NIR laser-triggered drug release from mesoporous-silica core/gold-shell nanoparticles

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In 2008 the U.S. demand for drug delivery systems was predicted to increase by more than 10 % a year, reaching $132 billion by 2012 [1]. Those desired drug delivery systems can be classified based on the method of administration either topical, enteral or parenteral as well as classified by the delivery mechanism active or passive. Passive drug delivery is controlled by the molecular diffusion of a previously attached, adsorbed or enclosed drug from its carrier towards the surrounding media depending exclusively on a concentration gradient and usually taking advantage of the specific human physiology or of the natural response of the immune system in order to accumulate the drug at a targeted site. Active drug delivery allows for the controlled triggered release of a therapeutic molecule (drug, gene or protein) by using a chemical characteristic of the carrier or of the drug itself (i.e., pH responsive [2,3], chemically responsive [4], enzymatically responsive [5], red-ox responsive release [6], etc.) responding to a an environmental stimulus, or by using a physical response of the carrier upon external stimulation (i.e., magnetically aided drug release [7], optically [8] or sonic [9]) or even by means of combinations of several triggering mechanisms (i.e., pH and temperature responsive hydrogels [10]).

Both active and passive delivery systems are ideally designed to avoid non-specific drug distribution throughout the body, to regulate drug-release kinetics, to minimize side-effects and to improve the therapeutic efficacy compared to systemic applications of the corresponding drug.

Of all those physically-triggered release systems, optically triggered systems in the near infrared (NIR) region (around 650–900 nm) of the electromagnetic spectrum have the main advantage of not being invasive. Also, NIR light is preferable as trigger in biomedical applications because it has maximal penetration in tissues or whole blood due to their minimal absorbance at those wavelengths [11]. Hemoglobin and water, the major absorbers of visible and infrared light, respectively, have their lowest absorption coefficient in the NIR region. NIR light has been shown to travel at least 10 cm through breast tissue, and 4 cm of skull/brain tissue or deep muscle using microwatt laser sources (FDA class 1) and with higher power levels (FDA class 3) light has been shown to penetrate through 7 cm of muscle and neonatal skull/brain [12].

In this work, we introduce a new system for the external control of drug release from mesoporous silica nanoparticles coated with a porous gold shell. The release of the guest molecule, adsorbed on the pores of the mesoporous silica, is triggered by applying a NIR laser.

The nanoparticles were prepared modifying a previous method described by Halas and co-workers [13] for the preparation of silica/gold core/shell nanoparticles in which the core is non-porous. In the work described here nanoshells were obtained from mesoporous silica nanoparticles [14] modified with amine groups where gold nanoparticles of 3-4 nm were used as seeds [15]. Following a re-growing process mesoporous silica/gold nanoshells were obtained with core and shell both porous. These nanoparticles were characterized by TEM, EDX, UV-VIS-NIR spectrophotometry, DLS, SAXS and

nitrogen adsorption. Ibuprofen sodium salt was used as a model drug and the capacity of heating and the controlled release from this system was demonstrated (Figure 1).

References

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Figures

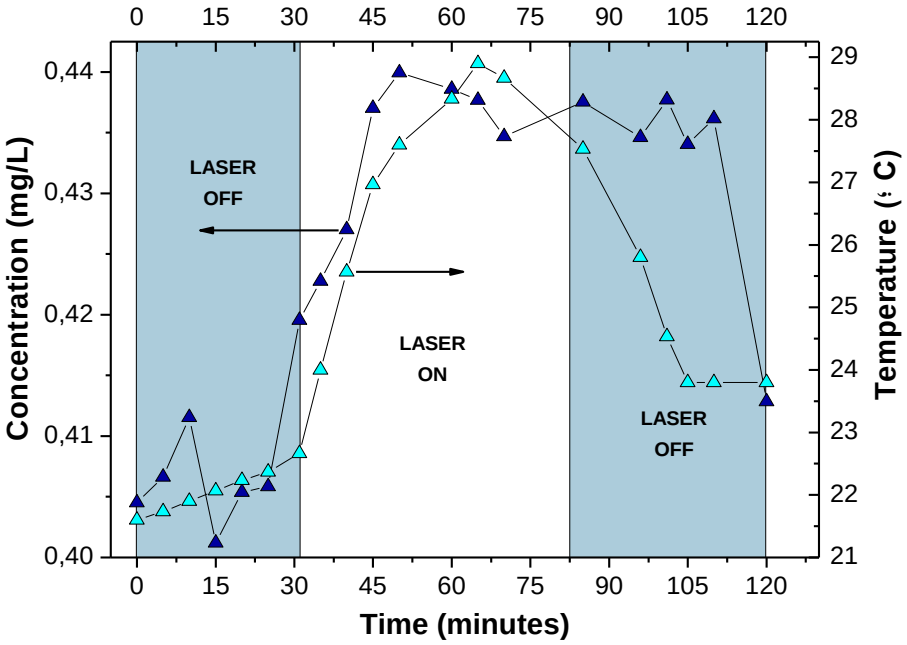

Figure 1. *Release of ibuprofen sodium salt from porous SiO_2@Au nanoshells externally controlled by NIR-laser radiation.*