Physically-triggered nanosystems for therapy and diagnosis

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Stimulus-responsive systems have demonstrated for some time now significant advantages for the therapeutic and imaging fields. Nevertheless, this last decade was marked by the emergence of innovative concepts, opening new avenues of investigation. Since the field's inception, the driving force for the development of responsive materials has been motivated by the potential to modulate remotely a therapeutic or diagnostic action, with precise spatial and temporal control via externally-applied physical stimuli, such as light, temperature, electric or magnetic fields. It became possible to actuate materials on-demand, by altering at distance molecular interactions at critical onset points, and to provide controlled and sustained drug delivery, drug activation, heat triggering and contrast enhancement.

This special issue covers the latest achievements and prospects related to physically-triggered nanosystems for therapy and diagnosis. Notably, important progress has been achieved for precision nanomedicine in nucleic acid delivery and theranostics, described by Do *et al* [1] and Mohamed *et al* [2], respectively. Also, recent developments on nano/micro-motors as well as electric field-responsive nanosystems for controlled drug release deserve special attention, being overviewed by Srivastava *et al* [3] and Kolosnjaj-Tabi [4], respectively.

We have also witnessed a new momentum in the field of physically-triggered nanosystems mainly due to the fast-forward progress in nanosystem design. Roca *et al* [5] shows how innovative synthesis routes revolutionized material combination, modular designs and shape possibilities. Dimers or multimers, multi-layered designs and exquisite shape control resulted in a new generation of materials featuring

highly tuned sensitivity for responding to a given stimulus within a very narrow range and at exceptional performance. For instance, light-responsive nanosystems are now successfully tailored to respond to wavelengths of high tissue penetration while combining enhanced photothermal conversion rate, optimized photodynamic effect, precise drug delivery or ultra-high sensitive detection, as complementarily overviewed by Costa *et al* [6], Zhu *et al* [7] and Son *et al* [8]. An especial emphasis on photo-triggered and thermoresponsive polymer nanosystems is addressed by Beauté *et al* [9] and Bordat *et al* [10], respectively, while Liu *et al* [11] set the focus of their contribution on persistent luminescence nanomaterials. Ji *et al* [12] described the assets of two-dimensional materials for cancer theranostics. An additional example of improved performance comes from magnetic-field responsive nanosystems reported to be co-stimulated by light, as highlighted by Cazares-Cortes *et al* [13]. This approach synergically combines the strengths of magnetic hyperthermia and photothermal therapy to overcome their intrinsic limitations. Besides, in a strategy crossing the boundaries of material science and cell biology, physically-triggered nanosystems are now designed to feature a cell-friendly biocamouflage provided by extracellular vesicles, endowing them with unique biogenic features, as complementary reviewed by Piffoux *et al* [14] and Kauscher *et al*. [15].

Importantly, the impulse towards physically triggered nanosystems is also characterized by unveiling possibilities not explored so far, at least the way they can be explored now. This is the case of nano-scale polymer grafting techniques enabling the control of cell behaviour, as addressed by Takahashi *et al* [16]. The same applies to iron oxide nanoparticles (i) for quantitative whole body imaging via magnetic particle imaging (MPI), as overviewed by Bulte [17]; (ii) for companion diagnostic in personalized nanomedicine, introduced by Dadfar *et al* [18] or (iii) for gene expression induced by magnetic hyperthermia, as highlighted by Moros *et al* [19]. Another remarkable example to be cited concerns metal-based nanoparticles in radiation therapy reaching early stages of clinical development, as further detailed by Pinel *et al* [20].

The relationship between new designs and new applications of physically-triggered nanosystems are key issues to transcend the concept of smart nanomaterials into an implementable strategy. This theme issue intends to appraise the current facets of physically-triggered nanosystems, the new promises they offer as well as the expectations they fulfil.

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