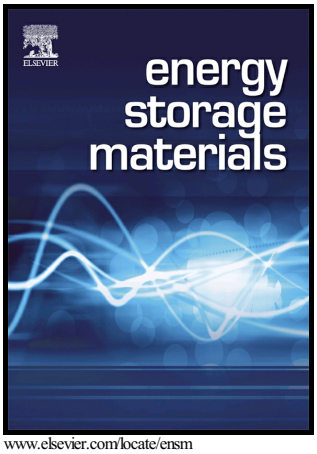
Nickel/sulfur composite electroplated nickel foams for the use as 3D cathode in lithium/sulfur batteries – a proof of concept

Şeniz Sörgel, Oliver Kesten, Anne Wengel, Timo Sörgel



www.elsevier.com/locate/ensm

PII: S2405-8297(17)30158-7
DOI: http://dx.doi.org/10.1016/j.ensm.2017.05.016
Reference: ENSM159

To appear in: *Energy Storage Materials*

Received date: 23 December 2016
Revised date: 26 April 2017
Accepted date: 22 May 2017

Cite this article as: Şeniz Sörgel, Oliver Kesten, Anne Wengel and Timo Sörgel, Nickel/sulfur composite electroplated nickel foams for the use as 3D cathode i lithium/sulfur batteries – a proof of concept, *Energy Storage Materials* http://dx.doi.org/10.1016/j.ensm.2017.05.016

Nickel/sulfur composite electroplated nickel foams for the use as 3D cathode in lithium/sulfur batteries – a proof of concept

Şeniz Sörgel[a], Oliver Kesten[b], Anne Wengel[b], Timo Sörgel[b*]

[a]Research Institute for Precious Metals and Metals Chemistry, Katharinenstr. 17, 73525 Schwäbisch Gmünd, Germany

[b]Aalen University of Applied Sciences, Research Institute for Innovative Surfaces, Beethovenstr. 1, 73430 Aalen, Germany

[*]Corresponding author. Tel.: +49(0)7361 576-2468; fax: +49(0)7361 576-2317. timo.soergel@hs-aalen.de

Abstract

In this work, a composite electroplating method of manufacturing organic binder and conductive carbon free electrode materials is applied on nickel foam substrates, used as 3D current collector. Thereby, sulfur particles (d_{50}=24 µm) are functionalized with polythiophene (layer thickness 100-200 nm) and brought to the surface of the nickel foam by means of composite electroplating while using nickel as a mechanically stable and electrically well conducting binding matrix for sulfur (Ni layer thickness around the sulfur particles < 1 µm). Therefore, organic nonconducting binders such as PVDF and conducting additives such as carbon are redundant. The method of composite electroplating ensures high sulfur loading with additional surface structuring, while keeping all pores accessible to the battery electrolyte. The naturally high surface of the metal foam is thereby further increased, which helps to decrease local current densities in the battery application. Cross-section SEM micrographs and CT images show that the functionalized sulfur particles are uniformly and densely distributed throughout the nickel foam. A battery capacity of about 300 mAh g^{-1}_{sulfur} over 100 cycles at a current density of 1 mA cm^{-2} (0.167 C) for a cathode containing 3.57 mg cm^{-2} sulfur is achieved. With an additional 50 nm thin NiS_x alloy coating, the utilization of sulfur is improved by 250-300 % (a battery capacity of about 800 mAh g^{-1}_{sulfur} over 100 cycles at a current density of 1 mA cm^{-2} (0.162 C) for a cathode containing 3.68 mg cm^{-2} sulfur is achieved). Furthermore, a high reversibility and rate capability is found when cycled between 0.1 and 1 C, respectively. A stable coulombic efficiency of about 100 % is achieved.

Graphical abstract