Investigation of eco-friendly, sustainable, natural resources for electrospun carbon nanofibers as energy storage materials

► STUDENTS / UNIVERSITIES
Tayis Arslan/Koç University
Işıl Demirkan/Sabancı University
Umut Yazlar/Sabancı University

► SUPERVISOR(S)
Serap Hayat Soytaş

Abstract

- There is a great potential of biomass-derived carbons for energy storage .
- Choosing "green" and economically viable precursor and synthesis process for the production of carbon nanofibers as a sustainable alternative for energy storage applications
- In this project, biomass-derived carbon precursors will be investigated for the production of electrospun carbon nanofibers. Then, the developed carbon nanofibers will be tested as potential anode material in lithium-ion batteries.

Purpose of Project

- Fabrication of carbon nanofibers by using lignin which is a sustainable, eco-friendly, non-toxic natural resource.

Introduction

- **Lignin**
  - Carbon rich polymer which can be obtained as a biowaste from paper industry
  - Second most abundant macromolecule in biosphere
  - Cheap, abundant, low weight and non-toxic
- **Polymer Highly Used in Literature for Carbon Nanofiber Fabrication**
  - **Polyacrylonitrile (PAN)**
    - Syntenic, semicrystalline organic polymer with high electrospinning ability
    - Not-soluble in water but dissolves in DMF
    - DMF is a toxic solvent and not sustainable.
    - Search for sustainable solvent and polymer alternatives
- **Water-soluble Polymer Alternatives**
  - **Polyvinyl Alcohol (PVA)**
    - Water-soluble synthetic organic polymer with high electrospinning ability
  - **Polyvinylpyrrolidone (PVP)**
    - Water soluble synthetic organic polymer with high electrospinning ability
    - Commonly used to produce carbon fibers, but not used with lignin
    - This project examines how PVP and lignin work together to fabricate carbon nanofiber.

Methods

- **Fabrication**
  - Solution preparation of PAN/DMF/Lignin, PVA/Water/Lignin, PVP/Water/Lignin
  - Electrospinning
- **Characterization**
  - Scanning Electron Microscopy (SEM)
  - Rotational Viscometer
  - Force Tensiometer

Scanning Electron Microscopy (SEM)

Lignin-PAN-DMF

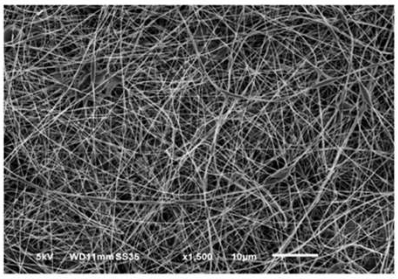

Figure 3. SEM images of nanofibers from Lignin-PAN solution (magnification time 5,000X).

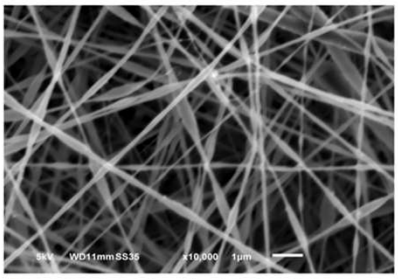

Figure 4. SEM images of nanofibers from Lignin-PAN solution (magnification time 10,000X).

Total solvent %	Total solid %	Lignin/PAN
88	12	2.348

Lignin-PVA-Water

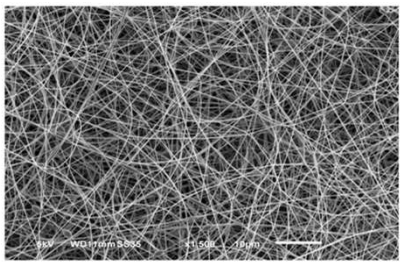

Figure 5. SEM images of nanofibers from Lignin-PVA solution (magnification time 1,500X).

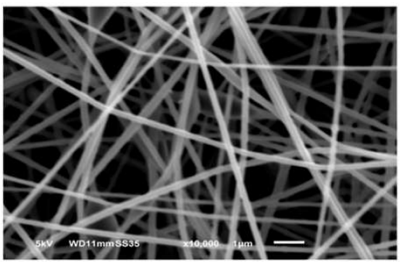

Figure 6. SEM images of nanofibers from Lignin-PVA solution (magnification time 10,000X).

Total solvent %	Total solid %	Lignin/PAN
88	12	2.307

23 Celcius for Surface Tension 50 Celcius for viscosity meauserement	LG1	LG2	LG2B	LG3	LG3B
Surface Tension (mN/m)	38.31	35.3	33.5	*in progress*	*in progress*
Viscosity (mPascal*s)	*in progress*	*in progress*	99.4	144.4	140.4

***LG1 (Lignin/PVA/Water – 12% solid, 2.3 Lignin/PVA),**
LG2 (Lignin/PAN/DMF – 11.9% solid, 2.3 Lignin/PAN),
LG2B(Lignin/PAN/DMF – 11.99% solid, 1.85 Lignin/PAN),
LG3 (Lignin/PVP/Water/Ethanol – 12% solid, 2.3 Lignin/PVP, Water/Ethanol 1.22),
LG3B (Lignin/PVP/Water/Ethanol – 12% solid, 2.3 Lignin/PVP, Water/Ethanol 1.5).

Summary

- Lg1, lg2, lg2b, lg3, lg3b solutions were electrospun. Viscosity and surface tension of these solutions were measured.
- Fiber formation was observed in lg1, lg2 and lg2b in SEM
- Lg3 and lg3b were not successfully electrospun due to high viscosity and solvent evaporation
- Evaporation of ethanol and multiple jet formation were major problems in electrospinning of Lg3 and lg3B.

Future Works

- Carbonization will be performed.
- Fibers will be formed from PVP/Lignin/Water solution.
- Nanoparticles of Si, Sn will be synthesized to increase battery capacity.
- Battery performance will be tested.