Carbon Nanofiber/Carbon Nanotube/Metal Hybrid Nanostructures for Lithium-ion Batteries

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Abstract

- Carbon nanofibers' application in lithium-ion batteries can result in improvements in their electrochemical performance.
- Metal nanoparticles, e.g. Sn, Sb, have very high theoretical specific capacities.
- Incorporation of CNTs can improve electrical conductivity of CNFs.

Purpose

- To enhance the capacity of the lithium-ion batteries by using metal nanoparticle hybrid structures.
- The general aim is to combine CNF and CNT in order to increase the conductivity of the whole structure.

Introduction

- **Commercial lithium-ion batteries**
  - The materials play a crucial role in their capacity.
  - Carbon nanofibers show excellent lithium-storage performance when used directly as anode materials.
- **Polyacrylonitrile (PAN)**
  - Organic polymer, high carbon yield, fit for electrospinning.
- **Electrospinning**
  - Effective method to produce ultra-thin fibers from a wide range of polymeric materials.
  - Suited to the production of fibers using large and complex molecules.
- **Carbon nanofibers (CNFs)**
  - Cylindric nanostructures with graphene layers arranged as stacked cones, cups or plates.
- **Carbon nanotubes (CNTs)**
  - Allotropes of carbon with a cylindrical nanostructure.
  - Used as additives to various structural materials.

Methods

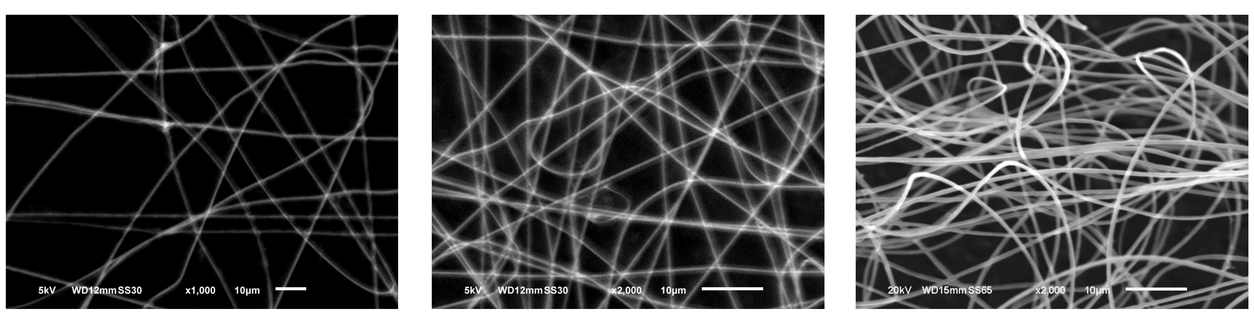
- **CNT/Sn**
  - Oxidation of CNT.
  - Microwave-assisted reduction of metal salts
  - Washing.
  - Purification and freeze drying the samples.
- **CNF/Sn**
  - Polymeric nanofibers with $SnCl_2$ via electrospinning.
- Characterization techniques
  - Scanning Electron Microscope (SEM)
  - Energy-dispersive X-ray spectroscopy (EDX)

Results

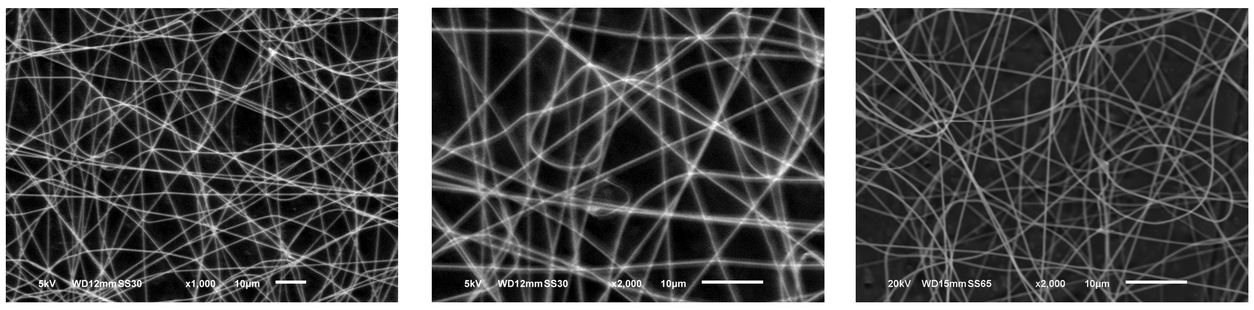
Electrospun nanofibers containing CNT/Sn

