

*Regular Paper***Synergistic Effect of Polar TiO₂ and Conductive Carbon in Freestanding TiO₂/C Electrode for Li-Polysulfide Battery****Anteneh Maregn BEYENE, Jong Hyuk YUN, Syed Abdul AHAD, Brindha MOORTHY and Do Kyung KIM****Department of Materials Science and Engineering, Korea Advanced Institute of Science and Technology (KAIST), Yuseong-gu, Daejeon 34141, Republic of Korea*

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Abstract

Li-S battery system is one of the promising candidates for the next generation energy storage demands as it has strong potential to provide two to three times higher energy density than the state of the art Li-ion battery. However, the highly insulative nature of sulfur and the high solubility and diffusivity of intermediate polysulfides (PSs) have impeded the realization of this potentially promising battery system by significantly reducing its performance. Efforts have been made to address these problems by compositing sulfur with different carbon nanostructures, which at the same time confine the PSs physically and reduce their diffusivity. The physical entrapment of PSs using different carbon nanostructures has brought some degree of performance improvement; nevertheless, for long term cycling chemical entrapment using polar materials was found to be more effective. TiO₂ is among the various polar hosts that have brought remarkable performance improvement in Li-S battery systems. Despite the strong polar nature of TiO₂, it is poor electronic conductive demands to be mixed with conductive carbon to be used as a sulfur host. In this work we attempted for the first time to use a 1-D TiO₂/carbon mixture for a freestanding electrode design to achieve a relatively high sulfur loading of 2.5 mg/cm². The influence of different TiO₂/C compositions on the electrochemical performance of the cells also has been discussed.

Keywords: Lithium-polysulfide batteries, Polar host, Titanium dioxide, Conductive carbon, Freestanding electrode

1. Introduction

The Li-sulfur battery is one of the promising candidates for next-generation energy storage demand [1-4]. On the basis of the high abundance of sulfur, its relative low mass, and its ability to adopt a wide variety of oxidation states the Li-S battery has remarkable potential for low cost and high energy density batteries [5,6]. Nevertheless, there are challenges that impede the realization of the full potential of Li-Sulfur batteries. The fundamental challenges in the Li-Sulfur system are the highly insulating nature of sulfur and lithium sulfides, the dissolution of polysulfides in the electrolyte and a consequent shuttling problem, high volume expansion at the cathode, and dendrite formation at the anode [5,7-9]. The aforementioned problems are exacerbated when high sulfur loading is employed at the cathode. Numerous studies have been carried out to alleviate these

problems since sulfur was first used as cathode in a Li-S battery system. The majority of Li-S based research has focused on the cathode part, although some groups have studied the anode, separator, and the electrolyte as well.

Earlier reports focus on using different carbon nanostructures for making a carbon-sulfur composite cathode in order to create a conductive network in the composite cathode and physically entrap polysulfides. It was possible to achieve remarkable performance improvement by employing different carbon nanostructures with different cathode architecture [10]. However, the physical entrapment was not strong enough to hold the polysulfides during long term cycling. Eventually the polysulfides dissolve into the electrolyte and migrate to the anode, leading to active material loss, accumulation of an insulating layer at the anode, and consequent capacity fading. Chemical entrapment of polysulfides using multifunctional

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