Development and characterization of bioelectronic devices using shape memory polymers with tunable degree of softening as substrates

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We want to understand how a key material property, stiffness, influences the robustness of implantable neuroprosthetic technology. The central hypothesis is that intracortical probes that soften within the brain, exhibit an improved tissue response and enhanced performance in chronic single unit recording.
The base materials used in traditional devices for neural interfaces are significantly stiffer (1-100 GPa) than brain tissue (1-40 KPa). The mechanical mismatch that exists between the flexible bioelectronics and the surrounding tissue often results in an acute inflammatory response. A new generation of responsive, softening neural interfaces address the problems caused by this mechanical mismatch. Recently, the Voit group has developed thiol-ene/acrylate polymer networks as substrates for softening neural recording electrodes. [1] The benefit of these stimuli-responsive polymers is that they are rigid during insertion but become elastomeric during use. In other words, devices based on these materials undergo softening from the glassy to the rubbery state in response to a stimulus such as temperature and humidity, or a combination of these stimuli. Now, we went one step further and designed a set of thiol-ene/acrylate polymers with tunable stimuli-responsive properties to quantitatively compare the tissue response and recording performance of novel intracortical probes which differ only by their degree of softening.
In Addition, when using biomedical devices *in vivo*, it is necessary to sterilize them without altering their thermomechanical properties. Therefore, we examined the effects of various sterilization methods including autoclave, UV and ethylene oxide on the thermomechanical properties of stimuli-responsive thiol-ene/acrylate polymers. [2] The use of immersion DMA allowed thermomechanical testing of polymers in dry states as well as in physiological solution such as PBS, mimicking *in vivo* conditions.
It was found that sterilization with ethylene oxide gas is the most appropriate one among the tested. The softening capability of the SMP test devices was not affected, as demonstrated by the significantly decreased glass transition temperatures after being immersed in PBS. In contrast to prior studies, all measurements were performed on polymer films having the same thicknesses as implantable devices (~30 µm). Thus, the thermal and mechanical properties were recorded the first time under representative conditions.

[1] Ware, T.; Simon, D.; Liu, C.; Musa, T.; Vasudevan, S.; Sloan, A.; Keefer, E. W.; Rennaker, R. L., II; Voit, W. *J. Biomed. Mater. Res. Part B* **2014**, *102*, 1.

[2] M. Ecker, V. Danda, A. J. Shoffstall, S. F. Mahmood, A. Joshi-Imre, C. L. Frewin, T. H. Ware, J. R. Capadona, J. J. Pancrazio, W. E. Voit, *Macromol. Mater. Eng.* **2017**, *302*, 1600331.