CNT/PAN/$SnCl_2$

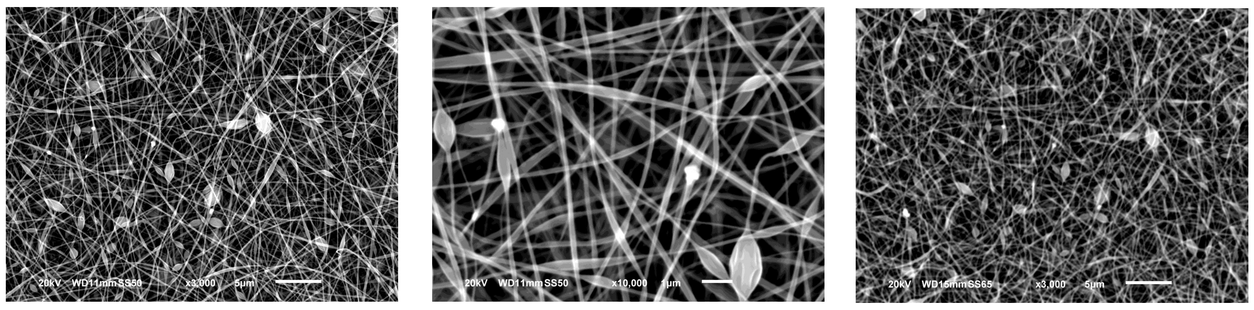
SEM images of RAE_SYB_CNT01



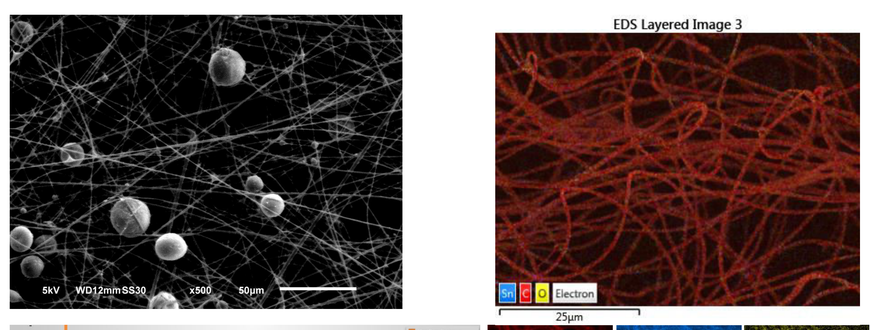
SEM images of RAE_SYB_CNT02

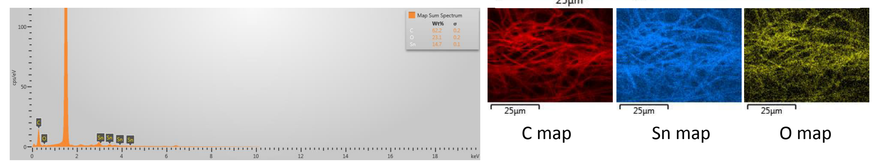


SEM images of RAE_SYB_CNT03

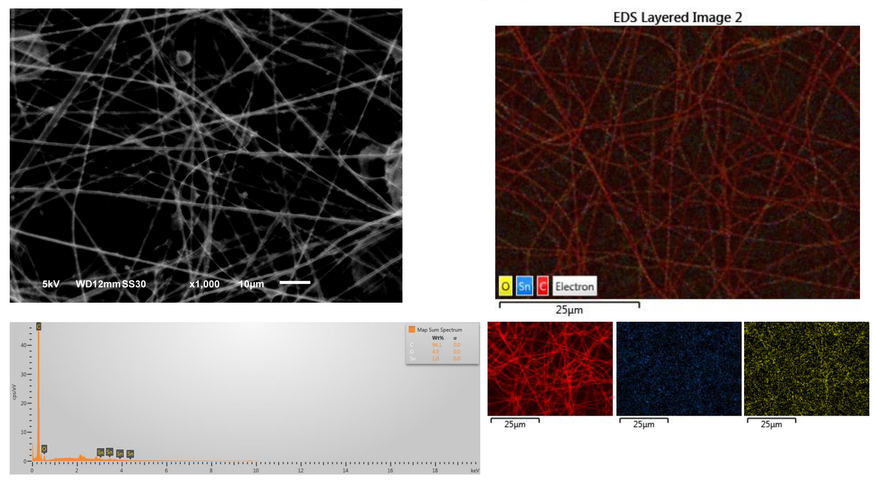


EDX images of RAE_SYB_CNT01

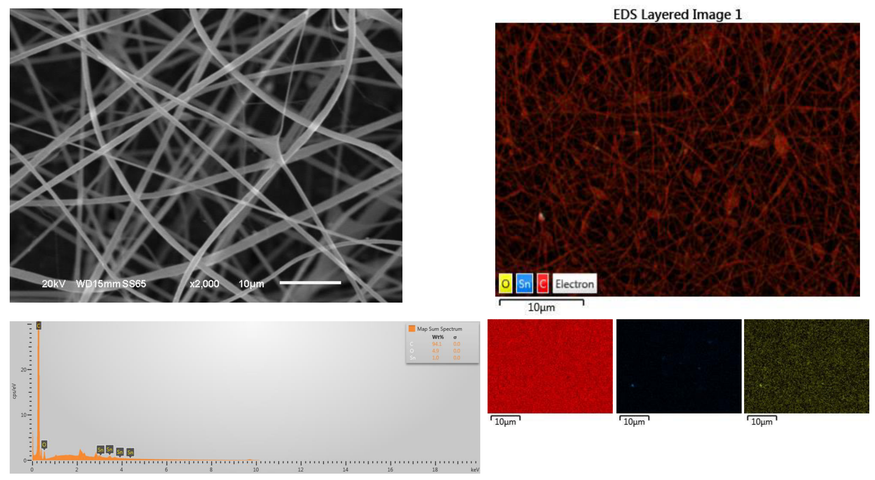




EDX images of RAE_SYB_CNT02



EDX images of RAE_SYB_CNT03



Summary

- CNT/Sn hybrid nanostructures were obtained via microwave-assisted reduction in milder conditions.
- CNF/CNT/Sn and CNF/Sn structures were obtained via electrospinning.
- The samples were characterized via SEM and EDX.

Future Work

- Transmission electron microscopy (TEM) analysis will be done.
- CNT/Sn synthesis will be optimized
- Synthesized CNT/Sn will be incorporated into CNF.
- Developed materials will be tested in lithium-ion batteries.

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References

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3. Li, W., Li, M., Adair, K. R., Sun, X., & Yu, Y. (2017). Carbon nanofiber-based nanostructures for lithium-ion and sodium-ion batteries. Journal of Materials Chemistry A, 5(27), 13882-13906. doi:10.1039/c7ta02153d