National University of Science and Technology POLITEHNICA Bucharest

Doctoral School of Chemical Engineering and Biotechnologies

ANTIMICROBIAL NANOSTRUCTURED MATERIALS FOR BIOMEDICAL APPLICATIONS

- Ph.D. Thesis Summary -

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1. Introduction

Nanotechnology is defined as the science that deals with manipulating and controlling matter at the nano level, being a multidisciplinary field that involves knowledge from multiple research areas [1,2]. In the medical field, nanotechnology contributes to a revolution through the development of nanomedicine, improving aspects such as diagnosis, personalized and targeted therapies, treatment costs, drug efficiency, and patients' quality of life [3]. Researchers focus on obtaining nano-sized materials with versatile and tunable properties, such as high surface-to-volume ratios, which make them ideal for creating innovative medical therapies [2,4,5].

Nanofibers are a type of nanomaterial that stand out due to their small diameter, with dimensions varying depending on the material used and manufacturing procedure, with lengths between a few nanometers and a few micrometers, large specific surface area, porosity, and ability to be functionalized, being of interest for applications such as medical uses, filtration membrans, sensors, protective clothing, and energy devices [6-8].

Nanofibers can be obtained by combining multiple materials, which contributes to improved mechanical strength, biocompatibility, and responsiveness [8,9]. This type of composite nanomaterial can be synthesized using various methods, including numerous conventional and modern methods. One of the outstanding nanofiber manufacturing methods is electrospinning, which offers precise control over fiber diameter, porosity, surface chemistry, and structural integrity [10]. Furthermore, recent studies are focusing on obtaining electrospun nanofibers from the recycling and reuse of polymer waste (e.g., polyethylene terephthalate (PET), polyamide, polystyrene, polyvinyl chloride), thus limiting their large-scale use and reducing pollution, ensuring their safe use in different applications [11-13].

In this regard, nanotechnology can be considered an alternative that offers technological solutions, particularly in waste management, demonstrating significant effectiveness compared to conventional alternatives in recycling [14]. At this moment, environmental pollution and climate change represent a serious worldwide problem that can seriously affect human beings' health by causing many health problems, such as allergies, cardiovascular disorders, infant mortality, and economic development [15]. In liquid waste treatment technologies, nanomaterials enhance the absorption of persistent contaminants more effectively than conventional chemicals due to their increased reactivity and selectivity for pollutants. Moreover, the use of nanotechnology reduces the traditional treatment steps required,

consequently reducing the energy, costs, and treatment time needed [16]. Additionally, plastic waste can pose severe environmental and public health issues due to its capacity to degrade into micro- to nanosized particles that are easily dispersed into the air, water, and soil [17].

Another global concern is the prevalence of bacterial infections, a leading cause of death. In this case, reducing deaths caused by multidrug-resistant bacterial infections is a global public health issue. At the same time, bacterial infections are not only prevalent in developing countries, but morbidity and mortality rates are also significantly higher. One alternative for treating and eradicating infections is to use antibiotics without harming the host. However, some bacteria have developed resistance to certain antibiotics, frequently causing severe infections in community and hospital settings. Pathogens can cause different types of infections, including urinary tract infections, post-surgical (wounds), respiratory infections, bloodstream (sepsis), and pneumonia. Thus, the need to develop new infection control strategies is also extremely urgent [18-20].

Thus, nanotechnology can be used to recycle plastic and develop new anti-infectious strategies. For example, PET is a non-biodegradable polymer that represents a severe worldwide environmental threat. Nanotechnology involves new strategies for PET recycling, obtaining electrospun nanofibers that can be used in different application fields, including antimicrobial applications [14,21,22]. Thus, electrospinning can be involved in PET fiber manufacturing due to its simple and cost-effective way of obtaining them [23,24]. Moreover, their applicability in the medical field has also been studied. Considering the electrospinning process, the choice of material is essential so that properties such as morphology, mechanical resistance of the fibers, degradation rate, and biocompatibility are optimal for medical applications. Thus, in recent years, these fibers have been studied in various medical applications, including tissue engineering and regenerative medicine, wound healing, drug delivery systems, diagnostics, biosensors, medical implants, and other related fields [25-28].

