Electrospun Nanofibers Using Whole Microalgal Biomass: A Novel Sustainable Approach in the Field of Biobased Composite Materials

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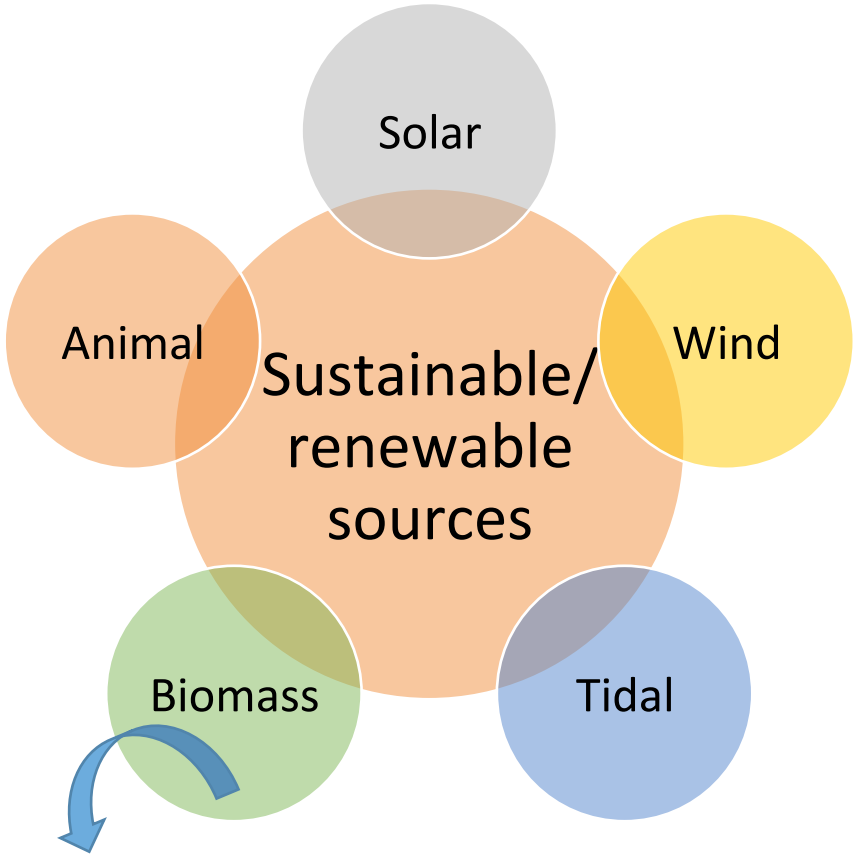
Outline

- Introduction
  - Sustainable
  - Electrospun nanofibers
- Experimental
- Results and discussion
  - Role of solvents
  - Role of biomass concentration
  - Role of solvent amount
- Conclusion

Introduction - Sustainable

- **Fossil sources** - Traditional sources - continuous drop and environmental polluting effects
- Alternative to fossil sources – **Sustainable** (are also called as renewables)
- **Biomass** (plant materials) occupies the top place compare to other sources
- **Algal** biomass sources – do not have competition with food crops in land issues – can be efficiently and productively cultivated in less space
- Sustainable sources derived products - best **replacement for most of the on-going petroleum products** - can be produced in bulk to satisfy the overall world's demand

