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Opto-Magnetic Nanosystems For Biomedical, Energy and Environmental Applications

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Extended Abstract

Opto-magnetic nanosystems, integrating the properties of light and magnetism at the nanoscale, offer immense potential for biomedical, energy, and environmental applications. By combining the precision of optical techniques with the versatility and controllability of magnetic materials, these systems enable wireless actuation to induce local heating, exert mechanical deformations and movement, induce electric responses, and activate electrochemical reactions, among others.

In the biomedical field, we will present magneto-plasmonic nanocapsules (MAPSULES) for wirelessly controlled drug delivery, bioimaging and nanothermometry [1,2,3]. The MAPSULES endow unprecedented magnetic strength, colloidal stability, photothermal efficiency and biodegradability, given by the metal iron layer that half-coats the drug loaded polymer nanocapsules. By exploiting the magnetic and optical control, we have demonstrated complete tumor eradication at ultralow drug concentration (i.e., between 200 and 500-fold lower than the therapeutic window of the free drug). This versatile technology can also be applied to other biomedical applications, such as combined photothermal and photodynamic therapies, anti-bacterial treatments or nanothermometry.

For energy applications, opto-magnetic nanosystems can be utilized in light harvesting to generate new photo-thermo-catalytic reactions. We will present Ni-based micro/nanocatalysts exhibiting highly damped plasmonic behavior, which can be used for the photothermal synthesis of high added-value biofuel precursors from biomass residues, showing a remarkable reduction of the reaction temperature and time.

In environmental science, opto-magnetic nanosystems can have a wide range of applications for water remediation. We will show how catalysts can be integrated with magnetic and opto-electric devices to achieve a highly amplified degradation and mineralization of organic pollutants [4, 5]. This strategy can also be applied to wirelessly trigger other electrochemical reactions [6].

In conclusion, opto-magnetic nanosystems represent a promising frontier in materials science and engineering. By harnessing the synergistic effects of light and magnetism at the nanoscale, these systems have the potential to address critical challenges in healthcare, energy, and environmental remediation.

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