

Characterization of Polymer Substrate for Biointerfacial Characterization *In-vivo*.

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Introduction

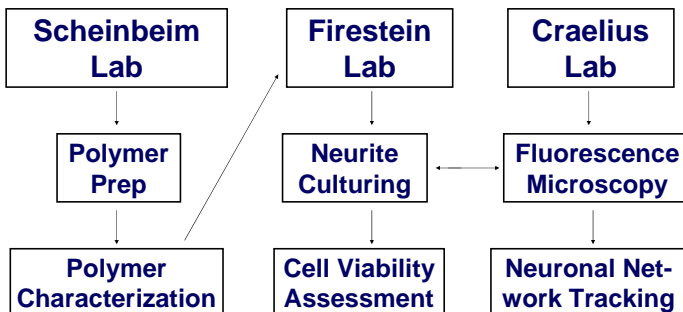
Only a handful of materials approved for implantation in the human body by the FDA have the unique property of being both completely *bioresorbable* and *piezoelectric*. Poly-L Lactic Acid (PLLA) is currently used in several varieties of implantable structures, implant coatings, and as an injectable wrinkle filler and treatment for hypo-lipoatrophy in AIDS patients.

PLLA's piezoelectric properties make it uniquely suited for use as an implantable biointerface for registration of neuromuscular activity. PLLA conduits are currently used as a substrate in nerve regeneration in spinal cord injury (SCI) and may be doped with an electro-active dye for tracking nerve growth *in-vitro*.

The present work describes work done under the NSF IGERT: Integratively Engineered Biointerfaces Traineeship, conducted concurrently in the Departments of Biomedical Engineering, Chemical and Biochemical Engineering, and Cell Biology and Neuroscience at Rutgers University. The project aims to characterise PLLA's piezoelectric behaviour as a function of preparation, and evaluate nerve growth on the polymer substrate.

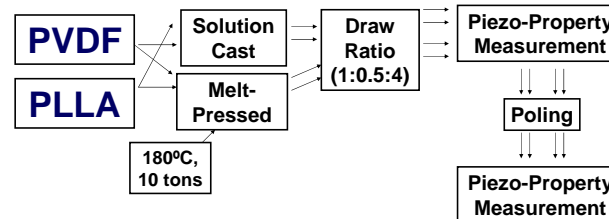
Experimental Design

Evaluation of the PLLA must run in 2 distinct phases: polymer preparation and evaluation; and in-vitro culture assay. In addition, parallel assessments of polymer- and culture system fluorescence will be run between all the labs to evaluate nerve-tracking modalities.



Polymer Preparation and Characterization

Introductory work has been done with both 2% PLLA and Poly-Vinylidene Fluoride. Pellets of PLLA were low-temperature impacted for 30 minutes at 2:2:2 (pre-cool, run, cool), into a fine powder, and sheets of PVDF were solution-cast onto a glass plate with Di-Methyl Fluoride (DMF). PLLA and PVDF samples were partitioned into 2 groups each: solvent-cast and melt-pressed, and are currently being evaluated for piezoelectric constants at various draw ratios and poling values.



Draw ratios range from 1 (original length) to 4 in half-length increments. Measurement of the piezoelectric properties both before and after corona poling is necessary to understand how to optimize the piezoelectric properties of the substrate: how much of the piezo-nature is due to the stretching, and what proportion is due to the poling?

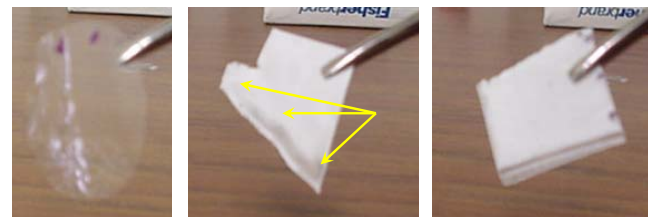


Figure: Films resulting from various prep methods: Melt-Pressed at high-temperature, high-pressure; solvent-cast film pressed at high-pressure for 1 hour (highlight of plastic deformation); solvent-cast film.

Polymer preparation methods with fluorescent dye are a point of interest, as the films have exhibited strikingly different composition in the initial run: doping of the PVDF with Di-4 ANEPPS yielded dissimilar results.

Fluorescence Microscopy



Figure: Effect of preparation on dye distribution and homogeneity: Solvent-cast and Melt-Pressed Film.

Solvent-cast films: thick, non-homogenous in thickness, opaque
Melt-pressed films: clear and uniform in thickness.

It is possible that the solvent-cast films did not sit in the DMF long enough to break apart the crystalline super-structure of the dye, forming a co-crystal structure, whereas the melt-pressed films were under intense heat and pressure which broke apart the crystals and dispersed them evenly.

-Controls will have to be run to ensure that the polymer isn't simply auto-fluorescing.

-Nerves growing on piezoelectric substrate doped with electroactive dye may yield **novel nerve-tracking methodologies** due to the field effects exerted by the growing nerves.

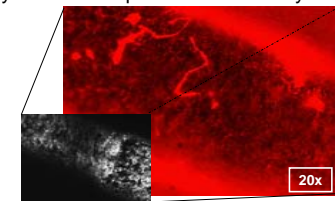


Figure: Solvent cast film exhibiting plastic deformation under the stretcher clamp: Bright Field and Fluorescence view.

Discussion

PLLA hydrolyzes to lactic acid, and thus is not only novel in its piezoelectric properties, but also because it is completely bioresorbable. By characterizing the material's behavior in response to mechanical stimuli, it may be possible to devise an implantable biointerface for the existing Myokinetic Interface technology for registration of muscular activity. Additionally, the polymer makes an attractive substrate for nerve regeneration *in-vivo* and *in-vitro* tracking of neuronal network tracking.

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