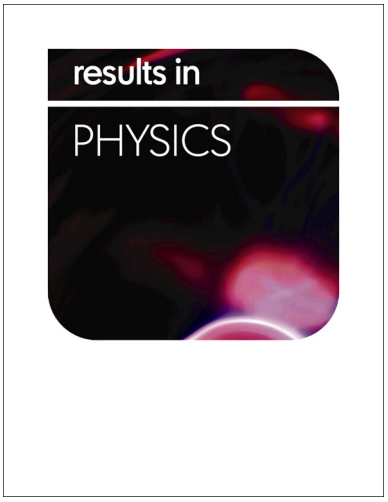


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# A Solid Polymer Electrolyte for Aluminum Ion Conduction

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**KEYWORDS**

Polymers, electrolyte, aluminum, ion conduction

**ABSTRACT**

We report on the synthesis and characterization of a solid polymer electrolyte for aluminum ion conduction. The solid polymer electrolyte is produced via the copolymerization of a low molecular weight polytetrahydrofuran and a cycloaliphatic epoxy. The crosslinked copolymer is swollen in THF solutions of different concentrations of aluminum nitrate as the aluminum ion source. The conductivity as a function of concentration is measured via AC impedance spectroscopy over a temperature range of 20-110 °C. We attain conductivities that increase with salt concentration, reaching a value of $2.86\times10^{-5}$ $S.cm^{-1}$. Thermogravimetric analysis shows the electrolytes are stable up to 150 °C. Raman spectroscopy reveals complete dissociation of the aluminum nitrate salt in the electrolyte over the concentration range explored. This study establishes a polymer system and synthetic route towards solid polymer electrolytes for aluminum ion conduction, for the development of all solid-state aluminum ion batteries.

## INTRODUCTION

Solid polymer electrolytes (SPEs) are a safe, promising alternative to meet the challenges of battery applications. SPEs address concerns about overheating, electrolyte leakage, fire safety, as well as effective separator operation to avoid short circuits between anode and cathode. In addition, they provide additional advantages of flexible, compliant shapes and processability during manufacturing. SPEs also provide the opportunity to obtain a true all solid-state battery, with the inherent benefits of better thermal and mechanical stability. SPEs have been developed for lithium, sodium and magnesium ion batteries;[1] however, there have been no reports of an SPE for aluminum ion conduction.

Aluminum ion batteries show some of the highest potentials, greatest charge densities, and greatest capacities, in addition to being an abundant, low-cost alternative, multi-valent ion species.[1] After oxygen and silicon, aluminum is the third most abundant element in the earth's crust. An aluminum metal anode is a superior multivalent system in terms of volumetric capacity (8040 $mAh/cm^3$), four times greater than lithium and twice that of magnesium. Aluminum also has a rich history due to the well-established aluminum electroplating industry and offers Coulombic efficiencies close to 100%.

In this report, we examine an SPE for aluminum ion conduction. The SPE is synthesized via photo-crosslinked using visible light to form a copolymer consisting of polytetrahydrofuran and a cycloaliphatic epoxy. The SPEs are loaded with aluminum nitrate salt, and the conductivity, thermal stability, and composition are interrogated. This SPE shows good conductivity and thermal stability, which provides opportunities towards further SPE development and expansion of the system for improved aluminum ion conduction and future battery prototyping.

## EXPERIMENT