In this case, this thesis aims to highlight the use of the electrospinning technique in the production of PET-based fibers while highlighting the impact and involvement of nanotechnology in the transformation of one of the most widespread plastic pollutants (i.e., PET) into a recycled material with potential use in biomedical applications, especially in fibers with antimicrobial properties. At the same time, this work aims to open new research opportunities that will lead to the evolution of this field, with the possibility of expansion and utilization on a large scale.

2. Electrospinning

Electrospinning is a versatile and viable technique used to manufacture continuous thin and ultrathin fibers with superior properties (e.g., high specific surface area, high porosity, variable pore size distribution (10-100 nm), low density, and a surface that allows functionalization) [29-32]. This technique enables precise control over the morphology and structure of fibers by adjusting process parameters, such as solution viscosity, voltage, and collector configuration [33].

The working principle involves applying a high voltage to a liquid solution or melt between two conductors, allowing the applied electrostatic charges to stretch the liquid droplet into fibers. A schematic of the equipment used is shown in Figure 1.

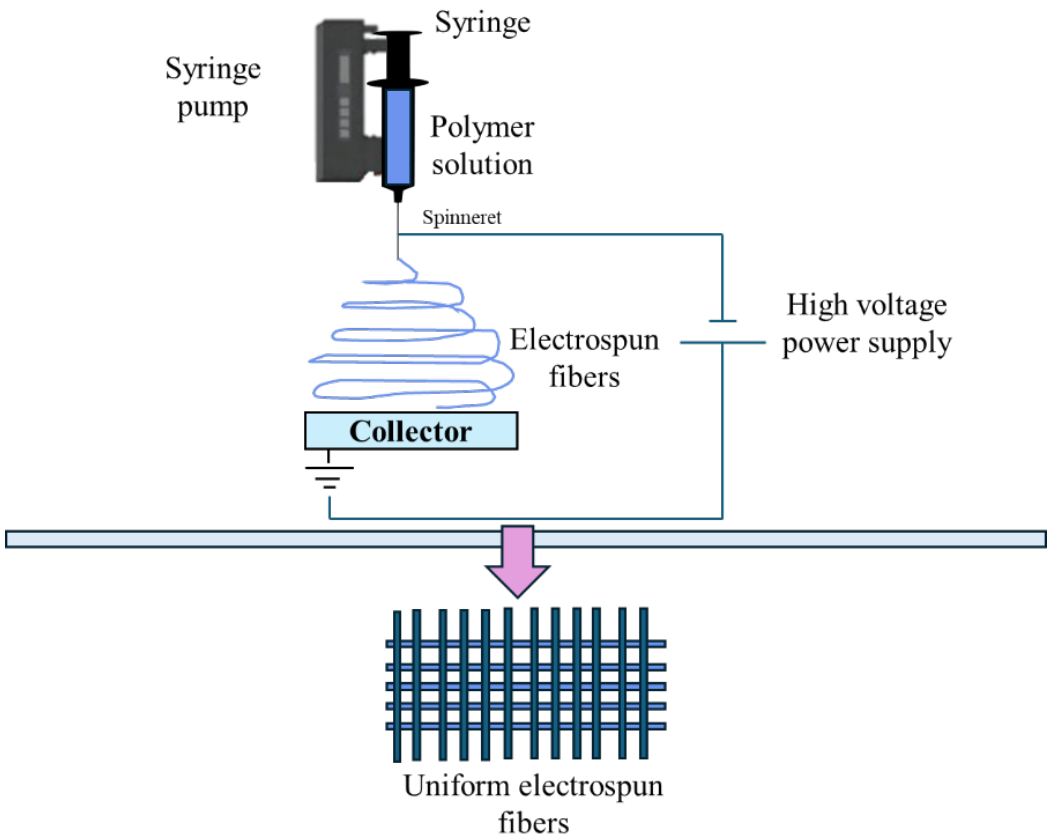


Figure 1. Electrospinning process. Created based on information from [34-36].

