Optical Coherence Tomography as a Research Tool for Biomaterials

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INTRODUCTION: Optical Coherence Tomography (OCT) is an imaging technique based on a Michelson's interferometer that allow penetration up to 3 mm in biological media. It fills the gap between confocal microscopy and ultra-sound imaging. The applicability of Fourier-domain optical coherence tomography (FD-OCT) for probing of different biological materials to allow for real-time imaging is demonstrated. The advantages of 3-D imaging and non-destructive imaging are shown.

Optical coherence tomography (OCT) combines broad bandwidth near-infrared probe light and fiber-optic interferometry to probe optically opaque samples in reflection or backscattering mode and affords generating micron-scale resolution 2-D and 3-D spatial maps of various specimen microstructures without staining or chemical treatment[1]. In-situ non-destructive, non-invasive and non-contact probing is a major offering of OCT unlike routine optical methods often requiring extensive and costly sample preparation including mechanical sectioning. FD-OCT is the current generation of OCT instruments employing a high-speed wavelength-swept near-infrared laser probing light source, a spectrometer and Fourier transformation algorithms to generate depth-resolved 2-D images of the specimen under evaluation within a shorter period of time.

METHODS: In this study a commercial FD-OCT (Model OCM1300SS) by Thorlabs Inc., USA was used. This system has the following performance specifications: 1300nm centre operating wavelength, a 110nm 3dB spectral bandwidth, transverse spatial air resolution of 15-um, a depth spatial air resolution of <20 um, a probing depth of 3mm in air, >25mm working distance and acquisition time of 30 seconds for a sample volume measuring 512 pixels (L) by 512 pixels (W) and 512 pixels (D). Images of the samples were acquired as positive grayscale images. Strongly backscattering microstructures appear lighter (high signal intensity regions) while darker areas indicate weaker backscattering locations (low signal intensity regions). The imaging resolution of the system was verified with a USAF resolution target from Edmund Scientific, USA.

Abdominal skin samples of a euthanized, 32 days old Wistar rat were monitored over a 15 days. The samples were stored in a CO_2 incubator at 37°C in Eagle's minimal essential medium and just removed for imaging each day. The 3-D capability of the system is illustrated with an image of a moth and a PNIPAAm scaffold sample (experimental scaffold for growing cells).

RESULTS: Figure 1 shows the sectioning images through the rat skin (X-Z Plane). The degradation of the skin is clearly visible when the sample on day 4 is compared to that of day 15. A 3-D image of a moth is shown in Figure 2a and Figure 2b is the 3-D image of a PNIPAAm scaffold sample.

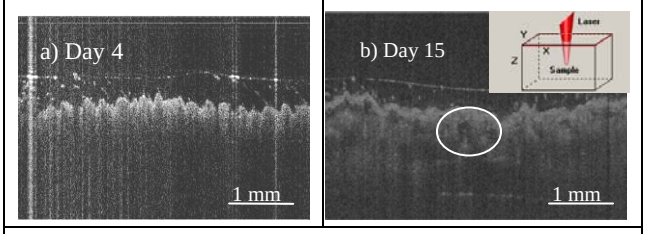

Fig. 1: OCT images of the degradation of rat skin over a 15 day period.

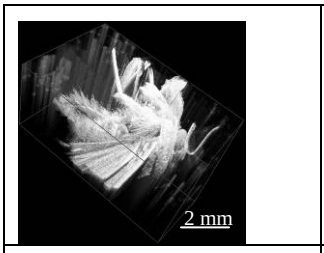

Fig. 2a:3-D OCT image of a moth.

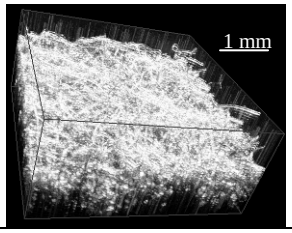

Fig. 2b:3-D OCT image of PNIPAAm scaffold.

DISCUSSION & CONCLUSIONS: The results in Figures 1 and 2 show that it is possible to image sub-dermal changes in the structure of the skin samples as well as sub-surface structures. This imaging technique has proven to be a versatile non-invasive imaging tool for biological materials.

REFERENCES: [1]Mather ML (2007), Morgan SP, Crowe JA, *Regenerative Med*. **2(2)**:145-160.

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