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Antimicrobial Electrospun Cellulose Acetate Micro-fibers Loaded with Oregano and Rosemary Essential Oil

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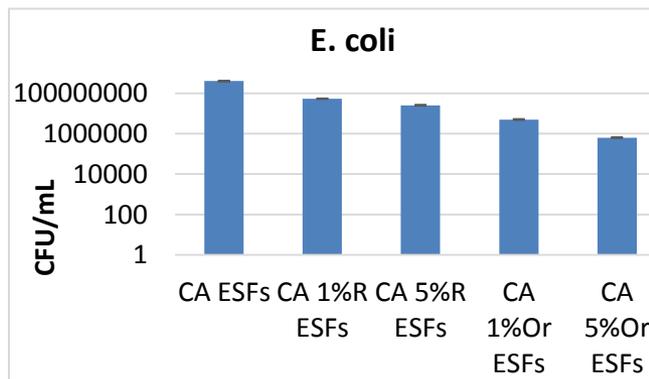
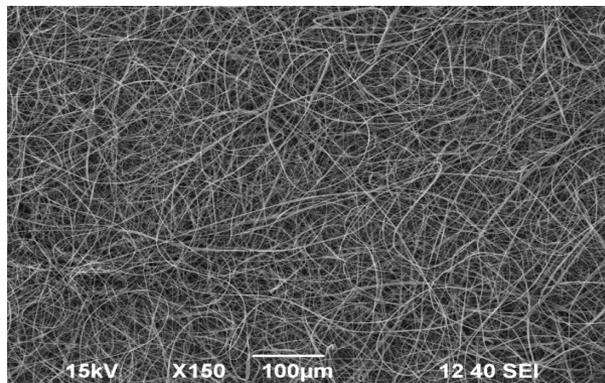
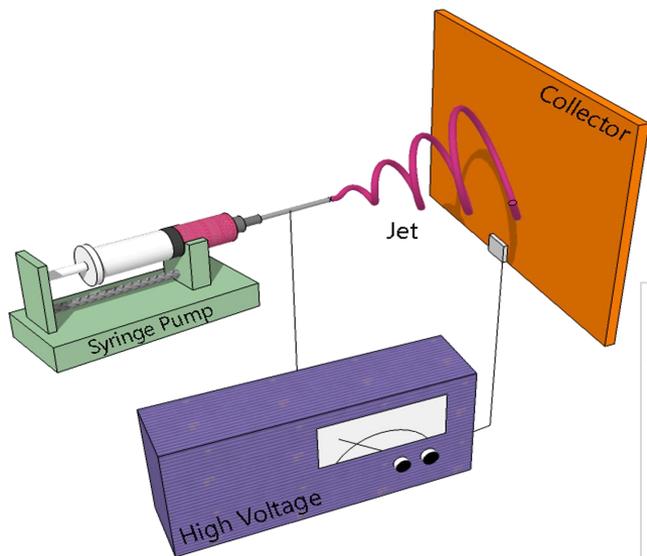
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Antimicrobial Electrospun Cellulose Acetate Micro-fibers Loaded with Oregano and Rosemary Essential Oil

Graphical Abstract



Abstract:

The method of electrospinning was used to create micro-fibers made of cellulose acetate (CA) and essential oils (EOs). CA polymer at 15% w/v was dissolved in acetone and then 1 or 5% v/v of EOs were added to the polymer solution. The essential oils chosen were oregano and rosemary oils. Then the CA-EOs in acetone solution was electrospun creating fibers with approximately 1.0 – 2.0 μm in diameter. Scanning electron microscopy was used to study the morphology, topography and dimensions of the micro-fibers. Raman spectroscopy was used to detect attachment of the EOs in the CA electrospun micro-fibers. The formed CA-EOs micro-fibers found to have good antimicrobial properties against common bacteria strains such as *E. coli*. The more concentrated with EOs micro-fibers showed the best antimicrobial effects. This work describes an effective and simple method to prepare CA-EOs micro-fibers and open new ways for many applications of such electrospun fibers such as wound dressings, anti-biofilm surfaces, sensors, packaging, cosmetics etc.

Keywords: Electrospinning nanofibers, essential oils, cellulose acetate, antimicrobial/antibacterial wound dressings.



