Electrospinning of Cyclodextrin Functionalized Nanofibers

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STATEMENT OF PURPOSE/OBJECTIVE

The purpose of our study is to produce cyclodextrin (CD) functionalized nanofibers by means of electrospinning.

INTRODUCTION

Cyclodextrins (CDs) are cyclic oligosaccharides consisting of α-(1,4)-linked glucopyranose units. The most common CDs are α-, β- and γ-CD with 6, 7 and 8 glucopyranose units, respectively (Figure 1). Their truncated cone-shaped molecular structure enable them to form host-guest inclusion complexes (ICs) with variety of molecules such as antibacterials, drugs, antioxidants, flavors, fragrances and pollutants etc. in order to improve the various properties of these molecules. For instance, increasing shelf life of foods with flavor/CD-ICs and controlling the release of poorly soluble drugs by forming inclusion complex between drug and CDs.

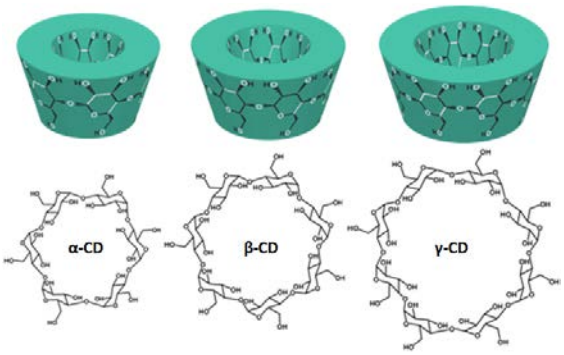

Figure 1. The schematic representation of α-, β- and γ-CD

Electrospinning is a versatile, cost effective and one of the most promising method to obtain nanofibers from polymers, polymer blends, sol-gels, metal oxides, ceramics, composites with diameter ranging from micrometer to nanometer range. During electrospinning process, high voltage is applied to the polymer solution or melt, therefore the solution is charged and a repulsive force is originated. When aforementioned force overcomes the surface tension of the solution, jet is formed and then fibers are formed on the grounded collector (Figure 2). Owing to the unique properties of electrospun nanofibers such as highly nanoporous structure and high surface to volume ratio, nanofibers are able to be used in many areas such as membranes/filtration, textiles, energy storage, biotechnology, tissue engineering and drug delivery systems. In addition, incorporation of additives inside the electrospun nanofibers could be achieved due to the design flexibility of these nanofibers [1-3].

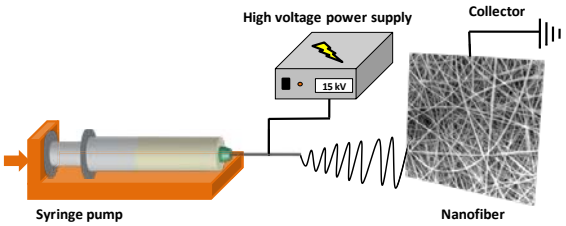

Figure 2. Schematic view of electrospinning

APPROACH

In our first study, we obtained electrospun nanofibers from cyclodextrins without using a carrier polymer matrix. Secondly, electrospun nanofibers including CD-ICs of several fragrances/flavors were produced. Lastly, surface of the electrospun nanofibers was functionalized by CDs [4-7].

RESULTS AND DISCUSSION

In electrospinning, normally high molecular weight polymers are used with high polymer concentrations due to the necessity of chain entanglement and overlapping. Therefore, electrospinning of CD and CD-ICs is a big challenge. Nevertheless, we attained nanofibers from cyclodextrin derivatives such as hydroxypropyl-β-cyclodextrin (HPβCD), methyl-β-cyclodextrin (MβCD) and hydroxypropyl-γ-cyclodextrin (HPγCD) without a carrier polymer matrix (Figure 3) [4-7].

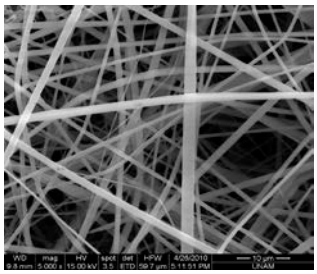

Figure 3. The representative SEM images of the electrospun HPβCD nanofibers obtained from water solution

In another study, nanomaterials for active food packaging and nanotextile were manufactured. We encapsulated CD-ICs of several fragrances/flavors into electrospun polymeric nanofibers (Figure 4). Due to the inclusion complexation; the controlled release, high thermal stability and long term shelf life were achieved for volatile compounds (fragrances/flavors) [7].

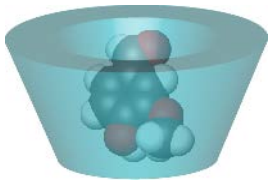

Figure 4. Inclusion complex of vanillin with CD

Finally, our motivation was combining CDs' ability to form inclusion complexes with various organic compounds and high surface area of nanofibers. For this purpose, we functionalized the surface of electrospun nanofibers with CDs and then we investigated the removal of organic wastes from the solution via so-called functionalized electrospun nanofibers.

CONCLUSION

As a conclusion, we produced CD functionalized electrospun nanofibers for different purposes such as molecular filtration, nanotextiles, active food packaging and slow release systems. These nanofibers are superior to others due to the high surface area of electrospun nanofibers and specific functionality of the CDs. This talk summarizes our recent findings on electrospun cyclodextrin functionalized nanofibers/nanowebs.

FUTURE WORK

As a future work, firstly the molecular filtration capability of CD nanofibers will be investigated. Secondly, the antibacterial and antioxidant activity of nanofibers containing IC of CD and related guest will be evaluated. Finally, specific molecular filtration studies will be done for surface functionalized nanofibers.

ACKNOWLEDGMENTS

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