Moreover, the electrospinning process is classified based on spinneret configuration into two groups: needle-based (Figure 2) and needleless (Figure 3).

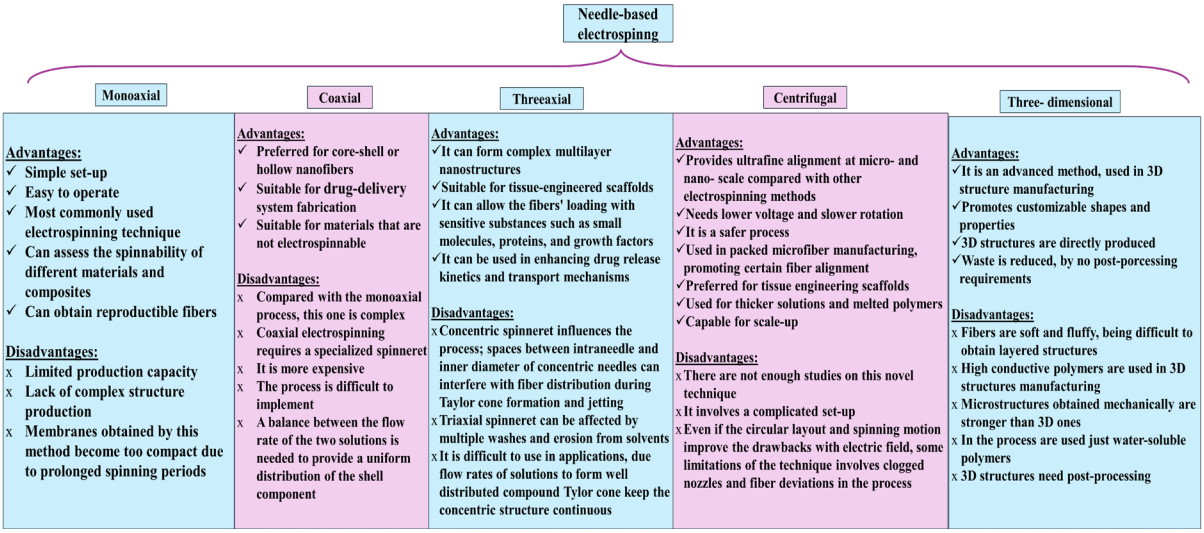


Figure 2. Needle-based electrospinning methods. Created based on information from [37].