Introduction

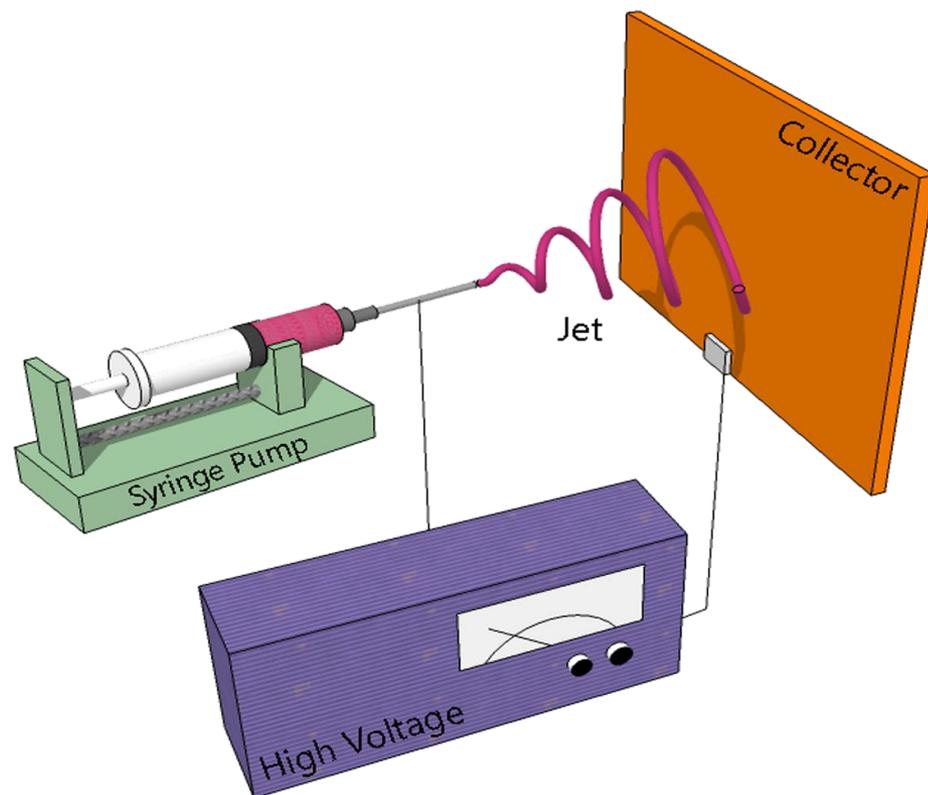
- The idea was to create cellulose acetate (CA) electrospun fibers (ESFs) with the incorporation of essential oils.
- Such composite ESFs should retain the antimicrobial activity of the essential oils.
- Moreover the high surface area to volume ratio of nano or micro fibers should enhance the antimicrobial activity of fibers compared to films.



Introduction

Basic electrospinning technique

- A feeding system: a spinnaret (metallic needle) connected to a syringe filled with the polymeric solution.
- A syringe pump.
- A high voltage power supply (10-60 kV).
- An anode attached to the tip of the syringe and a cathode attached to the collector.
- A collector plate.



