Plasmonic Photothermal Therapy (PPTT) with Small Functionalized Gold Nanoparticles on Individual Ba/F3 Cells

Phillip Witthöft, Lisa Prisner, Christian Strelow, Tobias Kipp and Alf Mews

Institut für Physikalische Chemie, Universität Hamburg, Hamburg, Deutschland

The interest in plasmonic gold nanoparticles has strongly increased over the last decades because of their possible applications in several fields, for example in biological imaging. A precise control of the nanoparticles' geometry allows the tuning of the plasmonic resonant over a large electromagnetic range. In particular the development of one dimensional gold nanorods has yielded structures with resonances in the near infrared wavelength region, within the so-called biological window, for which tissue is essentially transparent. Thus these structures are of interest for many biological applications like sensing, diagnostics or hyperthermia.

Here we present results on the application of gold nanoparticles (Au-NPs) in hyperthermia on individual Ba/F3 suspension cells. Ba/F3 cells were incubated for 10 min with thiolated polyethylene glycol (PEG) functionalized spherical gold nanoparticles. To indicate cell death trypan blue was added to the cell solution. This biological dye can intercalate with the DNA if the cell membrane becomes permeable in the case of cell death. The cell uptake leads to blue coloration of the cell. Hyperthermia was induced in a plasmonic photothermal therapy (PPTT) experiment. For this purpose we established an optical setup that enabled us to adress individual cells with a focused laser beam with a spot size of about 20 µm and simultaneously perform corresponding wide field microscopy. The microscope image in Figure 1(A) shows three living Ba/F3 cells with a diameter of roughly 10 µm before laser irradiation. The green marked cell was then individually excited by the light of a laser with a wavelength of 532 nm. The micrograph in Figure 1(B) shows the same image section after laser irradiation. The irradiated cell changed its color indicating cell death. Control experiments without laser excitation and Au-NPs show that this is actually an effect of PPTT: The laser-excited plasmons induce local heat that initiates cell death.

Our setup provides the possibility to investigate laser excitation without delay time. It allows to distinguish between irradiated and non irradiated cells. This is of interest for the development of PPTT as a medical technique. Next step of our project is the application of gold nanorods as PPTT particles because of their plasmonic properties in the near-infrared wavelength region and thus the application in living tissue. Furthermore specificity between Au-NPs and cells can be achieved with a biological receptor ligand interaction. The specific binding or uptake by the cell determines the position of the plasmonic particles either on the cell membrane or inside the cell and thus will influence the PPTT efficiency.

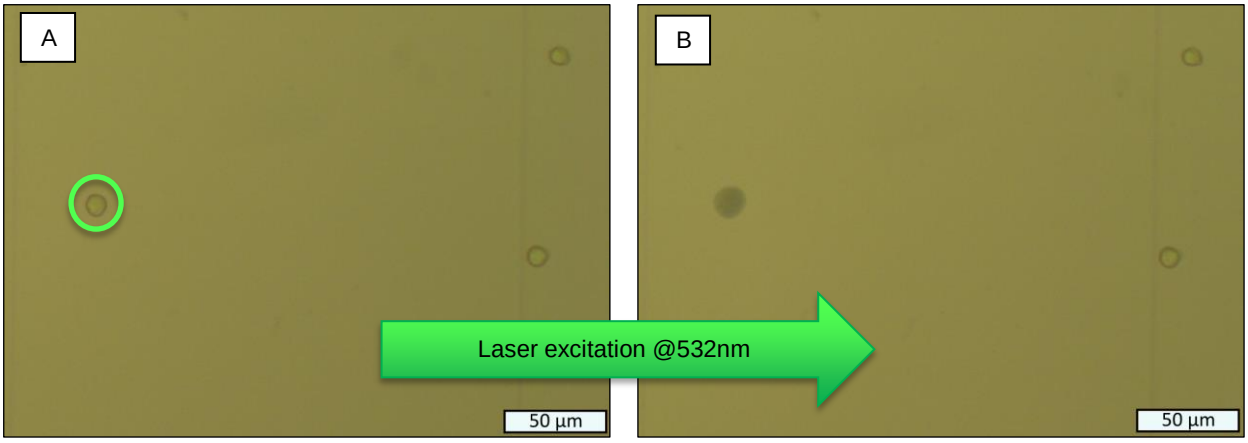

Fig. 1 (A) Light microscope image of three living Ba/F3 cells that were incubated with PEG functionalized Au-NPs. (B) Light microscope image of the same cells after excitation with a 532 nm laser at the green marked spot. The blue coloration of the cell indicates cell death while cells which stay outside the laser spot remain alive.