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Oil Adsorption by using Hollow/Porous ElectrospunCarbon nanofibers

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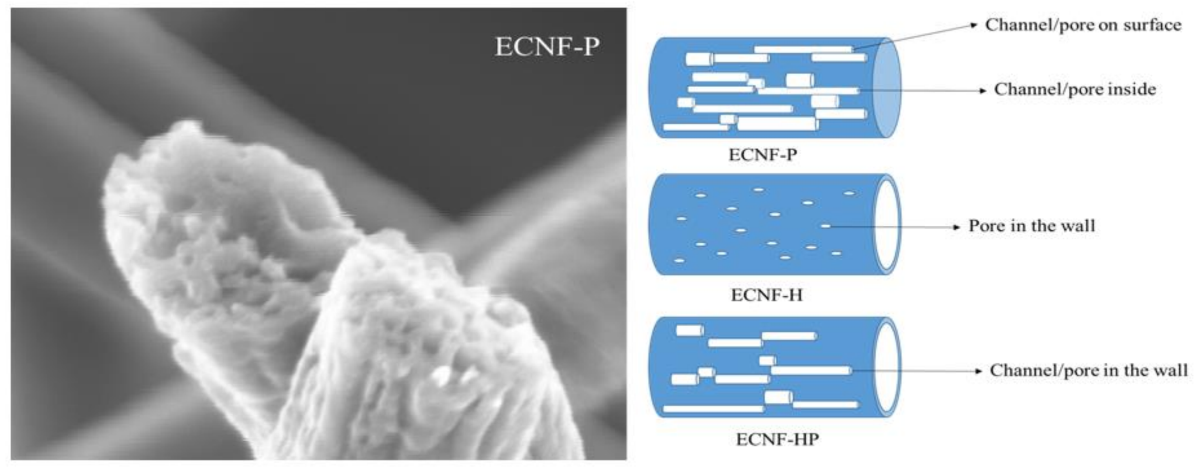

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Introduction

Oil pollution on water bodies can be caused by transportation of oil through water bodies, dumping of oily waste into the ocean or drilling of crude oil from ocean beds, which are referred to as oil spill accidents. One of the largest accidental marine oil spill in the world, the Deepwater Horizon accident in 2010, has spilled approximately 210 million gallons of crude oil to the Gulf of Mexico and resulted in massive ecological imbalance. Conventional methods for oil spill such as skimming, controlled burns etc are ineffective. Therefore scientist around world are looking for effective methods/products to effectively clean oil spills.

In this research we have demonstrated one such possible material for oil absorption purpose which are electrospun carbon nanofibers having hollow/interconnected pores developed by phase separation process.

Objective

Prepare carbon nanofibers in three different morphologies including Porous, Hollow, and Hollow Porous through electrospinning and investigate oil absorption performance of these three types of carbon nanofibers as well as their recyclability.

