Applications and Materials for Magnetohydrodynamic Microfluidics

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Background/Relevance

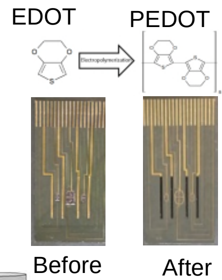
- Magneto hydrodynamics (MHD) as a pumping system, enables the ability to detect and follow the effect of treatment and improve accessibility of and decrease cost of healthcare through microfluidics.
- MHD follows the right hand rule **Force_{MHD}** = **current** X **magnetic field.**
- PEDOT(Poly 3,4-ethylenedioxythiophene) improves electrical response.
- PEDOT morphology can be modified by changing solvent and electrolyte increasing current and charge capacity creating a better pumping system allowing for longer operational time without need to recharge the film.

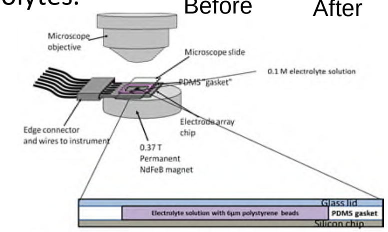
Innovation

- Conducting polymer as redox species
- Improve polymer electrochemical properties through different electrodeposition conditions.

Approach

- Deposit PEDOT onto gold electrodes using cyclicvoltammetry while varying deposition parameters
  - Used acetonitrile and propylene carbonate (PC) as solvents, and $LiClO_4$ and $TBAPF_6$ as electrolytes.
- Characterized modified electrodes using chronoamperometry (CA)
- MHD study using chronopotentiometry.
  - Particle image velocimetry software used to determine velocity profile.





MHD experiment setup. [Nash. C. K Modified-Electrodes for Redox-(MHD) Pumping for Microfluidic Applications. Ph D. Dissertation, University of Arkansas, Fayetteville, AR 2014)

Key Results

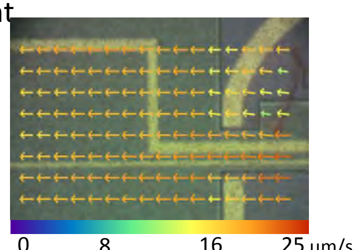
- Electrodeposition from PC and $LiClO_4$ provides maximum charge density.
- Increased scan rate during deposition decreases current density.
- PEDOT film is more stable in aqueous solution than in organic solution.
- Able to maintain flow rate above 20 µm/s for more than 200 s at 30 µA applied current, longer than previous attempts (75 s).

PEDOT Deposition Solution	Current Density A/m^2 (85% PBS and 15% glycerol)	Charge Density mC/cm²	Current Density A/m^2 (0.1 M NaCl)	Charge Density mC/cm²	Current Density A/m^2 (PBS)	Charge Density mC/cm²
0.1 M $LiClO_4$ in Propylene Carbonate	655 ± 4	75.7 ± 0.6	1005+ ± 23	118.7 ± 7	1797 ± 264	92.7 ± 4.5
0.1 M TBAPF6 in Propylene Carbonate	880 ± 1.8	54.2 ± 0.1	1167 ± 2	57.7 ± 0.1	2631 ± 8	67.0 ± 4.8

Current and charge response for PEDOT film deposited from PC with $LiClO_4$ or $TBAPF_6$ as electrolytes.

Conclusions

- PEDOT deposited from propylene carbonate and $LiClO_4$ can be effectively used as an immobilized redox species for use as an effective MHD pumping system.
- Films produced from propylene carbonate have higher stability.
- The use of an organic solvent has significant current and charge density improvements over water. This means MHD pumping can produce faster velocities and pump fluid farther.
- Future work: Optimize pumping system for use with cell cytometry and other lab-on-a-chip applications.



Average flow velocity during MHD study with 30 µA applied current and 0.37 T magnetic field.

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