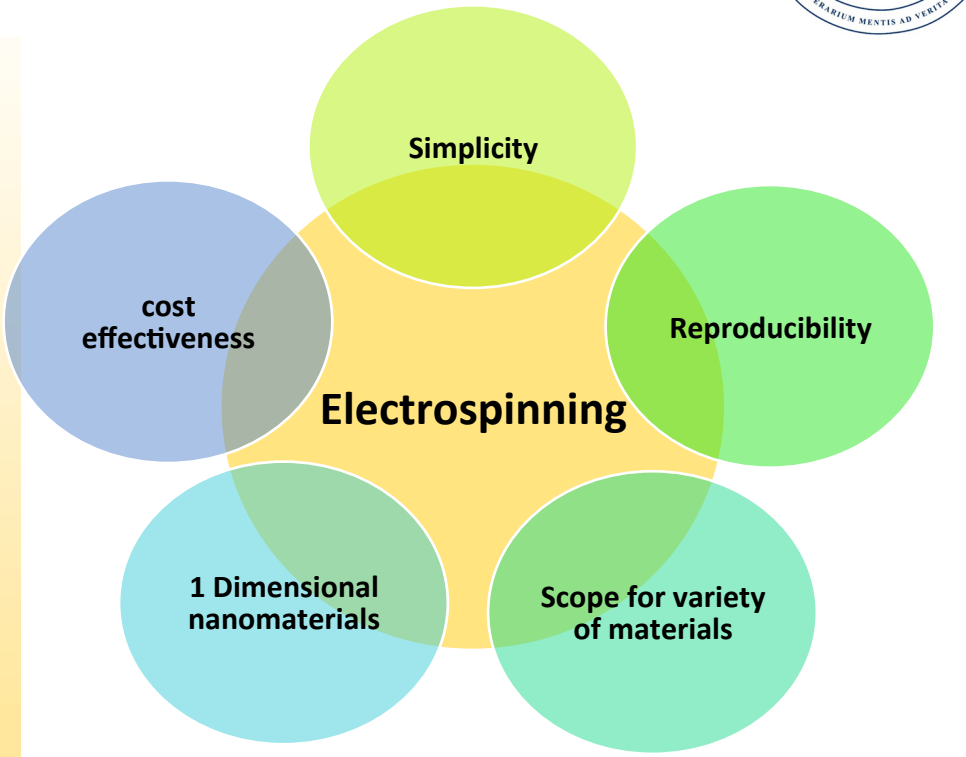
Sustainable: The development that meets the needs of the present without compromising the ability of future generations to meet their own needs



Biobased products: Fuels and chemicals derived from biomass sources

Introduction – Electrospun nanofibers

- **Nanofibers** - Fiberic material ranges from micrometer to nanometers - This modification greatly increases the specific surface area, flexibility in surface, functionality and mechanical performance
- Common polymer fibers, polymer fibers loaded with nanoparticles and functional molecules, ceramics fibers and metal/metal oxide fibers
- **Organic polymers** are one of the major source for nanofibers preparation due to their appropriate viscoelastic behavior in the electrospinning solution
- **Replacement of conventional sources** by biobased molecules for the preparation of nanofibers is of high interest



- **Development of nanofibers using completely bio-sources (whole as well as isolated components) for specific applications**
- **Numerous limitations due to their complexed nature**

Aim: To use whole microalgal biomass for the development of electrospun nanofibers

Experimental

Scenedesmus Almerjensis (SA) +
Solvent+ Poly(ethylene oxide) (PEO; in water)

