

# Electrode and Electrolyte Materials for Li-ion Batteries (09-009)

Improved Materials for Li-Ion Batteries that Enable Higher Power and Higher Charge Capacity

## Market Overview

These solid state Li-ion battery materials utilize large electropositive cations in the formation of transition metal phosphate frameworks, resulting in electrode materials with the ability to store more charge and deliver higher power outputs. The demand for highpower batteries for mobile devices and automotive applications is continually growing, with a shift towards cleaner and more efficient fuels and power options. Reflective of this demand, the Li-ion battery market has an estimated worth of \$29.98 billion and is expected to more than double in the next 10 years. Clemson University researchers have engineered a method of creating new Li-ion battery materials, developing new cathode materials with improved charge and discharge characteristics. Another component is the open-framework solids that possess superior ion transport properties pertinent to the electrochemical performance of next-generation electrode materials for battery devices.

## Technical Summary

This technology consists of new strategies for the synthesis of a novel family of electrode and electrolyte materials possessing enhanced capacities useful for primary and secondary battery device applications. The general formula is  $A_xM(XO_z)_n$ , whereas A = monovalent alkali metal cation and silver; M = first-row transition metal cation; X = P, As, V. The strategy employed for the synthesis of  $Ag^{+}$ -based cathode materials deals with the incorporation of transition metal cations possessing multiple oxidation states comparable with reduction potentials of  $Ag_2V_4O_{11}$  (SVO). SVO is a state-of-the-art commercial material for the highrate/power primary Li-ion battery applications in medical devices such as implantable cardioverter defibrillators (ICDs). The new materials have extended capacity at  $\sim 3$  V due to the reductions of  $Ag(1^{+})$  to  $Ag(0)$  and  $M(n^{+})$  to  $M(m^{+})/Mn^{+}$  ( $n = m + a$ ,  $a \geq 1$ ). For the secondary battery materials, the use of combined solid state and soft (ion-exchange) chemistries facilitates the development of new openframework solids that otherwise cannot be isolated via direct synthesis. Additionally, these materials exhibit facile ion-transport.

### Application

Automotive batteries for hybrid/electric vehicles, portable electronics, medical devices

### Development Stage

Functional Prototype

### Advantages

- Novel synthesis of materials allows for more targeted development, creating batteries to meet specific applications.
- The cathode materials have superior properties compared to current Li-ion phosphate materials, delivering higher power and storing more charge.

App Type	Country	Serial No.	Patent No.	CURF Ref. No.	Inventors
Utility	United States	13/201,238	9,077,037	09-009	Dr. Shiou-Jyh Hwu

## About the Inventor



### Dr. Shiou-Jyh Hwu

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Dr. Shiou-Jyh Hwu received his Ph.D. in Chemistry from Fu-Jen Catholic University in 1978 and a Ph.D. in Inorganic Chemistry from Iowa State University in 1985. Prior to his career at Clemson, he conducted postdoctoral research in materials chemistry and superconductivity at Northwestern University and served on the faculty at Rice University. His research interests pertain to extended solids containing magnetic nanostructures, porous and polar solids via salt inclusion synthesis, and extended solids with periodic arrays of quantum dots.

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