# Redox-active Interface for Flow Batteries (2019-014)

An electrode designed for increased reaction rate and energy storage capacity in flow cell batteries

## Market Overview

Electricity currently comprises half of the energy that is generated and supplied globally, but energy consumption is steadily on the rise as populations burgeon and industrialize. Global industrial applications primarily use fossil fuels, which produce 86% of the world's total electricity. However, high carbon emissions are causing a global concern regarding the negative environmental impact of how we power society. Advancements in the development of renewable energy are shifting demand towards more sustainable, safer fuels. But renewable power is often derived from intermittent natural processes, such as wind, water, or solar energy. As such, efficient energy storage is necessary to capture, retain, and distribute this generated power on demand. Current storage systems include redox flow batteries, but these are frequently inefficient and cannot handle large power volumes. Clemson researchers have developed a novel interface to accelerate liquid-solid transfer reactions within redox flow batteries, offering advanced energy storage, extended power capacity life cycles, and efficient and affordable operation.

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## Technical Summary

This process uses unpurified carbon nanotubes, which means iron nanoparticles are left in the electrodes from the synthesis process. This provides the technology with its inherent technical advantages while also eliminating a costly production step. The kinetical advantage stems from coupling these nanoparticles with an iron electrolyte, and this "electrochemical pairing" of two similar redox materials, one in the liquid and one in the solid state, drastically increases the rate of charge transfer at the electrode-electrode interface. In order to store or access a charge, electrons must pass through the solid-liquid interface in the battery, and this is the rate limiting step for charge transfer. The addition of the redox mediator acts as a catalyst to promote charge transfer, leading to improved power density (faster charging and discharging).

### Application

Redox flow batteries,
Electrochemical gas sensors,
Micro fuel cells

### Development Stage

Proof of Concept

### Advantages

- Electrochemical pairing of redox materials drastically increases rate of charge transfer, leading to improved power density
- Utilize carbon nanotube electrodes, leading to improved conductivity
- Utilize unpurified carbon nanotubes, removing a costly step in nanotube synthesis
- Modified electrodes generate nearly 10x the typical level of power density

| App Type | Country | Serial No. | Patent No. | CURF Ref. No. | Inventors |
|---|---|---|---|---|---|
| Provisional | United States | 63/006,771 | NA | 2019-014 | Dr. Mark Roberts |

## About the Inventors

### Dr. Mark Roberts

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Dr.Mark Roberts received his B.S. from Montana State University in 2002, and his M.S. from Stanford University in 2005. He continued his education at Stanford, graduating with his Ph.D. in 2009. His research is focused on developing functional polymers with unique electronic and electrochemical properties for an array of electronic systems, from electrical energy storage devices to chemical sensors.

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