↓

Mixed well using high speed

↓

Dispersed solution

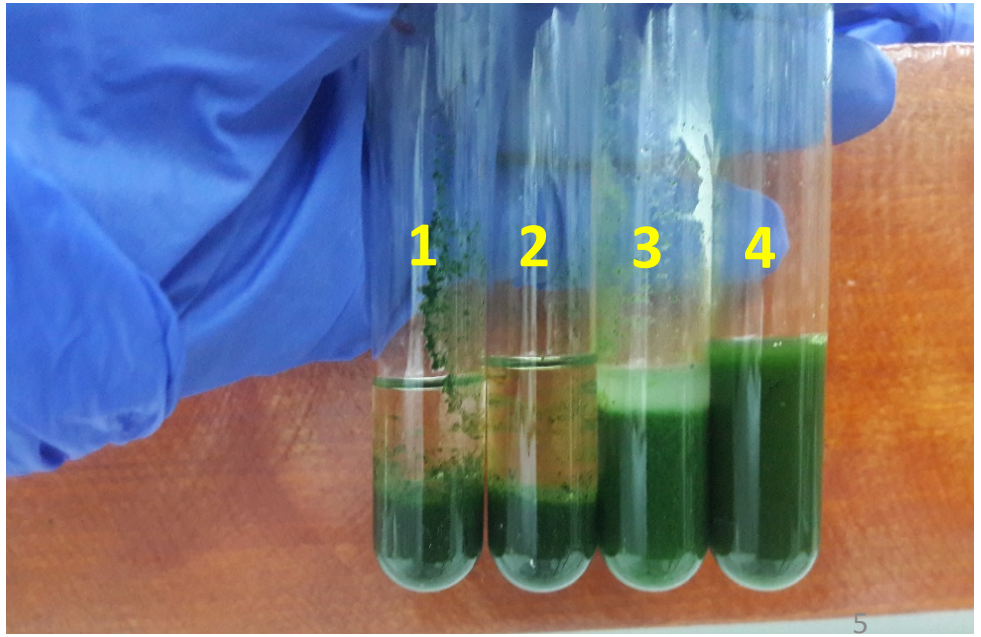
↓

Electrospinning process

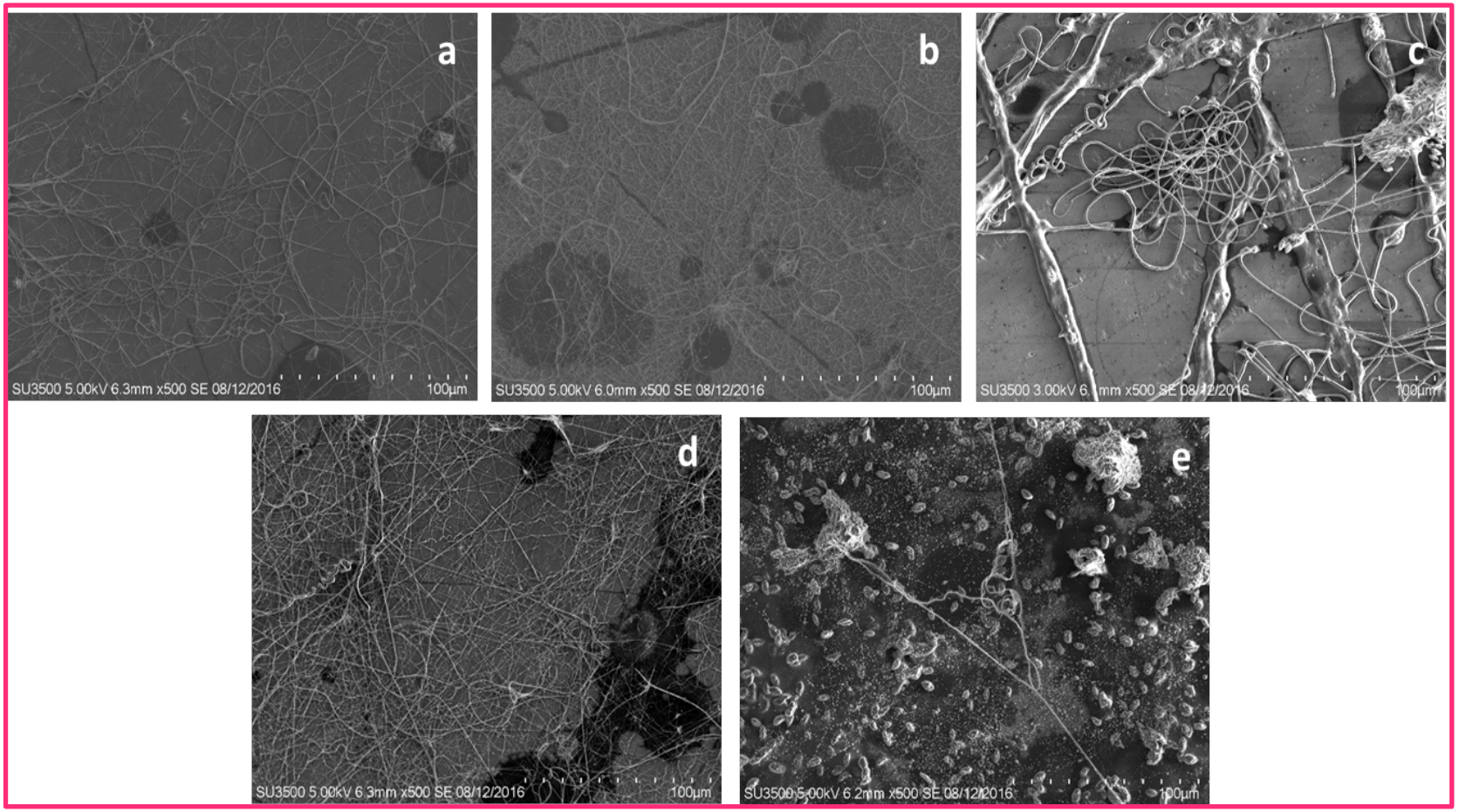
Solvents used for the study

- Acetone – Suspension formed
- Methanol – Suspension formed
- Petroleum ether – Suspension not formed
- Hexane – Suspension not formed
- Chloroform – Partially suspension formed
- Ethanol – Suspension formed
- Water – Suspension formed

Parameters	Range
Flow rate (mL/h)	1.5 to 3
Temperature (°C)	20
Operating voltage (kV)	+25 (to) +20 ; -3 (to) -4
Collector distance (cm)	20