Methodology

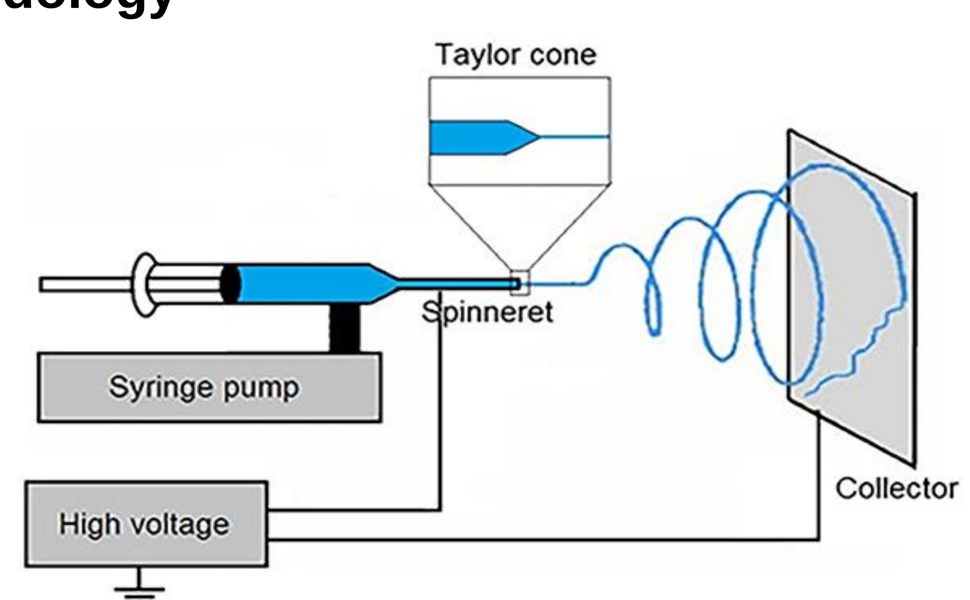

Fig 1: Schematic of Electrospinning setup

Electrospinning conditions

Type of fiber	Solution used for spinning	Flow rate ml/hr	Distance from collector (cm)	Applied Voltage (kv)
Porous ECNF-P	PAN 10wt%	Flow rate 1ml/hr	15	18
Hollow ECNF-H	PAN 10wt% (shell) and PMMA 25wt% (core)	Shell flow rate 1ml/hr Core 1ml/hr	15	18
Porous hollow ECNF-HP	PAN 10wt% and PMMA 25wt% (75:25) for shell PMMA 25wt% for core	Shell flow rate 1 ml/hr Core 1ml/hr	15	18

Preparation of ECNFs

Step 1: As spun fibers are stabilized at 280°C at 1 °C/ min and dwell for 1 hr

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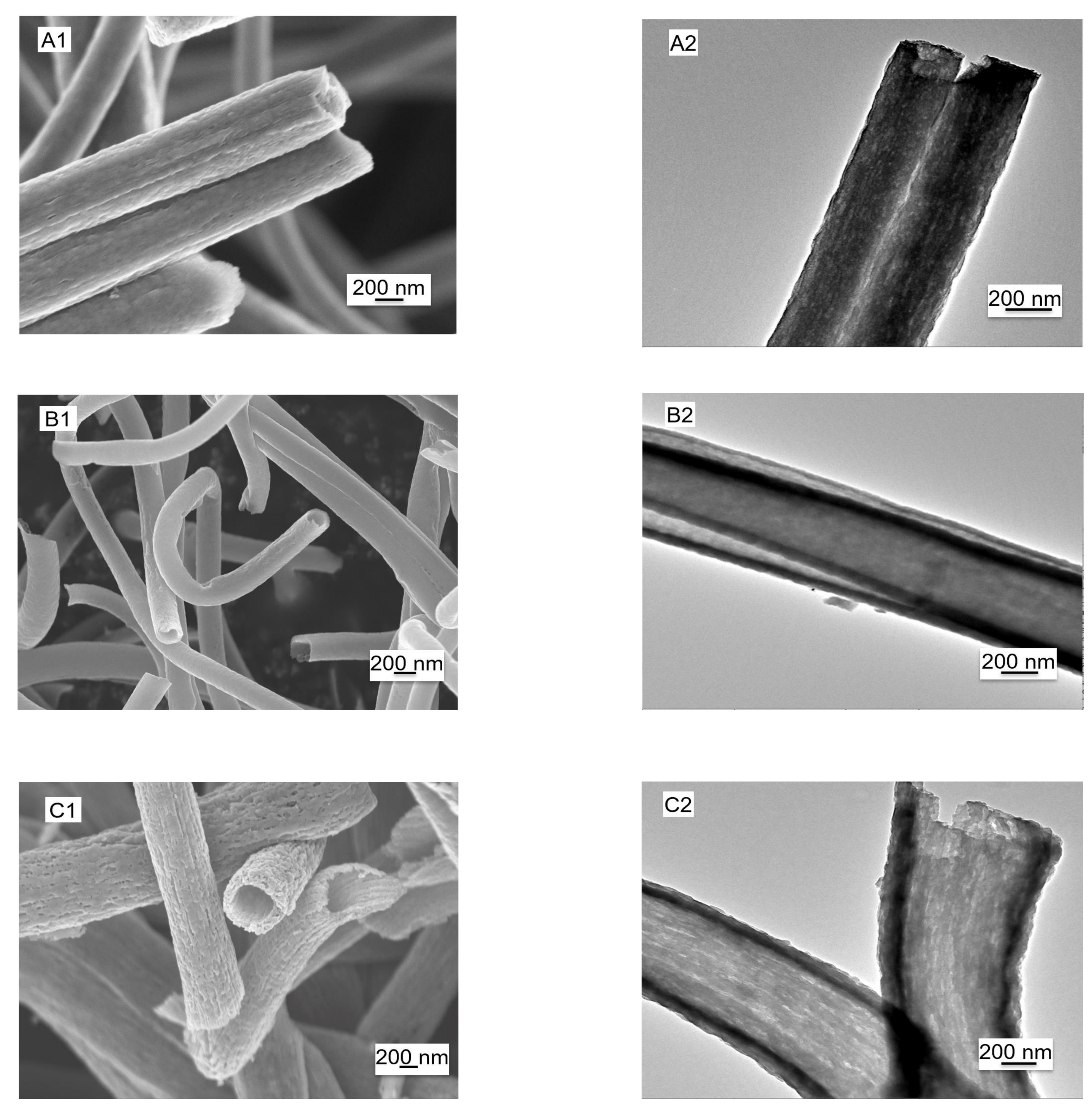
Step 2: Fibers from step 1 are Carbonized at 800 °C in nitrogen atmosphere at 5 °C /min and dwell for 1hr.

