Detecting Neurotransmitters Using Resonant Nanoparticles

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Abstract—Resonant gold nanoparticles (nanorods) are functionalized with a neurotransmitter’s receptor and their absorption spectra are measured before and after binding to the neurotransmitter. The observed 7 nm redshift in their absorption peak is promising for brain activity mapping.

1. THE IDEA AND THE PRELIMINARY RESULTS

The proposed concept in this project is to detect neurotransmitters using resonant nanoparticles functionalized with appropriate receptors. Fig. 1 depicts the proposed idea schematically. The sparsely released neurotransmitter in the extra-synaptic region of a neuron is to be detected optically by means of the reflection spectroscopy [1]. Biding neurotransmitters to the coated nanoparticles are expected to change their reflected/transmitted spectrum detectably.

In order to confirm the concept, gold nanoparticles were coated with anti-glycine, which acts as a receptor for glycine neurotransmitter. Then, neurotransmitter was added to the solution and its effect on the absorption spectra was measured using a photo-spectrometer. Fig. 2 shows the absorption spectra of bare nanoparticles, as well as nanoparticles coated with the receptor, with and without the added neurotransmitter. The absorption spectra were normalized as we only rely on the frequency shifts which are least sensitive to the concentration. The nanoparticles used in Fig. 2 were gold nanorods with aspect ratio 3 and diameter 25 nm. The observed 7 nm red-shift of the spectrum, after binding the neurotransmitter, confirmed the proposed approach. However, the redshift could be enhanced by choosing nanoparticles with higher resonance quality factor. This leads to a stronger localized electric field around the nanoparticle and makes it more sensitive to its surrounding materials [2]. It is straightforward to show that, in nanorods, a higher aspect ratio will lead to a higher resonance quality factor.

The same experiment was done using nanospheres with diameter 80 nm and dopamine as the neurotransmitter. A red shift of 1 nm was observed after adding the neurotransmitter which is lower than the nanorods due to the lower quality factor. We used commercially available gold nanoparticles from Nanopartz Inc. (both spheres and rods) to keep the experiments reproducible. The nanoparticles were then coated with anti-dopamine and anti-glycine from abcam company which was cleaned using abcam antibody cleaning kit.

We determined the concentration using Bradford assay and then we conjugated anti-dopamine antibodies with nano-rods bought from Nanopartz Inc. using their established protocol. We also confirmed the experiment with several nano-spheres from a different company (Innova Biosciences). The shifts in nano-spheres smaller than 80nm appeared to be too small for detection.

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REFERENCES