Results and discussion – Role of solvents

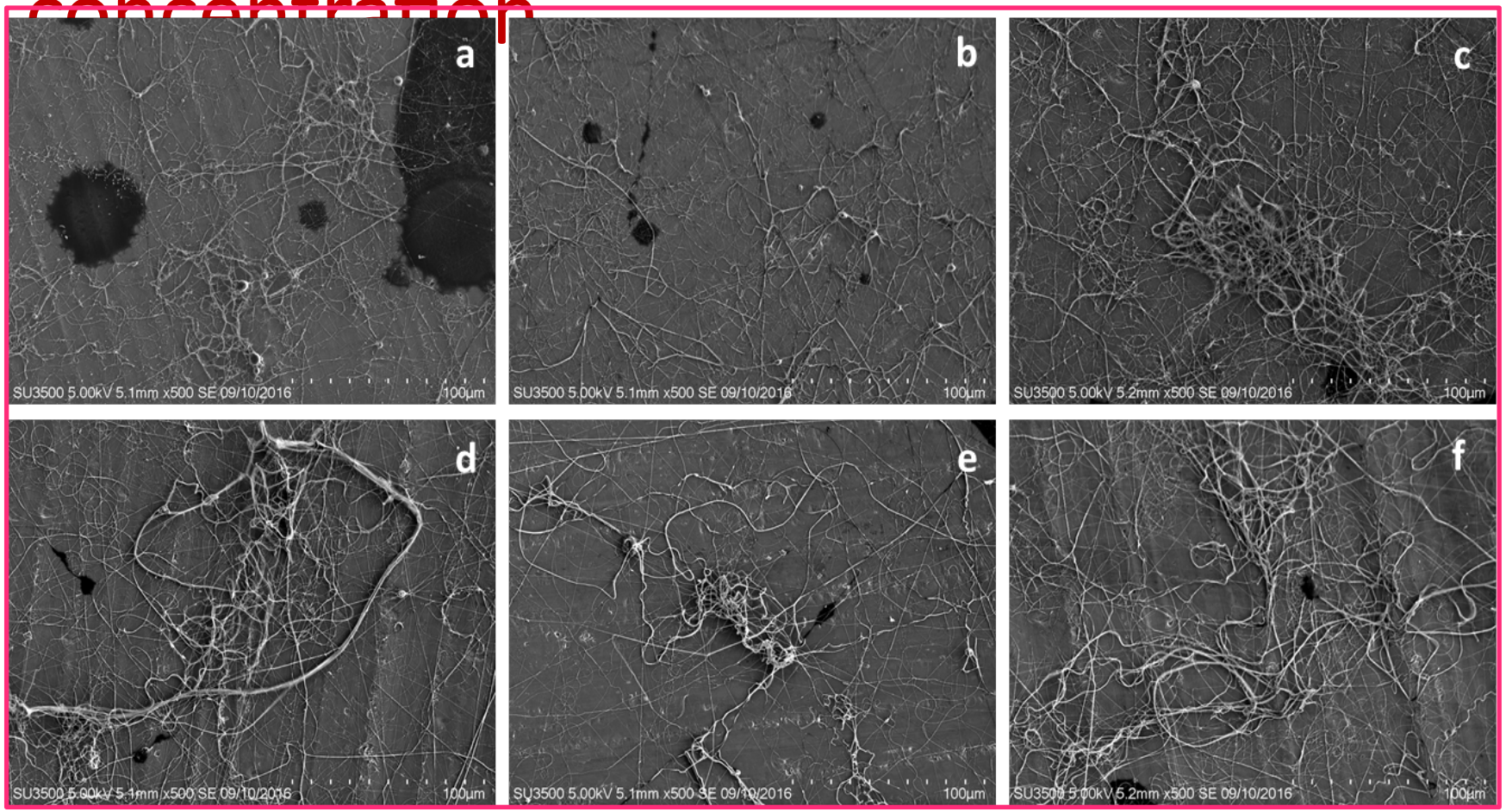


Scanning electron microscope (SEM) images of electrospun nanofibers of SA with PEO in presence of different solvents **(a) Acetone, (b) Methanol, (c) Chlorofrom, (d) Ethanol, (e) Water**

- Acetone, methanol and ethanol were resulted better formation of nanofibers - uniform structures (< 200 nm size)
- Big sized nanofibers were found due to overlapping
- Using chloroform as solvent, no uniformity was found in the nanofibers (size of 560-820 nm)
- Removal of lipids from the biomass by chloroform may leads to the formation big sized nanofibers
- Nanofiber formation was not observed with water solvent - not the suitable solvent for our study

Ethanol was chosen as the solvent for further studies – Low cost and possibility from biosources.

