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Different nozzle types in electrospinning applications

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ABSTRACT

Electrospinning technique, which is the most common method in the production of nanofiber filament, has been used for a long time, and it continues to be developed and gained new features with the changes made day by day. The parameters affecting the production depend on the main topics of solution properties, ambient parameters and operating parameters. In this study, the types of nozzles used in the electrospinning technique and their usage patterns are examined as a part of the production conditions. General information about the nozzles is given by examining the studies in the literature.

Introduction

The most common method for nanofiber production is the electrospinning method. In this method, nanofiber jet formation is provided by using electrical charges. With the effect of electrical charges, these jets are depositing on a grounded surface, then a nanofiber surface is obtained [1].

Today, nanofiber-sized surfaces produced by using the electrospinning method are widely used in the filtration industry, biomedical fields, tissue engineering and textile fields. Since the desired properties can be obtained in a low volume, the usage area and the resulting need are increasing even more [2].

The traditional electrospinning method is applied using a syringe with a single chamber and a single nozzle. In this way, nanofiber surface production can be done with very low values such as 0.1g/h or 0.01g/h. In line with the increasing demand, different nozzle types are being researched and innovations are brought to the literature [3].

In this study, types of nozzles produced as an alternative to the traditional electrospinning method and their usage patterns were investigated.

Nozzle Types and Usage in Electrospinning Process

Nozzles have important roles such as increasing efficiency, adjusting process parameters and controlling fiber morphology [4]. In order to obtain nanofiber surfaces,where includes different solutions can be used and which can have different properties on a single surface, it is necessary to use multiple nozzles or coaxial nozzles. Since the production speed of nanofibers produced with using a single nozzle is low, multiple nozzles or multi-hole nozzles are used. It is difficult to prepare mixed solutions and ensure homogeneity, since the consumable chamber is single in multi-hole and single nozzle use. Single nozzle, parallel multiple nozzle, circular multiple nozzle, coaxial nozzle and triaxial nozzle, which were developed for use in many applications, are shown in Figure 1 [5-6].

Multi-chamber nozzle that is using in coaxial electrospin works is called coaxial nozzle. Although they are most commonly used with 2 chambers, they can be designed with more chambers. Using this type of nozzle allows the materials to be spun to form a surface by covering each other. In these fibers, the inner surface is called the core, and the outer surface is called the shell. Since the fibers formed by the use of coaxial nozzles provide the properties

of the materials used in fiber size, the desired nanofiber surface can be obtained more easily. Figure 2 and Figure 3 show schematically how electrospinning processes are applied relative to the nozzles [7].