Results



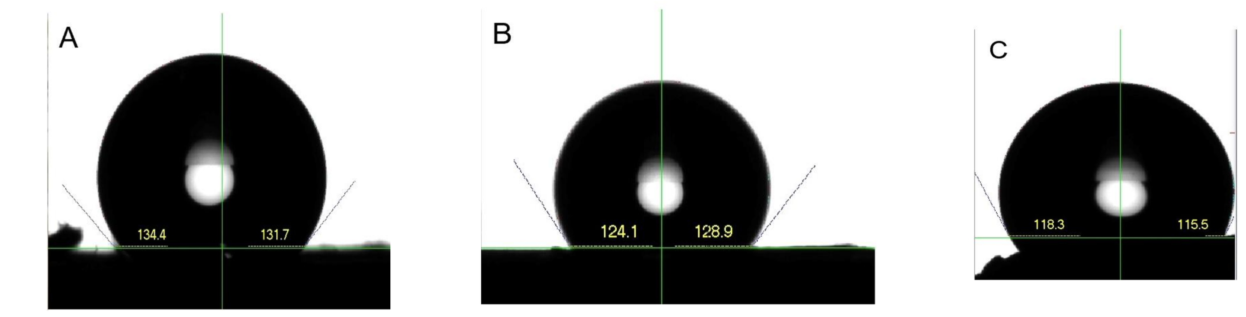
SEM images of ECNF-P, ECNF-H, ECNF-HP (A1,B1,C1)
TEM images of ECNF-P, ECNF-H, ECNF-HP (A2,B2,C2)

The average diameter of ECNF-P nanofibers was 430 ± 100 nm. ECNF-H showed a hollow fiber (tubular) structure and a wall with some surface roughness and surface pores (B1-B2). The average inner diameter was 200 ± 40 nm and outer average diameter was 560 ± 90 nm. ECNF-HP demonstrated a hollow fiber structure and a porous wall clearly showing both surface and internal pores and channels at nanometer scale (a few to a few tens of nanometers) (C1-C2). The average inner and outer diameter was 360 ± 40 nm and 780 ± 85 nm

BET Surface area analysis of ECNF-P, ECNF-H and ECNF-HP

Sample	BET Surface Area (m^2/g)	Average Pore Width (nm)	Total Pore Volume (cm^3/g)	Micropore Volume (cm^3/g)	Mesopore Volume (cm^3/g)	Macropore Volume (cm^3/g)
ECNF-P	485	3.21	0.389	0.179	0.153	0.0567
ECNF-H	419	2.78	0.291	0.150	0.0824	0.0590
ECNF-HP	346	2.78	0.241	0.140	0.0448	0.0556