Results and discussion – Role of biomass concentration

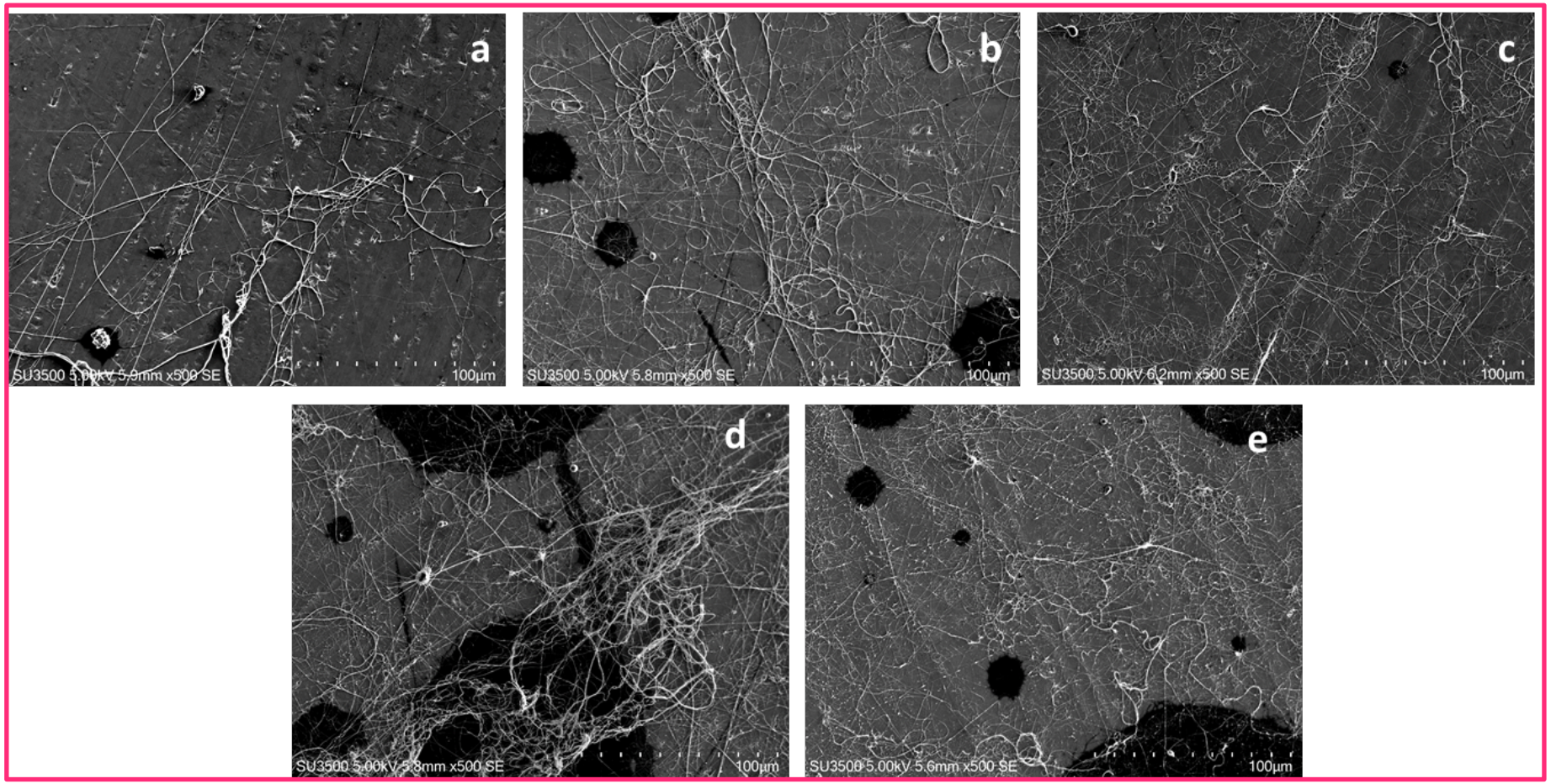


SEM images of electrospun nanofibers of SA with PEO with different concentrations of SA **(a) 15 wt.%, (b) 12.5 wt.%, (c) 10wt.%, (d) 7.5 wt.%, (e) 5 wt.%, (f) 2.5 wt.% w.r.t. PEO**

10wt.% of SA was optimized for further studies.

- The size of the nanofibers - range of 120-190 nm till 10 wt.% of SA
- Decrease in the SA concentration less than that resulted the large sized nanofibers (110-390 nm) – Found difficulty in maintaining the suspension due to higher viscosity of PEO – Leads to the precipitation of SA as separate layer while performing the electrospinning
- Also increase in the size of the nanofibers indicating that only PEO was involved in the spinning process
- 10 wt.% of SA is the better concentration for electrospinning of whole biomass with PEO

Results and discussion – Role of solvent amount



Scanning electron microscope (SEM) images of electrospun nanofibers of SA with PEO in different amount of ethanol **(a) 1 mL, (b) 2 mL, (c) 3 mL, (d) 4 mL, (e) 5 mL.**

- The size of the nanofibers were affected well by the amount of ethanol (range of 100-290 nm)
- Experiments using 1 to 3 mL of ethanol resulted less densed nanofibers
- 4 ml of ethanol resulted highly densed nanofibers
- 5 ml of ethanol resulted less densed nanofibers along with some beeds formation
- 4 ml of ethanol is resulted high densed, uniform nanofibers under the studied conditions

4 mL of ethanol is best for the formation of nanofibers under the studied conditions.

Conclusion

- ✓Electrospun nanofibers were successfully prepared by using whole biomass (*Scenedesmus Almeriensis*) with poly(ethylene oxide) as polymer source
- ✓ Electrospinning process using ethanol as solvent resulted more dense uniform structured nanofibers with < 200 nm size
- ✓Non-uniform and bigger size nanofibers were observed while using chloroform as solvent and this may be due the extraction of lipids from the biomass
- ✓It was found that water is not a better solvent for our study
- ✓Out of the concentrations studied, 10 wt.% of SA w.r.t. PEO resulted better formation of nanofibers
- ✓4 mL of ethanol as solvent resulted highly densed, uniform sized nanofibers compare to lower amount under the studied conditions
- ✓Further studies are in progress to get high dense nanofibers with uniform size to evaluate them as active adsorbent materials

Acknowledgements

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THANK YOU