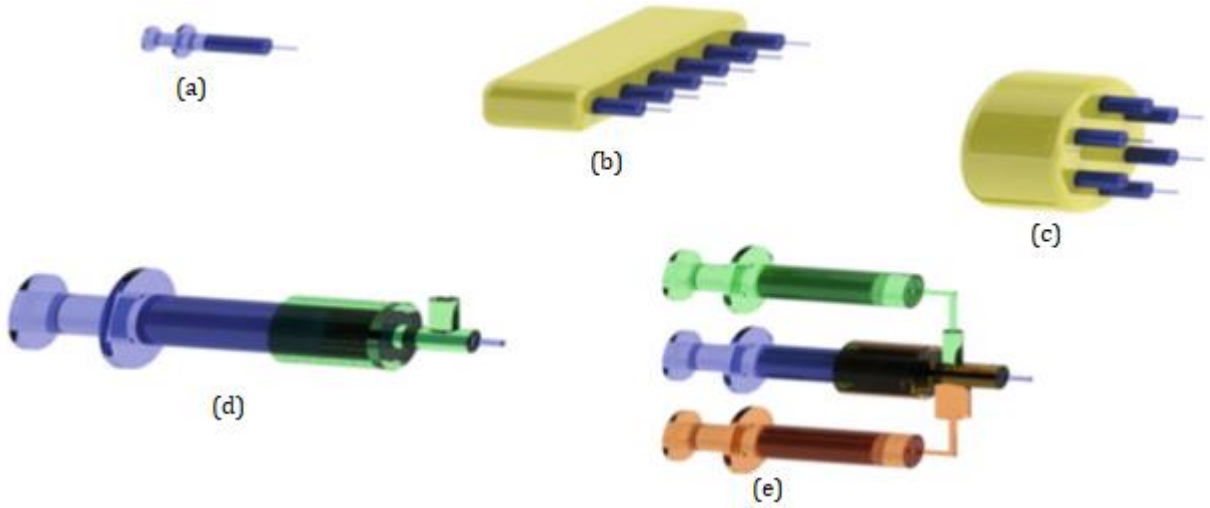
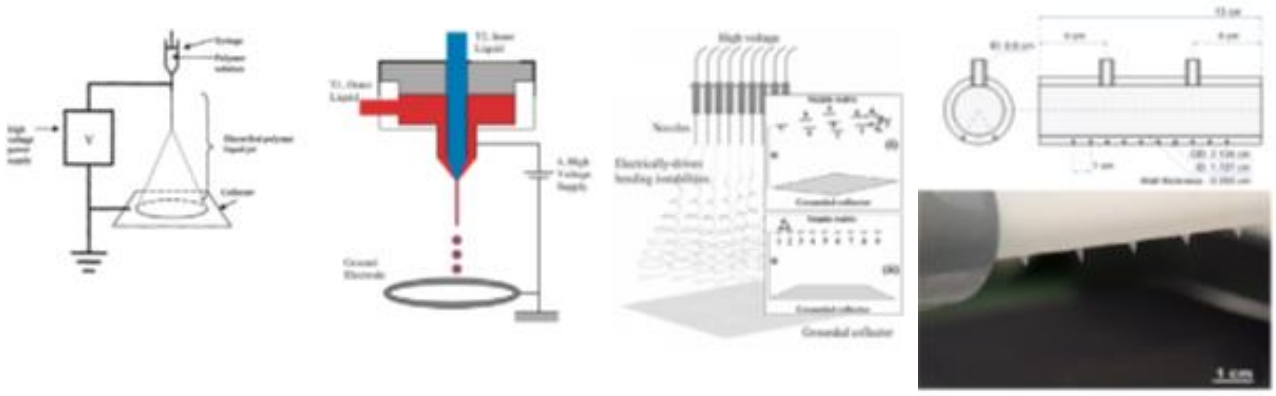
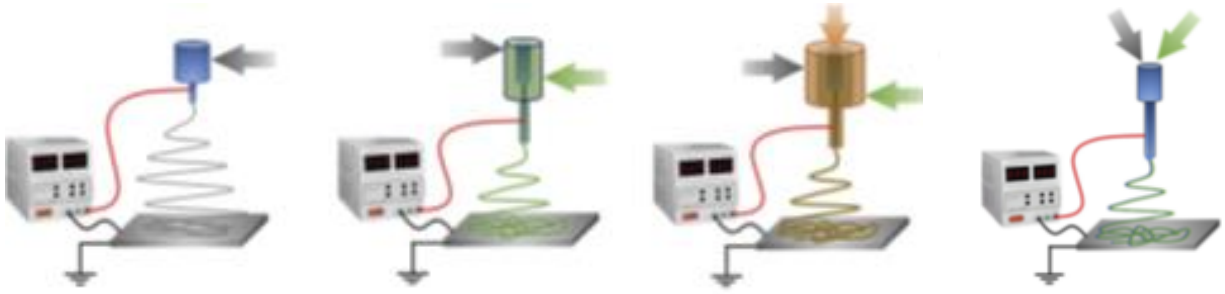


Figure 1. (a)single-nozzle, (b)parallel multi-nozzle, (c)circular multi-nozzle, (d)Co-Axial Nozzle, (e)Triaxial Nozzle [1]



(a) **(b)** **(c)** **(d)**

Figure 2. Evolution of the electrospinning system: **a)** single-jet electrospinning system; **b)** coaxial electrospinning; **c)** multi-nozzle electrospinning; **d)** multihole electrospinning; [9]



(a) **(b)** **(c)** **(d)**

Figure 3. (a) Traditional electrospinning, (b) Co-axial electrospinning, (c) Triaxial electrospinning, (d) Multichannel electrospinning, [2]

Coaxial nozzle types are also divided into three groups, as seen in Figure 4. This grouping made according to the nozzle ends and changes the properties of the formed fiber and surface. Although not much work has been done on this subject yet, the most commonly used type is inward coaxial nozzle [8].

Figure 4. Coaxial Nozzle End [3]

Results and Discussion

With the use of multi-hole and multi-nozzle in electrospinning applications, the production has been accelerated, but the efficiency has decreased due to the repulsion of the formed jets as a result of electrical forces.

Conclusion

In nowadays electrospinning applications, using nozzle types that can meet multiple conditions for the needs, the production speed has been increased and the co-production of fiber-sized materials has been ensured.

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Author contributions:

Uzay Gezer: Conceptualization, Investigation, Methodology, Writing-Original draft preparation. **Bünyamin Demir:** Investigation, Visualization, Writing-Original draft preparation. **Alper Günöz:** Visualization, Writing-Reviewing and Editing, Writing-Original draft preparation. **Memduh Kara:** Conceptualization, Methodology, Writing-Reviewing and Editing. **Yusuf Kepir:** Investigation, Writing-Original draft preparation.

Conflicts of interest:

The authors declare no conflicts of interest.

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