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Abstract

Microswimmers for Biomedical Applications: Focus on Light †

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Microswimmers are microscopic objects that can move and perform tasks in liquid environments. Although only two decades have passed since their emergence [1], microswimmers have already attracted significant attention in the scientific world because of their many valuable potential applications. Among these, biomedical applications seem particularly promising, and many interesting studies have been performed already in vitro or even in vivo [2]. However, no microswimmers have so far been approved for clinical use, which is why ongoing research is often focused on clinical translation or relevant related issues such as biocompatibility. Different propulsion and control modalities are employed for microswimmers, including biohybrid, optical, magnetic, chemical, thermal or acoustic propulsion. Among these, our group focuses on the use of optical forces generated by manipulating light. For most intents and purposes, light is a biocompatible actuator. However, because of the limited tissue penetration depth, light is only suited for applications in superficial tissues of the human body [3]. On the other hand, light-controlled microswimmers can be employed for various laboratory studies relevant for biomedical research, such as cell manipulation, fluid viscosity characterization, or drug delivery. Furthermore, supplementing the use of light with that of, e.g., a magnetic actuator can help overcome the challenges encountered in the human body [4]. Light is a flexible actuator which can be tailored to the desired application. When it comes to light-controlled microswimmers, one option is to use focused near-infrared laser beams for optical trapping. This enables extremely precise manipulation of the microswimmers with six degrees of freedom. Another option is to use visible light to induce shape changes in light-responsive polymers in a controlled manner. Both options are interesting for biomedical applications and have characteristic advantages and challenges [5]. Designing and fabricating light-controlled microswimmers currently needs tailoring to specific applications, which often requires interdisciplinary teams of highly trained researchers [6]. Ultimately, gathering sufficient knowledge and overcoming the existing challenges in the field should enable the development of a toolbox of light-controlled microswimmers readily available for various biomedical studies.

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