



HAL
open science

Physically-triggered nanosystems for therapy and diagnosis

Claire Wilhelm, Florence Gazeau, Amanda K A Silva

► **To cite this version:**

Claire Wilhelm, Florence Gazeau, Amanda K A Silva. Physically-triggered nanosystems for therapy and diagnosis. *Advanced Drug Delivery Reviews*, 2019, 138, pp.1-2. 10.1016/j.addr.2019.03.001 . hal-02408366

HAL Id: hal-02408366

<https://cnrs.hal.science/hal-02408366>

Submitted on 13 Dec 2019

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Physically-triggered nanosystems for therapy and diagnosis

Claire Wilhelm, Florence Gazeau, Amanda K. A. Silva

Laboratoire Matière et Systèmes Complexes (MSC), UMR 7075, CNRS and Université Paris Diderot, Université Sorbonne Paris Cité (USPC), 10 Rue Alice Domon et Léonie Duquet, 75205 Paris Cedex 13.

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.

References

- [1] H.D. Do, B.M. Couillaud, B.-T. Doan, Y. Corvis, N. Mignet, Advances on non-invasive physically triggered nucleic acid delivery from nanocarriers, *Advanced Drug Delivery Reviews*, (2018).
- [2] S.M. M, S. Veerananarayanan, T. Maekawa, S.K. D, External stimulus responsive inorganic nanomaterials for cancer theranostics, *Advanced Drug Delivery Reviews*, (2018).
- [3] S.K. Srivastava, G. Clergeaud, T.L. Andresen, A. Boisen, Micromotors for drug delivery in vivo: The road ahead, *Advanced Drug Delivery Reviews*, (2018).
- [4] J. Kolosnjaj-Tabi, L. Gibot, I. Fourquaux, M. Golzio, M.-P. Rols, Electric field-responsive nanoparticles and electric fields: physical, chemical, biological mechanisms and therapeutic prospects, *Advanced Drug Delivery Reviews*, (2018).
- [5] A.G. Roca, L. Gutiérrez, H. Gavilán, M.E. Fortes Brollo, S. Veintemillas-Verdaguer, M.d.P. Morales, Design strategies for shape-controlled magnetic iron oxide nanoparticles, *Advanced Drug Delivery Reviews*, (2018).
- [6] D.F. Costa, L.P. Mendes, V.P. Torchilin, The effect of low- and high-penetration light on localized cancer therapy, *Advanced Drug Delivery Reviews*, (2018).
- [7] D. Zhu, S. Roy, Z. Liu, H. Weller, W.J. Parak, N. Feliu, Remotely controlled opening of delivery vehicles and release of cargo by external triggers, *Advanced Drug Delivery Reviews*, (2018).
- [8] J. Son, G. Yi, J. Yoo, C. Park, H. Koo, H.S. Choi, Light-responsive nanomedicine for biophotonic imaging and targeted therapy, *Advanced Drug Delivery Reviews*, (2018).
- [9] L. Beauté, N. McClenaghan, S. Lecommandoux, Photo-triggered polymer nanomedicines: From molecular mechanisms to therapeutic applications, *Advanced Drug Delivery Reviews*, (2018).
- [10] A. Bordat, T. Boissenot, J. Nicolas, N. Tsapis, Thermoresponsive polymer nanocarriers for biomedical applications, *Advanced Drug Delivery Reviews*, (2018).

- [11] J. Liu, T. Lécuyer, J. Seguin, N. Mignet, D. Scherman, B. Viana, C. Richard, Imaging and therapeutic applications of persistent luminescence nanomaterials, *Advanced Drug Delivery Reviews*, (2018).
- [12] D.-K. Ji, C. Ménard-Moyon, A. Bianco, Physically-triggered nanosystems based on two-dimensional materials for cancer theranostics, *Advanced Drug Delivery Reviews*, (2018).
- [13] E. Cazares-Cortes, S. Cabana, C. Boitard, E. Nehlig, N. Griffete, J. Fresnais, C. Wilhelm, A. Abou-Hassan, C. Ménager, Recent insights in magnetic hyperthermia: From the “hot-spot” effect for local delivery to combined magneto-photo-thermia using magneto-plasmonic hybrids, *Advanced Drug Delivery Reviews*, (2018).
- [14] M. Piffoux, A. Nicolás-Boluda, V. Mulens-Arias, S. Richard, G. Rahmi, F. Gazeau, C. Wilhelm, A.K.A. Silva, Extracellular vesicles for personalized medicine: The input of physically triggered production, loading and theranostic properties, *Advanced Drug Delivery Reviews*, (2018).
- [15] U. Kauscher, M.N. Holme, M. Björnmalm, M.M. Stevens, Physical stimuli-responsive vesicles in drug delivery: Beyond liposomes and polymersomes, *Advanced Drug Delivery Reviews*, (2018).
- [16] H. Takahashi, T. Okano, Thermally-triggered fabrication of cell sheets for tissue engineering and regenerative medicine, *Advanced Drug Delivery Reviews*, (2019).
- [17] J.W.M. Bulte, Superparamagnetic iron oxides as MPI tracers: A primer and review of early applications, *Advanced Drug Delivery Reviews*, (2018).
- [18] S.M. Dadfar, K. Roemhild, N.I. Drude, S. von Stillfried, R. Knüchel, F. Kiessling, T. Lammers, Iron oxide nanoparticles: Diagnostic, therapeutic and theranostic applications, *Advanced Drug Delivery Reviews*, (2019).
- [19] M. Moros, J. Idiago-López, L. Asín, E. Moreno-Antolín, L. Beola, V. Grazú, R.M. Fratila, L. Gutiérrez, J.M. de la Fuente, Triggering antitumoural drug release and gene expression by magnetic hyperthermia, *Advanced Drug Delivery Reviews*, (2018).
- [20] S. Pinel, N. Thomas, C. Boura, M. Barberi-Heyob, Approaches to physical stimulation of metallic nanoparticles for glioblastoma treatment, *Advanced Drug Delivery Reviews*, (2018).