Introduction

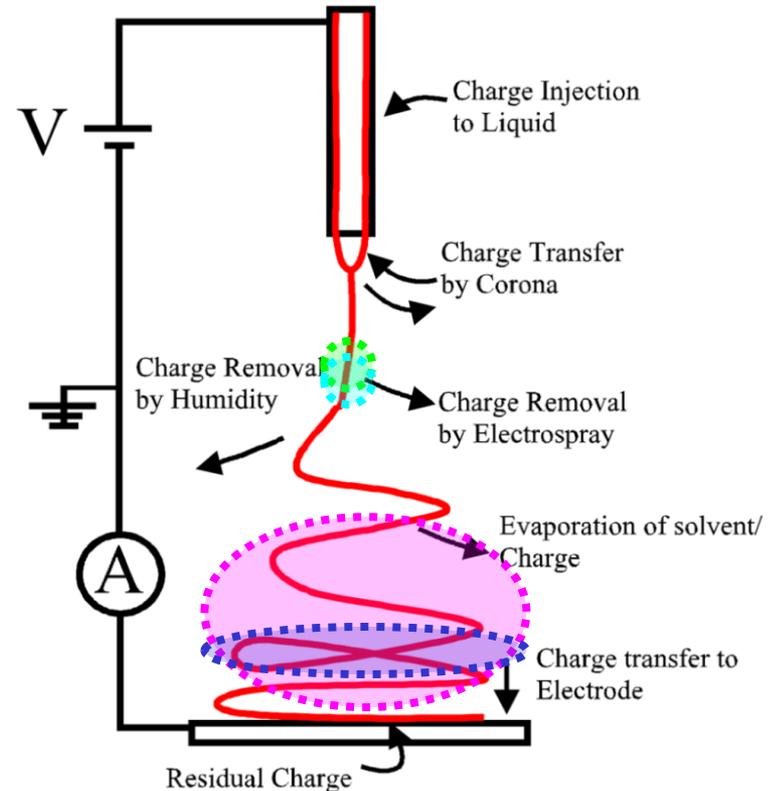
Three phases: (1) jet initiation; (2) bending instability; (3) solidification of the fibers

Stress induced on the charged solution by the electric field and formation of the Taylor cone

At high potentials, the electrical force overcomes the surface tension of the liquid drop and a thin jet emerges at the edge of the drop

Chaotic motion of the filament due to electrically driven instability resulting in stretching of the jet and solvent evaporation

Fibers are deposited on a collector



G. Collins et al., JAP 111, 044701 (2012)



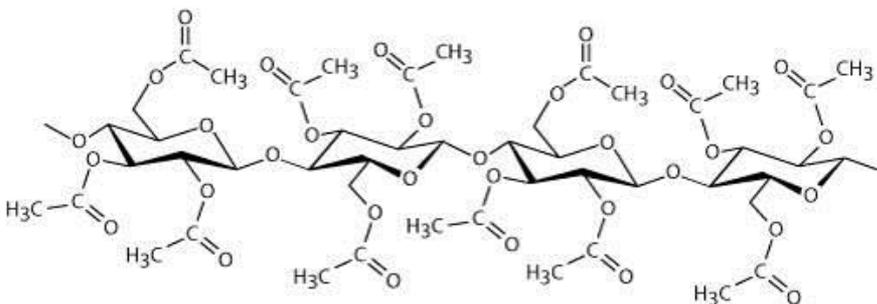
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Introduction



- Cellulose acetate is the acetate ester of cellulose, used in photography, eyeglasses, cigarette filters and playing cards.
- It is a biocompatible and biodegradable polymer.
- It can be used to produce electrospun fibers.



