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Gold Nanorods as Potential Contrast Agents for Ocular Optical Coherence Tomography

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Abstract – Gold nanorods (NRs) are appealing candidates for spectral domain optical coherence tomography (SD-OCT) imaging of the eye because they can be designed to be backscattering at the same wavelengths (near-infrared) that are used in commercial SD-OCT ophthalmic devices. The goal of this study was to engineer scattering gold NRs suitable for enhancing contrast between structures of interest in the eye. We injected these scattering gold NRs into the vitreous of C57Bl/6 mice and imaged them using SD-OCT at various time points post injection. An increase in backscattered intensity was seen in the vitreous after injection using SD-OCT detection.

Optical coherence tomography (OCT) is a technique for acquiring optical biopsies of tissue in vivo and noninvasively; optical detection is based on the principle of backscattering interferometry. OCT is used to obtain optical cross-sections of the retina and optic nerve in order to evaluate the extent of tissue changes caused by diseases such as glaucoma. There have recently been improvements in image resolution afforded by the introduction of spectral domain OCT (SD-OCT) imaging. However, there remain specific structures within ocular OCT images, such as retinal ganglion cells, that are of interest to clinicians but consistently have low contrast.

Gold nanorods (NRs) are an appealing candidate for optical imaging because gold is mostly an inert immunologic compound and because gold NRs exhibit the surface plasmon resonance (SPR) phenomenon. SPR is the collective excitation and coherent motion of conduction band electrons in the presence of an electromagnetic field [1]. The NR aspect ratio (length divided by width) influences the resonant frequency of nanorods and this can be customized to be at or near the center wavelength of an OCT light source. Our goal was to engineer backscattering gold NRs suitable for enhancing contrast between structures of interest in the eye in SD-OCT images.

Gold NRs were grown using a well-established seed-mediated surfactant-directed synthesis (Figure1) [2], and an aspect ratio of ~4.5 was chosen to maximize the SPR response at the wavelengths used in our SD-OCT system (λ_{spr} = 840nm). NRs were coated with 1% PAA, 0.2 M (*N*-ethyl-*N'*-(3-dimethylaminopropyl) carbodiimide) EDC and 100µl of 0.2M (*N*-hydroxy-succinimide) NHS [3]. An intravitreal injection of 2 µl of the NR solution was administered to a healthy adult male C57Bl/6 mouse; a sham intravitreal injection of 2 µl of phosphate buffered saline (PBS) was administered to a separate male C57Bl/6 mouse. Raster SD-OCT images of the retina were acquired before and after injection using the same scanning protocol (Bioptigen, Inc; Research Triangle Park, NC; 250x250 A-scans, 1.5x1.5 mm area). Using SD-OCT imaging, we were able to observe a localized increase in reflectivity in the mouse eye after an intravitreous injection of NRs (Figure 2).

Figure 1: Transverse electron microscopy image of gold nanorod solution

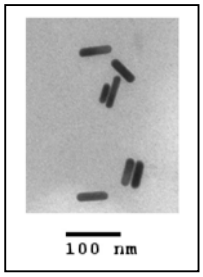
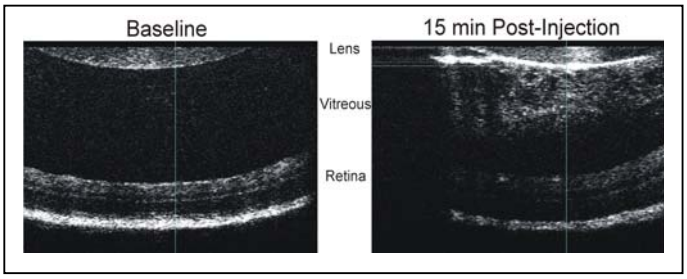


Figure 2: SD-OCT image of the mouse lens, vitreous and retina before (left) and after (right) a 2µl NR vitreous injection.



References:

1. Link S and El-Sayed MA. Optical properties of ultrafast dynamics of metallic nanocrystals. Annu. Rev. Phys. Chem. 2003;54:331-66.
2. Nikoobakht B and El-Sayed MA. Preparation and growth mechanism of gold nanorods using seed-mediated growth method. Chem. Mater. 2003; 15:1957-1962.
3. Kim K, Agarwal A, Huang SW, Denny MF, Kaplan MJ, Ashkenazi S, O'Donnell M, Kotov NA. Photoacoustic imaging of early inflammatory response using gold nanorods. Appl. Phys. Lett. 2007; 90,223901.