3) Remotely-activated nanobombs for selective destroy of cancer tissues

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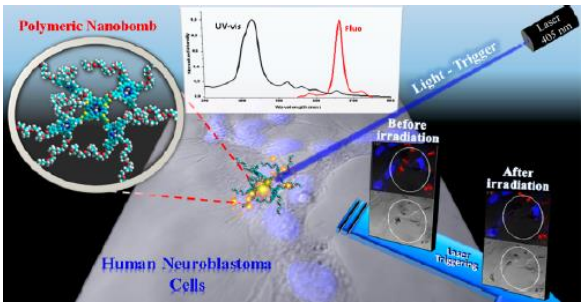
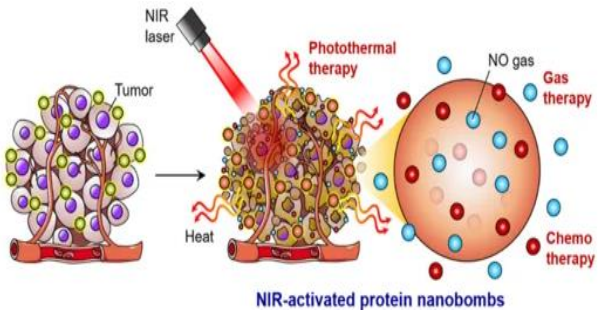
Cancer and other undesirable new-grown tissues can be selectively disrupt by the shock waves generated by nanobombs (photoacoustic, light-triggered polymeric, chemical or other types). The nanobombs can be delivered into the tissue and attached to the target cells by the receptor-mediated mechanism. Then the bomb can be activated by external laser or ultrasound irradiation or by fast chemical reaction inside the bomb. As a result, a strong point heat source appears and the heat wave accompanied by the pressure and flow waves propagates towards the cell membranes and disrupt them by both thermal and mechanical mechanisms. The force applied to the membrane must be estimated for more detailed calculations of the size and composition of the bomb(s) needed for guaranteed disruption of a tumor (or other undesirable tissues) without any significant influence on healthy tissues. Thermodynamics of the heat transfer, shock wave propagation at the nanoscale with high curvatures must be accounted for.

In this project, the student will familiarize with irreversible thermodynamics at the microscale and learn how the heat front and pressure shock wave propagates. The project will be carried out according to the following steps:

1. Classification of the nanobombes (composition, mechanism of activation, physical parameters, measured effects)
2. Problem formulation: wave equation for the heat/pressure propagation at nanoscale
3. Computations of the total entropy production across the front of the shock wave
4. Computations of the mechanical impact on the viscoelastic membrane
5. Biophysical applications of the results: numerical estimations of the mechanical and thermal damage for the cells/cellular structures of given geometry and material parameters.





Literature

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