Enzyme-powered nanomotors towards biomedical applications

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Bio-catalytic micro- and nanomotors are capable of self-propulsion in fluids due to the enzymatic conversion of substrates into products. [1,2] These structures have been focus of interest for biomedical applications, such as the active transport and delivery of cargoes to specific locations, as well as to modulate cell targeting and internalization phenomena. Here, we present fuel-dependent anti-cancer drug doxorubicin release and efficient delivery to cancer cells by urease powered nanomotors based on mesoporous silica nanoparticles,[3] as well as their potential to target bladder cancer cells in the form of 3D spheroids by anchoring anti-FGFR3 antibody on their surface. [4] We observed that these nanomotors propel in physiologically relevant fluids, such as PBS. Furthermore, we found a four-fold increase in anti-cancer drug doxorubicin release by nanomotors after 6 hours exposure to urea, compared to static particles. Moreover, active drug-loaded nanomotors present improved anti-cancer efficiency toward HeLa cells, which arises from a synergistic effect between enhanced anti-cancer drug release and generation of ammonia during bio-catalysis. We found that in the presence of urea, a higher content of anti-cancer drug is uptaken by cells after 1, 4, 6- and 24-hour incubations with active nanomotors, compared to static carriers. In addition, we anchored anti-FGFR3 antibody to the surface of urease-powered nanomotors to target 3D bladder cancer spheroids. These nanomotors are able to self-propel in both simulated and real urine. We observed that the internalization efficiency of antibody-modified nanomotors into the spheroids in the presence of urea was significantly higher compared with antibody-modified static particles or non-targeted nanomotors. Furthermore, cell proliferation studies indicated that targeted, active nanomotors induce higher suppression of spheroid proliferation compared with non-targeted nanomotors, which could be due to a synergistic effect between the inhibition of the fibroblast growth factor pathway by anti-FGFR3 antibody and the local production of ammonia by the active nanomotors. Altogether, these results point towards the applicability of urease-powered nanomotors as tools for enhancing disease detection and simultaneous treatment, by combining improved drug release and targeting functionalities.

References

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