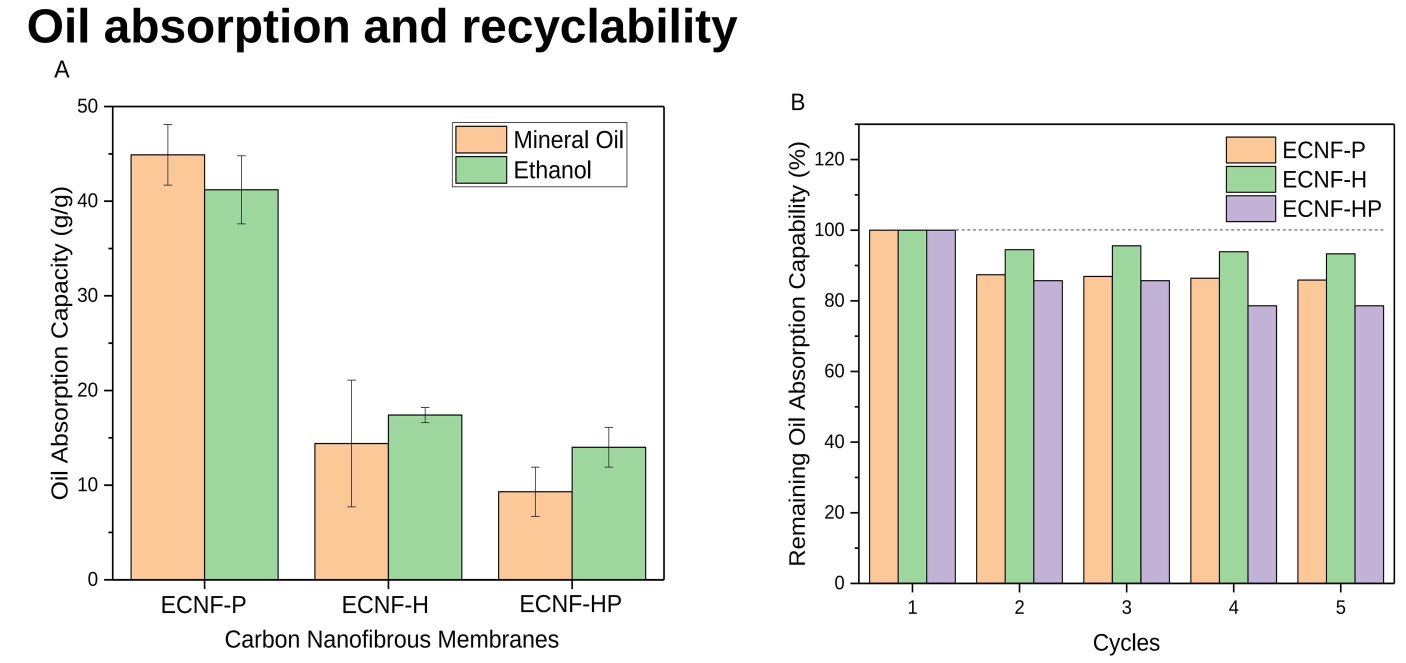
Surface property (Contact angle):



A,B,C are optical images of ECNF-P, ENCF-H,ECNF-HP

The water contact angle results indicated that ECNF-P had larger degree of surface roughness than that of hollow nanofibrous membranes and possessed finer surface porous structure

Oil absorption and recyclability



(A)Oil absorption an(B)Recyclability of three types of ECNF

The largest mesopore volume and corresponding total pore volume of ECNF-P contributed most to its excellent oil absorption capacity

Conclusions

- Three different types of ECNFs were successfully prepared via coaxial electrospinning.
- The prepared ECNF are successfully employed for oil and organic solvent absorption.
- ECNF-P has interconnected pores and outperformed ECNF-H by 3 times and ECNF-HP by 5 times, respectively, owing to its surface roughness and capillary forces.

Acknowledgements

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