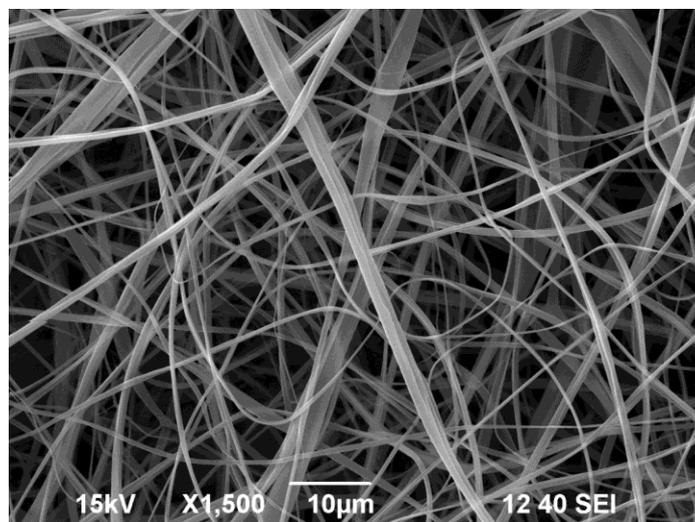
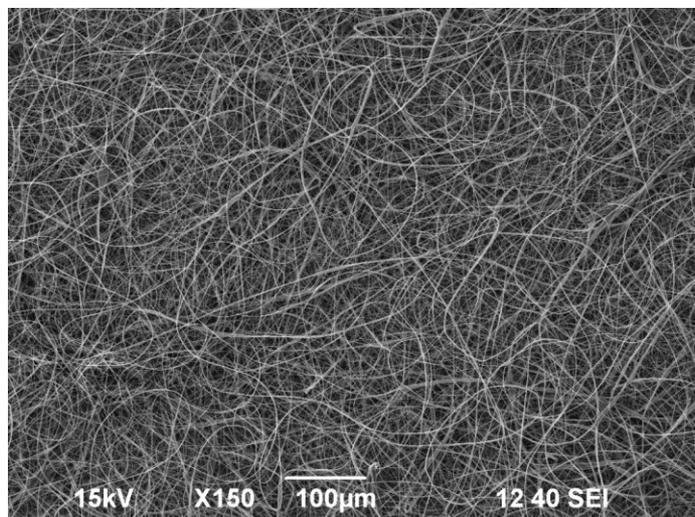
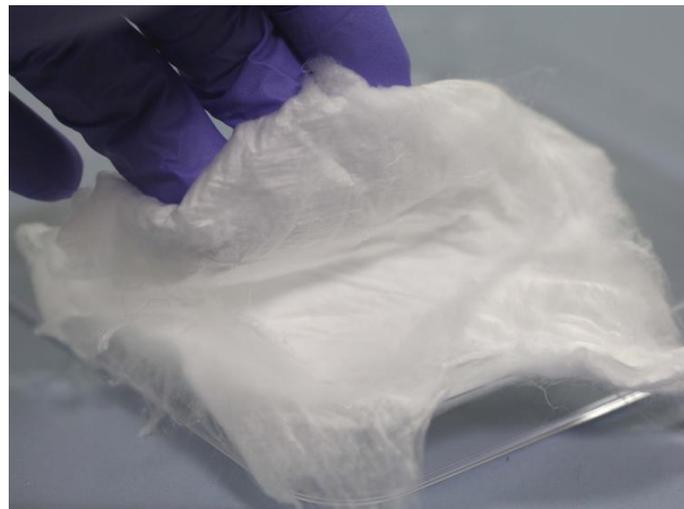
Introduction

- Essential oils are derived from plant distillation and have many pharmaceutical properties.
- One of the properties of some essential oils is their antimicrobial activity.
- In this work oregano and rosemary oils have been used.



