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Engineered Microbots for Biomedical Applications

Mariana Medina Sánchez
IFW Leibniz Institute, Germany

Micro- and nanotechnologies together with the creation of new materials have facilitated the development of a variety of medical microbots, with low power consumption and certain degree of complexity. Such medical microbots are classified in three main categories, according to their propulsion mechanism: chemical, physical, and biohybrid.[1] The first group are the ones that employ cata-lytic materials which react with the microbot surroundings, forming sub-products which lead to their forward motion if the asymmetry in any of its forms is present. In this work, catalytic micromotors made by using two-photon lithogra-phy, with highly reproducible geometry, are presented as model structures to understand the different propulsion regimes which are present when varying parameters such as medium viscosity, microbot surface tension or fuel concentration. Physical microbots on the other hand need external physical sources to be actuated. For example, magnetic fields, light or acoustic waves. An application using magnetically driven helical micromotors is shown to capture, transport and release immotile but living sperm cells, to encounter one of the most common men infertility prob-lems, asthenozoospermia or reduced sperm motility.[2] Therefore, the proposed artificial flagellum is conceived as a sperm prosthesis to help sperm reach the oocyte. Finally, the third category, bio-hybrid microbots, are constituted by a biological and an engineered component to combine the advantages of both, such as the ability of cells to move through different taxis mechanisms (e.g. chemotaxis, rheo-taxis, thigmotaxis), their compliance which allow them to move in intricated and complex cavities and channels in living organisms, and their ability to sense their environment and interact with the surrounding biological tissues. On the other side, the engineered component is used to improve cargo-capacity, as contrast agent for imaging, to perform alternative operations such as micro-drilling, micro-grasping, or synthetic sensing, among others.[3] In this presentation, one of the most known bio-hybrid systems is presented, the so called spermbots or sperm-hybrid mi-crobots.[4]–[6] In this assembly, the sperm is motile and provide the whole system with a natural propulsion mecha-nism. The synthetic part is used for sperm guidance, release, and cargo-delivery of drugs. All of the above mentioned microbots have in common the engineered microparts which can also be functionalized with imaging reporters for further in vivo bioimaging, which is a key prerequisite to transfer this technology to in vivo settings. Thus, the use of different materials and structures is shown to improve their contrast and selectivity when visualized below biological tissues.[7] Other current challenges which still remain like microbots biocompatibility, multifunction, and adaptability will also be discussed.