capsules prepared were found to display high stability both in time and upon redispersion in a variety of solvents, facilitating their subsequent processing for the fabrication of functional materials

where fast photochromic response is required, such as photoprotective coatings and optical data processing devices.

References

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Figures

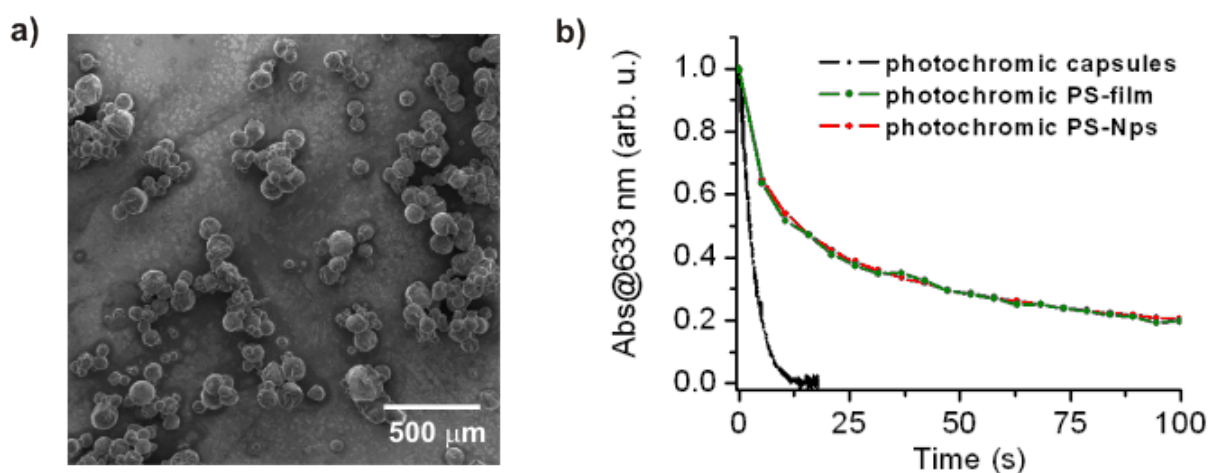


Figure 1. a) SEM image of polyamide capsules containing a photochromic solution of 1,3-dihydro-1,3,3-trimethylspiroindoline-2,3'-(3H)-naph(2,1-b)-(1,4)oxazine (Photorome I). b) Thermal decoloration kinetics of photochromic polyamide capsules, photochromic polystyrene thin film (**PS-film**) and photochromic polystyrene nanoparticles (**PS-Nps**).