Analyzing memcapacitive and memristive capabilities of lipid and polymer bilayers for use in smart materials

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Background
Neuromorphic engineering is the practice of creating software and hardware computing systems that mimic the connectivity and adaptivity of neurons and synapses in the brain. The goal of this approach is to enable computing technologies that are both reconfigurable and capable of co-located processing and memory, features that make the brain very efficient at computation. [2]

Research Objectives:
1. Quantify memcapacitance for polymer bilayers in different oil and medium with input signals of varying amplitudes and frequencies.
2. Demonstrate the reconfigurability and adaptability of a neuron using a biomolecular memristor.

Testing Memcapacitance in Polymer Bilayers
Memcapacitance was measured using a non-adhesive bilayer formed from the tri-block copolymer PEO-PDMS-PEO. A sine wave voltage with triangle wave overlaid were run through the bilayer and the output current was recorded.

Using a Biomolecular Memristor as a Neuron Synapse
Adhesive bilayers with the protein alamethicin were used to create a voltage-dependent gated membrane. Voltage pulses were sent through the membrane and the resulting current was amplified and converted to a voltage using a gain stage circuit before being sent through a solid-state neuron circuit.

Discussion and Conclusion
Output current was recorded and processed in MATLAB.

Decane and hexadecane oils were used to test memcapacitance in a PEO-PDMS-PEO bilayer. The charge vs. voltage plots for both oils showed clear hysteric curves, indicating memcapacitance. For identical input conditions, an increased area in the QV curve is apparent on the decane curve.

The alamethicin voltage-gated bilayer was tested in hexadecane with varying gap lengths between pulses.

Future Directions
The next step for characterizing memcapacitance is to define the state variables of the bilayer that cause changes in area of the QV curve. The next step in creating a biomolecular memristor-based neuron is to determine pulse and gap widths for ideal firing rate.