INCREASING CONDUCTIVITY OF ALGINATE – CARBON NANOTUBES HYDROGELS THROUGH INDUCED ALIGNMENT

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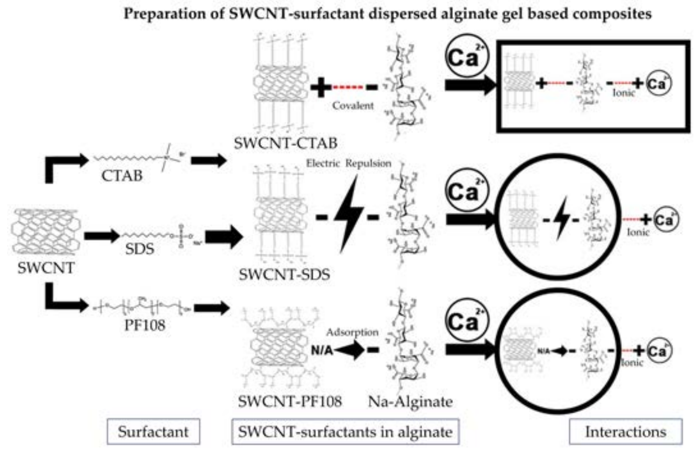
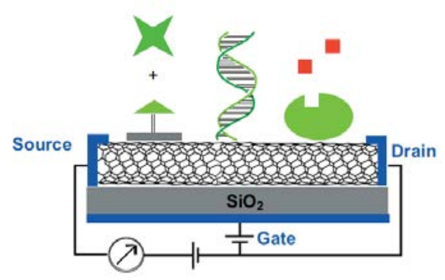
Background

- Alignment of CNTs
  - Current density is anisotropic
    - Greater conductivity observed laterally along the CNTs, than transversely [1]
  - Large magnetic flux densities are necessary to align tubules due to CNTs paramagnetic properties [2]
- Alginate (ALG) – Single Walled Carbon Nanotubes (SWCNTs) Hydrogels
  - Biocompatibility was successfully observed with cardiomyocytes for Pluronic F108 – Alginic Acid crosslinked with CaCl2 hydrogel composition [3]

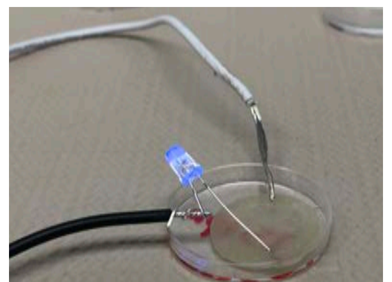


- Biosensors
  - Carbon Nanotubes Field- Effect Transistors (CNFETs) have been created using SWCNT's as receptor binding for detection of proteins, DNA hybrids, and cancer markers [4]



Methods

- Determination of conductivity across ALG – SWCNT's hydrogels crosslinked with Calcium Chloride ($CaCl_2$)
  - A 25 mm hydrogel disk displayed sufficient current flow to allow the operation of a blue LED (Forward voltage: 2.5 – 3.7 V)
  - Multimeter measured 300 mV across circuit



- Based on Maxwell's Equation – Faraday's Law of Induction, an inductor/ solenoid was created for the purpose of generating a magnetic flux within an aqueous solution

$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$$

Results

Figure 1. Primary system to induce a magnetic field based on Faraday's Law of Induction, within the central area of a solenoid. Composition of the solenoid operator system was constructed based on schematic below, having a potentiometer to control the allowed current across the inductor/solenoid. Measurements of the magnetic flux demonstrated preliminary recordings of up to 1Tesla.

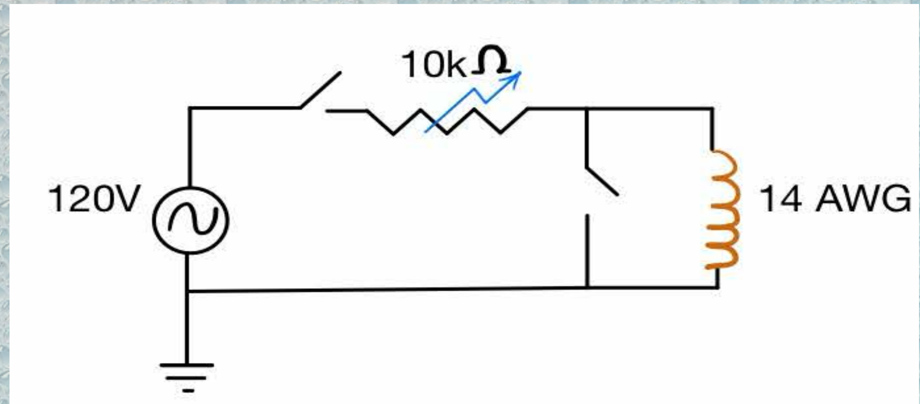


Figure 2. Secondary system designed with neodymium magnets to obtain alignment of SWCNT's within a medium through the reorientation of their magnetic dipoles.

Figure 3. Halbach array of neodymium magnets aligned SWCNTs in fragmented depositions within a water solution due to reorientation along the greatest magnitude of magnetic flux generated across the magnets.

Conclusions

- Even through an unaligned dispersion of SWCNTs, conductivity is observed, sufficiently to power low voltage components
- The solenoid model was able to demonstrate a significant magnetic field (~1T), sufficient for a small area required for hydrogels
- Neodymium magnets have the ability to control the alignment of SWCNTs, allowing manipulation even in dispersion of a medium

Future Directions

- Crosslink SWCNTs in Alginate medium to obtain static reorientation
- Construct a hybrid solenoid with neodymium magnets to allow proper reorientation of SWCNTs into wires
- Assess the conductivity across three functionalization of CNTs
  1) Alginate – SWCNTs (nonaligned)
  2) Alginate – SWCNTs (aligned)
  3) Alginate – Multiwalled CNTs (aligned)

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Acknowledgments

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