Results and discussion

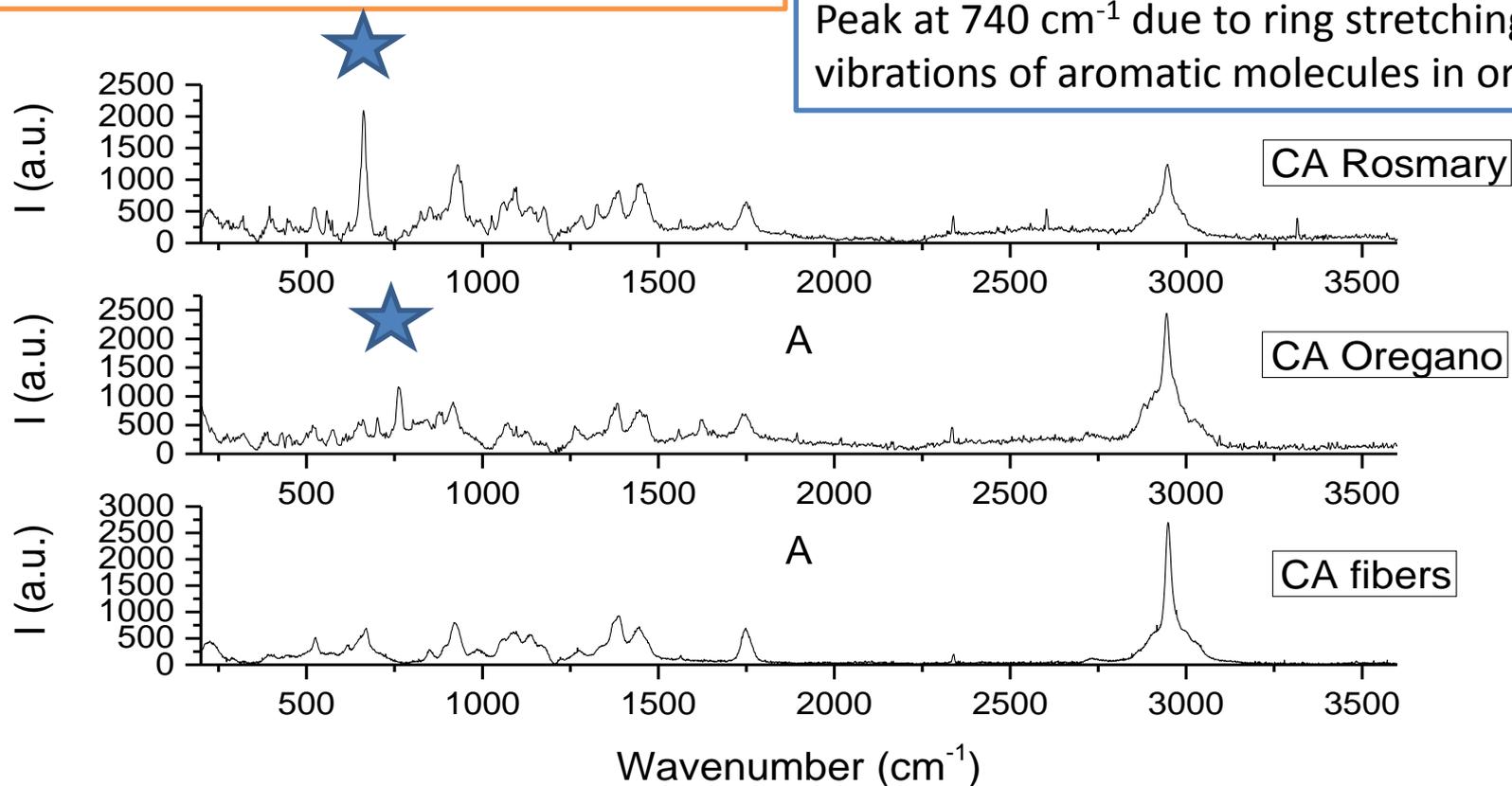
Cellulose acetate (15% w/w) and essential oils are mixed in acetone for 24 h to ensure a complete mixing. Then the solutions are ready to be inserted to the syringe for the electrospinning process.



Results and discussion

Micro Raman spectroscopy was used to analyse the formed fibers and detect the presence of essential oils

Peak at 650 cm^{-1} due to vibrations of camphor molecules in rosemary
Peak at 740 cm^{-1} due to ring stretching vibrations of aromatic molecules in oregano.

