Current Progress of Electrospun Nanocarriers for Drug Delivery Applications

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https://www.journals.elsevier.com/current-opinion-in-biomedical-engineering/editorial-board

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Published book on electrospinning and nanofiber By Seeram Ramakrishna
Nanotechnology in day to day life
Though small making big difference

Nanomaterials synthesis techniques

- Atomic/Molecular condensation
- Vapour deposition
- Sol-gel process
- Spray pyrolysis
- Chemical/electrochemical deposition
- Aerosol process
- Bioretardation

- Spinning
- Sputtering
- Chemical etching
- Thermal/laser ablation
- Mechanical/ball milling
- Explosion process

Electrospun and electrospray nanomaterials: their applications in various domains

Energy
- Including (Solar cell, battery, fuel cells, electronics, oil and gas)

Health Care

Water filtration, Air filtration, Defence

Electrospinning process and various healthcare and biomedical applications of nanofibers

S. M. Shatil Shahriar, et.al., *Nanomaterials* 2019, 9(4), 532
Types of electrospinning, different therapeutics-loaded nanofibers and their route of administrations

S. M. Shatil Shahriar, et.al., Nanomaterials 2019, 9(4), 532
Drug loading strategies to nanofibers

(a) Basic antibacterial delivery systems,
(b) Advanced antibacterial delivery systems (core–shell structure, nanoparticle decorated and multidrug loaded),
(c) Smart delivery systems (stimuli responsive)

S. M. Shatil Shahriar, et al., Nanomaterials 2019, 9, 4, 532
The biopharmaceutical classification system based on solubility and permeability

Class I
High solubility
High permeability

Class II
Low solubility
High permeability

Class III
High solubility
Low permeability

Class IV
Low solubility
Low permeability

Electrospun nanofibers for the delivery of active drugs through nasal, oral and vaginal mucosa

Properties of drug loaded nanofibers in Transmucosal delivery
- Highly mucoadhesive
- Stable formulations
- High surface area
- High porosity
- Suitable for wide range of drugs
- Tailored drug release
- High drug payload
- Ease of administration via different mucosal tissues
- Biodegradable
- Can be prepared aseptically

Administration to different Mucosal Sites
- Oral
- Sublingual
- Vaginal
- Nasal
- Rectal
- Ocular

Hasham S. Sofi, et. al., Materials Science and Engineering: C, 2020, 111, 110756
Drug delivery challenges

Gupta, D. *et.al.*, *Molecules* 2018, 23, 1719
Nanocarriers for drug delivery and biophysicochemical properties

Nanocarriers

Materials
- Carbon nanotube
- Dendrimer
- Protein-drug conjugate
- Polymer particles
- Liposome
- Metal nanoparticles
- Hydrogel particle
- Solid-lipid hybrid particles

Shape
- Cube
- Plate
- Star
- Rod
- Sphere

Surface
- PEGylation or other coating (-SH, NH₂, -COOH)
- Surface charge
- Targeting ligand (Antibody, peptide, aptamer)

Size
1 nm
100 nm
Various mechanisms of drug release from nanocarriers

Solvent control release

Hendrik Hein, et.al., *Surface Science Reports*, 2017, 72, 1, 1-58
Current spinning methods

Electrospinning

Microfluidic spinning

Solution blow spinning

Centrifugal spinning

Electrospray

Jie Cheng, et al., Biomaterials, 2017, 114, 121-143
Types of electrospinning for fabrication of nanocarriers for drug delivery applications
Nanofiber Cross section

Core shell

Hallow

Single fiber

Side by side/ Janus

Coaxial

Triaxial

Multiaxial

Islands-in-the-sea
Materials used for electrospinning

- PAN-MA
- PCU
- PDS
- PPC/PHC Polyamide-6
- Dextran
- Chitin
- Cellulose sodium salt (CMC)
- Methylcellulose (MC)
- Hydroxypropyl methylcellulose
- Collagen
- Gelatin
- Fibrinogen
- Elastin
- Hyaluronic acid (HA)
- Chondroitin sulfate

Synthetic polymers

- PES
- PS
- pNIPAM
- PVP
- PNmPh
- PEU

Natural polymers

- PCE
- PVA
- PGS
- PHBV
- PLA
- PLLA-C
- PEO
- PGA
- PCL
- PCEC

- PLGA
- PU
- PMMA

Microfluidic spinning

- Alginate
- Chitosan
- Silk fibroin

- PPDO-co-PCL-b-PEG-b-PPDO-co-PCL

Jie Cheng, et al., 2017, Biomaterials, 114, 121-143
<table>
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<th>Morphology</th>
<th>Polymer materials system</th>
<th>Drug types</th>
<th>Applications</th>
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</thead>
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<tr>
<td>Particles</td>
<td>PLGA</td>
<td>Doxorubicin</td>
<td>Antineoplastic drugs</td>
<td>[1]</td>
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<tr>
<td>Particles in fiber</td>
<td>PHB</td>
<td>hydroxyapatite nanoparticle</td>
<td>Antineoplastic drugs</td>
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<tr>
<td>Fiber</td>
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<td>Insulin</td>
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<td>Buccal delivery of Carvedilol</td>
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<tr>
<td>Particles</td>
<td>triglyceride tristearin</td>
<td>Superparamagnetic iron oxide nanoparticles and fluorophore</td>
<td>Theranostic agent</td>
<td>[5]</td>
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<tr>
<td>Particles</td>
<td>Lactose</td>
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<tr>
<td>Particles</td>
<td>Alginate</td>
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<td>Long term drug delivery</td>
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<tr>
<td>Fiber</td>
<td>PCL</td>
<td>Metronidazole/ciprofloxacin</td>
<td>Antimicrobial</td>
<td>[8]</td>
</tr>
<tr>
<td>Particles in fiber</td>
<td>PLGA</td>
<td>NaYF₄:Eu³⁺</td>
<td>Antineoplastic drugs</td>
<td>[9]</td>
</tr>
<tr>
<td>Fiber</td>
<td>PCNU</td>
<td>Antimicrobial oligomer (AO)</td>
<td>Antimicrobial</td>
<td>[10]</td>
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<tr>
<td>Particles</td>
<td>PLGA</td>
<td>Curcumin</td>
<td>Antineoplastic drugs</td>
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Conclusion

- In conclusion, it is clear that the electrospinning method by the generation of desired nanofibers and nanoparticles possesses excellent potential in pharmaceutical applications.

- However, optimization of the different factors is crucial to generate nanocarriers with the desired function and morphology for drug delivery application.

- Also, the electrospinning approach is an effective strategy for sustainable drug release, target delivery, and encapsulation of drugs.

- Moreover, there are drawbacks to this system for the commercialization of nanocarriers for drug delivery. Therefore, further studies, standardization, and understanding of public health concern are required to develop marketable products.
Thank You

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References


References


