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Influence of the Temperature on the Cycling Performance of Polymer-Based Solid-State Batteries

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Extended Abstract

All solid-state batteries (ASSBs) are destined to be the technology which will substitute the actual Lithium-Ion batteries due to their enhanced safety and energy density. Several electrolyte substitutes are available, but among them, the polymer solid electrolyte present higher benefits due to their processability and achieved ionic conductivities. However, current ASSB polymer technologies present limitations on both cyclability and durability, which hinders the full deployment on everyday applications[1].

Whereas many alternatives have been proposed to overcome these limitations, in this work, an optimized molecular weight polymer cathode is proposed as a successful solution. In this regard, an enhanced ionic conductivity is obtained while preserving a good mechanical resistance across the cathode, leading to an excellent cyclability at C/5 when operated at 70ºC [2]. Also, an increase in processability, enables the cathode to be processed with a solid content close to 50%, decreasing significatively the required amount of solvent. Therefore, good compaction enables thicker cathodes to be used with a higher capacity. These benefits may open the deployment of this technology to applications such as electric mobility and others where the effect of temperature must be investigated in detail.

In this work, the battery behaviour is studied as a function of the temperature in the 70 ºC - 100 ºC range, introduced as a fair balance between safety and efficient cyclability, which may require a thermal management of the final battery operability. Consequently, the complete thermo-electrical characterization is required, being the aim of this work. On one hand, electrical behaviour of the battery is experimentally determined by means of charge and discharge experiments at various currents ranging from C/20 to C/5. As a result, the open circuit voltage (OCV) and the effective bulk electrochemical conductance (Y) have been obtained for charge and discharge sequences. The first, shows a nearly constant value as a function of state of charge (SoC) around 3.4 V for both charge and discharge processes, and is found to be independent of the temperature. The second, shows a noticeable quasi-linear variation of 40% with the SoC, and increasing with temperature, which enables faster charge and discharges. In addition, the electrical conductivity of the cathode has been also measured by means of AC and DC polarization techniques. The results show a clear increase of the conductivity with the temperature around 40% with an average value of 0.6 S/m. This last magnitude has shown to be very dependent on the sample preparation and testing processes, which may lead to slight variations between measurements. On the other hand, the thermal properties, namely heat capacity, thermal conductivity and thermal diffusivity of the electrolyte and the cathode materials have also been experimentally measured. Experiments were conducted using a modulated differential scanning calorimeter, hot disk and laser flash methods, respectively. All properties have shown a nearly constant value on the proposed operation temperature range. Overall, the performed investigation has demonstrated the suitability of the proposed battery to cycle at the mentioned temperature range, benefiting of higher temperature increases.

References

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