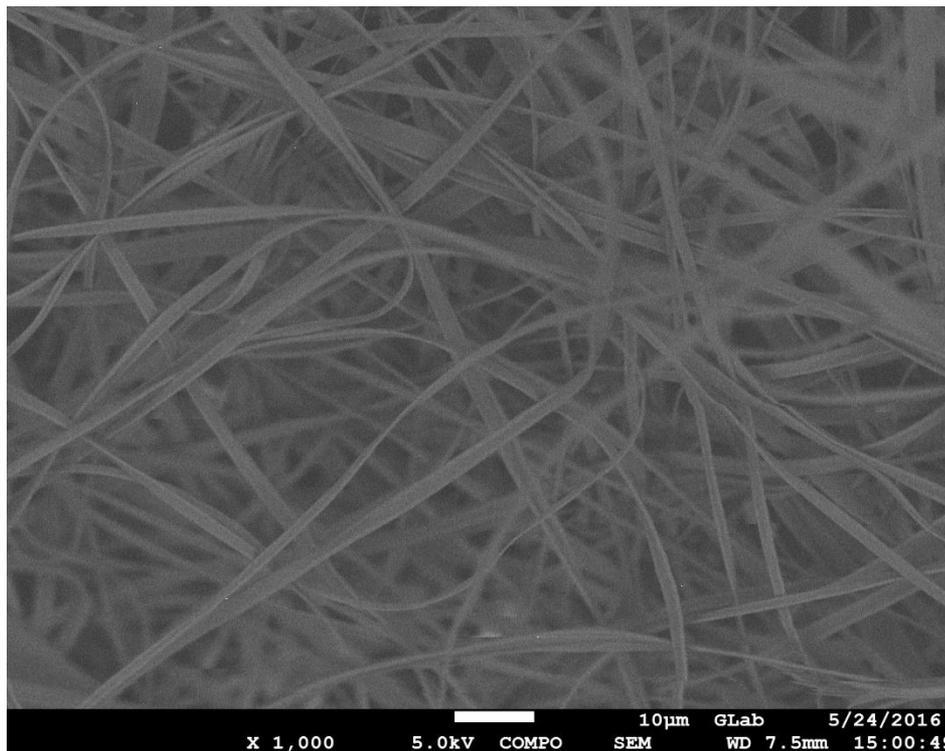


Results and discussion

SEM was used to study the topography and dimensions of electrospun fibers

CA + 1% Rosemary
oil

Diameter
between 800 nm
to 1.2 μm

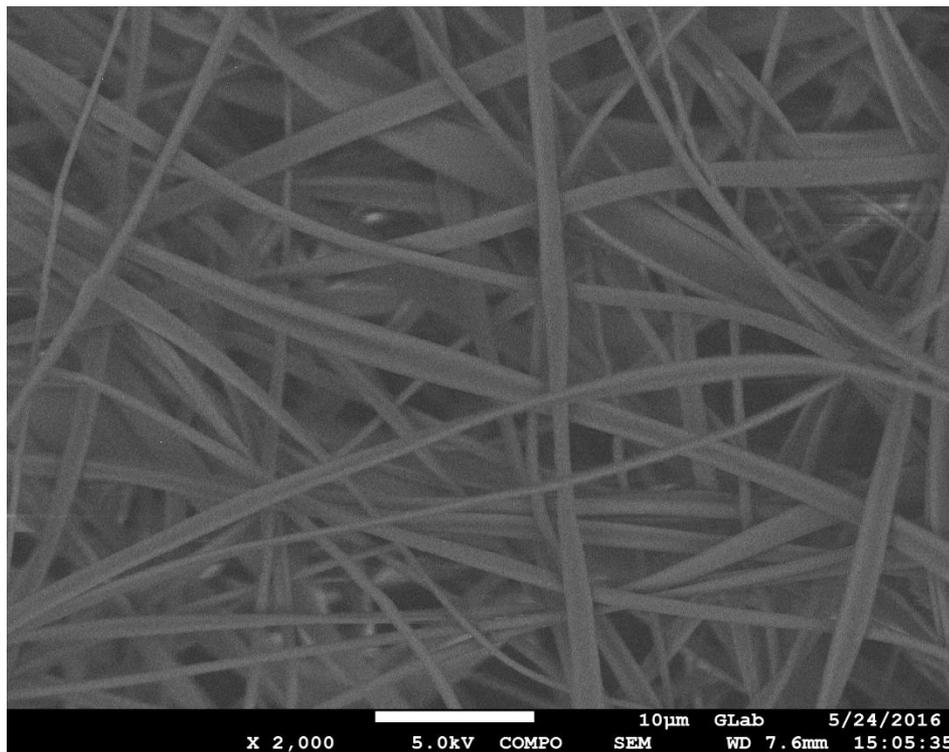


Results and discussion

SEM was used to study the topography and dimensions of electrospun fibers

CA + 5% Rosemary
oil

Diameter
between 800 nm
to 1.2 μm

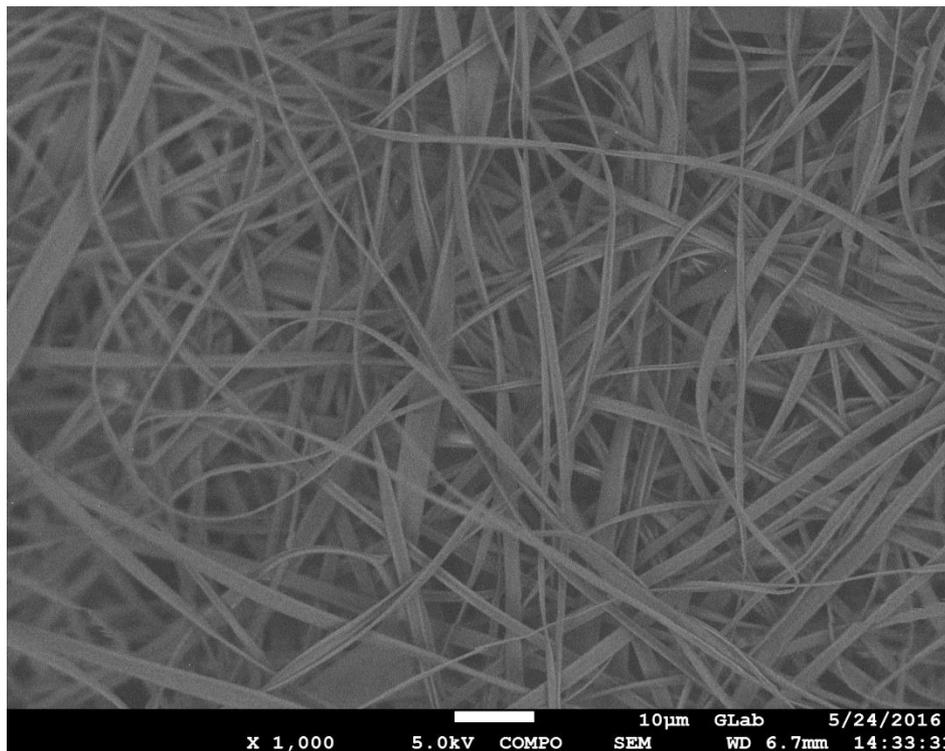


Results and discussion

SEM was used to study the topography and dimensions of electrospun fibers

CA + 1% Oregano
oil

Diameter
between 800 nm
to 1.2 μm

