Accelerated aging and electrochemical characterization of Parylene C coated implantable microwires

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ACHIEVING long term reliable recordings from neural tissue via implantable electrodes [1] is a major barrier for clinical translation of brain machine interfaces. One of factors affecting the performance of implantable electrodes is the integrity of the insulation coating protecting the underlying device from the *in vivo* environment. Parylene C, owing to its biocompatibility and pinhole free coatings, is a common choice of insulation for neural interfaces. Here we report preliminary investigations to test the integrity of Parylene C as coating for implantable Pt/Ir microwires (75 µm diameter). The samples (n=6) were age accelerated and characterized electrochemically using impedance spectroscopy (50 mVpp, 10 mHz-50 kHz) and leakage currents were measured with 5 V DC bias. The setup involved a two-electrode cell with AgCl as the reference and looped Parylene C coated microwires as the working electrode, immersed in phosphate buffered saline (pH 7.4) held at 60 ºC. The microwires were looped to avoid exposure of the tip to the electrolyte while keeping the bending radius of the large enough (~ 4 mm) to avoid any mechanical duress to the coating. The metrics used to define insulation failure were derived from the literature [2][3]. Within the first 4 days of testing, 30% of the samples failed, while remaining samples survived the 1 month test period. Here intact coatings maintained high impedances and DC leakage currents below 1 nA over the 1 month study period. The failed coatings show a decrease in impedance, increase in phase angles from –80° (frequency>1Hz) and DC leakage currents above 1 nA, indicative of electrolyte penetration through the coating. Surface characterization via scanning electron microscope (SEM) revealed micro cracks along the surface of the Parylene C coating (figure1). Initial changes in the low frequency (< 1 Hz) impedance reflected the decrease in the insulation resistance and increase in capacitance due to electrolyte penetration. Exposure of the underlying metal decreases the mid frequency (1- 100 Hz) impedance as presented by failed electrodes with microcracks. Thus, we compared the impedance measured at the lowest frequency (0.1 Hz) with that of 1 kHz, a commonly used metric to evaluate that the ability of a recording electrode to measure neuronal action potential [4], as well as the performance of encapsulation for neural interfaces [5]. It is important to recognize that the failures of Parylene C coating on microwires were not observed in the 1 kHz impedance modulus (figure 2). A reduction in the 1 kHz impedance of failed microwires was observed when the 0.1 Hz impedance decreased below 10 MΩ. These results offer insight into the lifetime and mechanisms of insulation failure on implantable microwires.

Figure 1: SEM image of microwire (Pt/Ir 75 µm) with micro cracks on the surface of Parylene C coating.

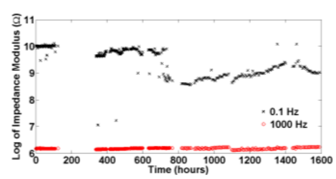

Figure 2: Impedance modulus over 1,600 h at 0.1 Hz and 1 kHz of microwire (Pt/Ir 75 µm) kept at 60 ˚C showing decrease in low frequency impedance over time, while at 1 kHz it remains stable. Electrode failed at 700 h.

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