Light-driven soft matter systems: from light-powered DNA nanomachines and optogenetics to optofluidics and optical particle patterning

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We optically actuate various biological and synthetic systems by exploiting their intrinsic soft matter properties. Encoding structural information (DNA origami), biological function (encoded or conjugated protein) or physico-chemical reactivity (reagents, nanoparticles) in these systems allows us to regulate the resulting functionality in a robust, programmable and highly dynamic manner. For instance, we use photocontrol of DNA compaction [1-3] to regulate the activity of encoded [4,5] or conjugated [6,7] proteins while photoreversible DNA hybridization/melting is applied to control the assembly/disassembly of DNA nanostructures by light at a constant temperature [8]. In the presence of photosensitive surfactants, we optically modulate interfacial energies [9] to control the flow and mixing behaviors in microfluidic devices [10,11] (light-driven microfluidics [12]) as well as to manipulate discrete drops [9,13] (digital optofluidics) and liquid marbles [14]. We also use light to address particle deposition from evaporating suspension drops, therefore controlling the so-called coffee-ring effect [15] or guiding particles into desired patterns [16]. I will show how the simple visual inspection of a stain left after the evaporation of a drop containing proteins allows us to detect a pathogenic mutation, thus constituting a new concept for fast and low-cost diagnostics [17]. Finally I will show a highly original way to manipulate liquids with portable permanent magnets and without any magnetosensitive particles by exploiting a new concept we call "paramagnetofluidics" [18].

[1] A. Diguet, N. K. Mani, M. Geoffroy, M. Sollogoub, D. Baigl, ***Chem. Eur. J.*** **2010**, *16*, 11890
[2] A. Estévez-Torres and D. Baigl, ***Soft Matter*** **2011**, *7*, 6746
[3] A. Venancio-Marques, A. Bergen, C. Rossi-Gendron, S. Rudiuk, D. Baigl, ***ACS Nano*** **2014**, *8*, 3654
[4] A. Estévez-Torres, C. Crozatier, A. Diguet, T. Hara, H. Saito, K. Yoshikawa, D. Baigl, ***Proc. Natl. Acad. Sci. USA*** **2009**, *106*, 12219
[5] A. Venancio-Marques, Y.-J. Liu, A. Diguet, T. di Maio, A. Gautier, D. Baigl, ***ACS Synth. Biol.*** **2012**, *1*, 526
[6] S. Rudiuk, A. Venancio-Marques, D. Baigl, ***Angew. Chem. Int. Ed.*** **2012**, *51*, 12694
[7] L. Zhou, M. Morel, S. Rudiuk, D. Baigl, ***Small*** **2017**, *13*, 1700706
[8] A. Bergen, S. Rudiuk, M. Morel, T. Le Saux, H. Ihmels, D. Baigl, ***Nano Lett.*** **2016**, *16*, 773
[9] A. Diguet, R.-M. Guillermic, N. Magome, A. Saint-Jalmes, Y. Chen, K. Yoshikawa, D. Baigl, *Angew. Chem. Int. Ed.* **2009**, *48*, 9281
[10] A. Diguet, H. Li, N. Queyriaux, Y. Chen, D. Baigl, ***Lab Chip*** **2011**, *11*, 2666
[11] A. Venancio-Marques, F. Barbaud, D. Baigl, ***J. Am. Chem. Soc.*** **2013**, *135*, 3218
[12] D. Baigl, ***Lab Chip*** **2012**, *12*, 3637
[13] A. Venancio-Marques, D. Baigl, ***Langmuir*** **2014**, *30*, 4207
[14] N. Kavokine, M. Anyfantakis, M. Morel, S. Rudiuk, T. Bickel, D. Baigl, ***Angew. Chem. Int. Ed.*** **2016**, *55*, 11183
[15] M. Anyfantakis, D. Baigl, ***Angew. Chem. Int. Ed.*** **2014**, *53*, 14077
[16] S. N. Varanakkottu, M. Anyfantakis, M. Morel, S. Rudiuk, D. Baigl, ***Nano Lett.*** **2016**, *16*, 644
[17] S. Devineau, M. Anyfantakis, L. Marichal, L. Kiger, M. Morel, S. Rudiuk, D. Baigl, ***J. Am. Chem. Soc*** **2016**, *138*, 11623
[18] J. Vialetto, M. Hayakawa, N. Kavokine, M. Takinoue, S. N. Varanakkottu, S. Rudiuk, M. Anyfantakis, M. Morel, D. Baigl, ***Angew. Chem. Int. Ed.*** **2017**, *56*, 16565