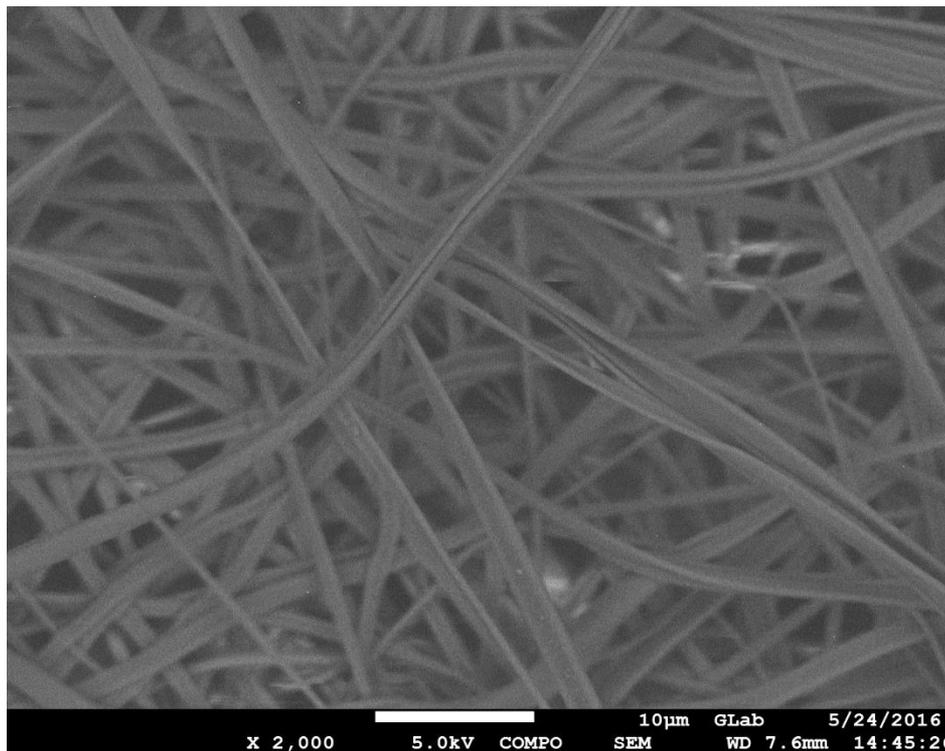


Results and discussion

SEM was used to study the topography and dimensions of electrospun fibers

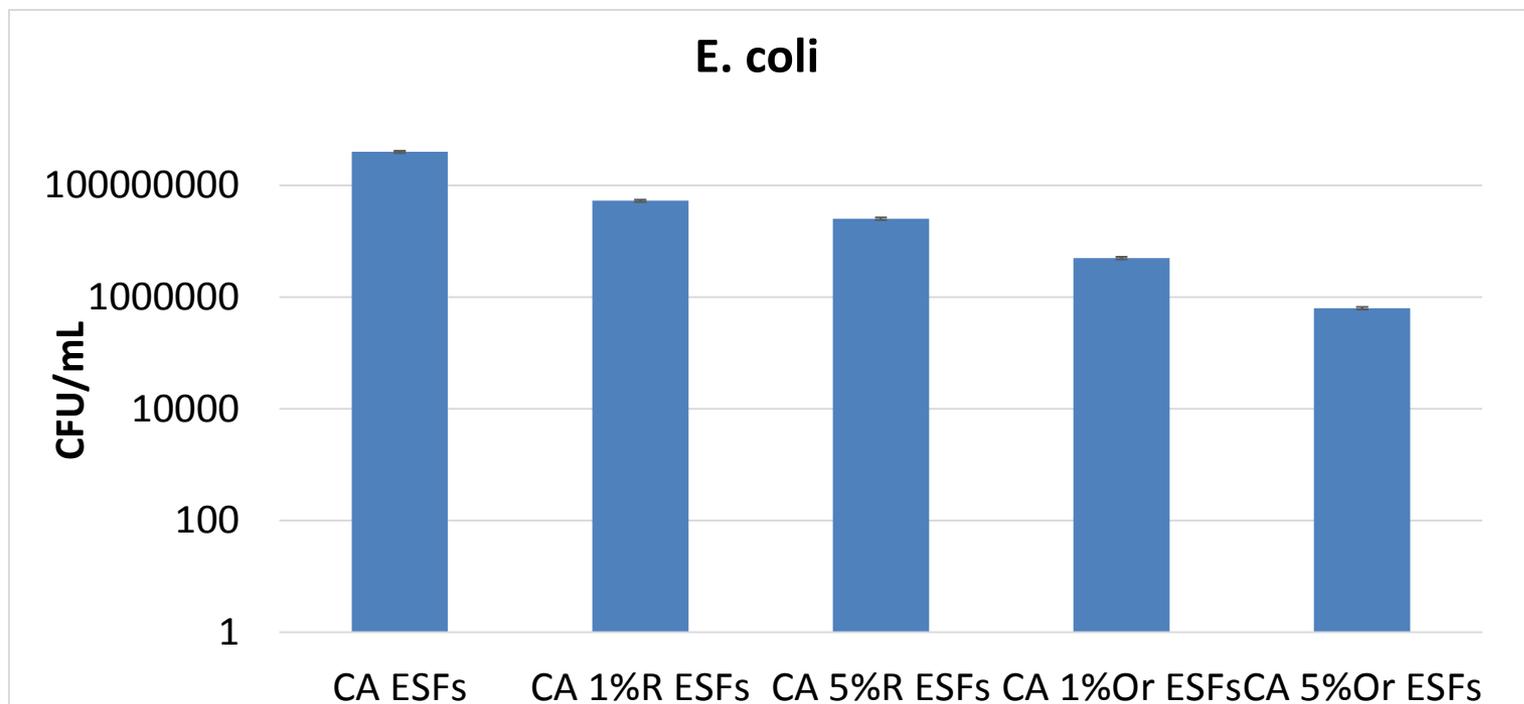
CA + 5% Oregano
oil

Diameter
between 800 nm
to 1.2 μm



Results and discussion

Antibacterial activity of fibers



The electrospun fibers (ESFs) of CA with Rosemary or Oregano oil found to inhibit the *E. coli* growth. The higher their concentration in the fibers the higher the inhibition to *E. coli* growth.



Conclusions

- The electrospun fibers of CA with Rosemary or Oregano oil were made by dissolving the polymer and the essential oil into acetone and then placing the mixture to the electrospun technique.
- The fibers had diameter between 800 nm to 1.2 μm and they were free of defects and homogeneous in composition.
- Essential oils were clearly detected using micro Raman instrument.
- Antimicrobial studies against *E. coli*, showed that the fibers were able to block the growth of such bacteria.
- The higher their concentration of essential oil in the fibers the higher the inhibition to *E. coli* growth.
- Oregano oil found more potent than rosemary oil in blocking the growth of *E. coli*.