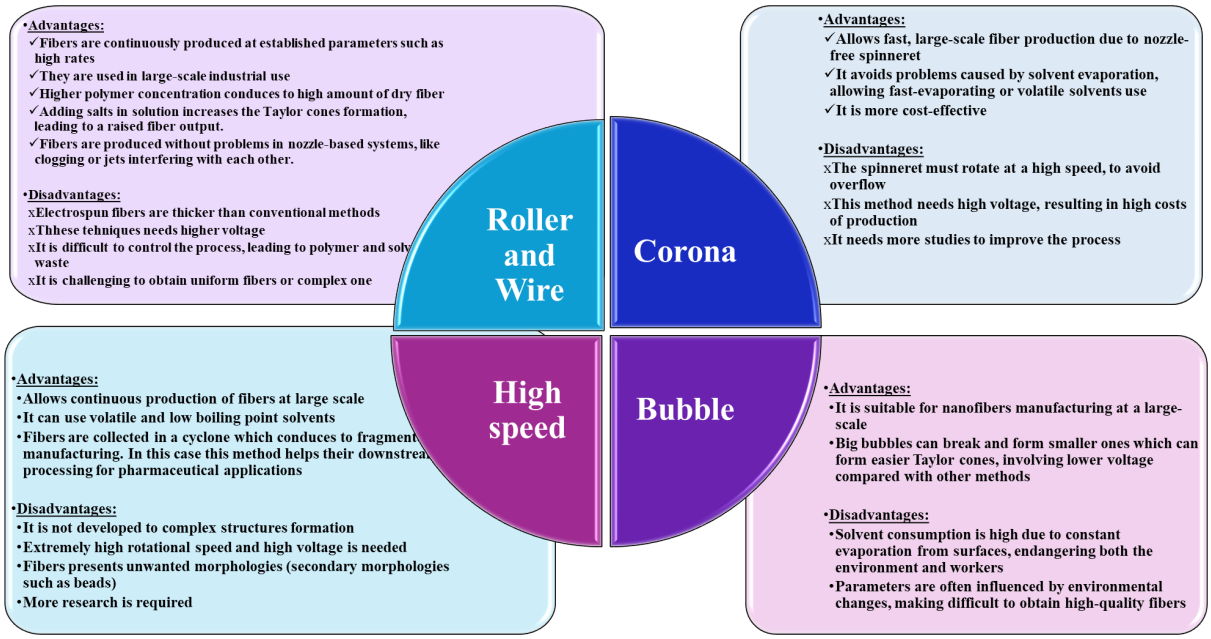


Figure 3. Needless electrospinning methods. Created based on information from [37].

Obtained electrospun fibers are characterized by nanometer-to-sub-micrometer sizes, which confer an exceptional surface-to-volume ratio. This ratio, combined with increased porosity, enhances their suitability for numerous applications, including filtration, drug delivery, and tissue engineering [38]. Moreover, in the medical field, electrospun nanofibers can be used to obtain structures that mimic the extracellular matrix (ECM), thereby introducing them in applications where cell adhesion, proliferation, and differentiation are required [39].

By selecting appropriate materials, electrospun fibers can be modified to ensure biocompatibility and biodegradability [40,41]. Several types of polymers have been successfully

used in the electrospinning process. Both natural polymers (e.g., chitosan, hyaluronic acid, gelatin, alginate) and synthetic polymers (e.g., polylactic acid, polyglycolic acid, polyurethane, polyvinyl alcohol), as well as composite materials, are suited for the electrospinning process. Natural polymers can be utilized due to their enhanced biodegradability and because they are derived from renewable sources, thereby also improving the properties of natural polymers for safe use in various applications [30,32,42,43].

A particularly useful synthetic polymer is polyethylene terephthalate (PET). This linear homopolymer has two structural forms, amorphous (transparent) and semi-crystalline (opaque and milky white), and is widely produced due to its properties, such as high tensile strength, abrasion resistance, chemical resistance, and stability [14,44-47]. Due to its remarkable features, PET is often used in packaging, the textile and automotive industries, as well as the electronic, construction, and medical fields [14,47-49].

While PET has many benefits, it is a significant contributor to pollution, with a substantial presence in municipal solid waste, estimated to be 12% by volume globally [50]. PET degradation is essential and can be achieved in several ways, including thermal, mechanical, chemical, hydrolytic, radiative, and biochemical processes, which produce polymer chain scissions [49,51,52]. Currently, recycling PET focuses on high-value recycling approaches, such as electrospinning recycled PET (rPET), which can be used to obtain nanofibers for different applications, including medical applications [53,54].

Electrospun fibers can be utilized for a wide range of medical applications. One of the most appealing applications is their use as drug delivery systems. A drug delivery system (DDS) represents a formulation or a device that provides a safe and effective way of administering pharmaceutical compounds through the body, using different formulations, to achieve optimal therapeutic outcomes. Moreover, DDS are developed to enhance the bioavailability and pharmacokinetic profile of active substances, improving their release and stability, and targeting specific body tissues [55-57].

Depending on the treatment requirements, DDS can be administered through various routes, as presented in Figure 4. Even if formulations addressed to these administration routes are widely used, conventional dosage forms suffer from limitations such as the need for frequent dosing, systemic side effects, and poor bioavailability [55].

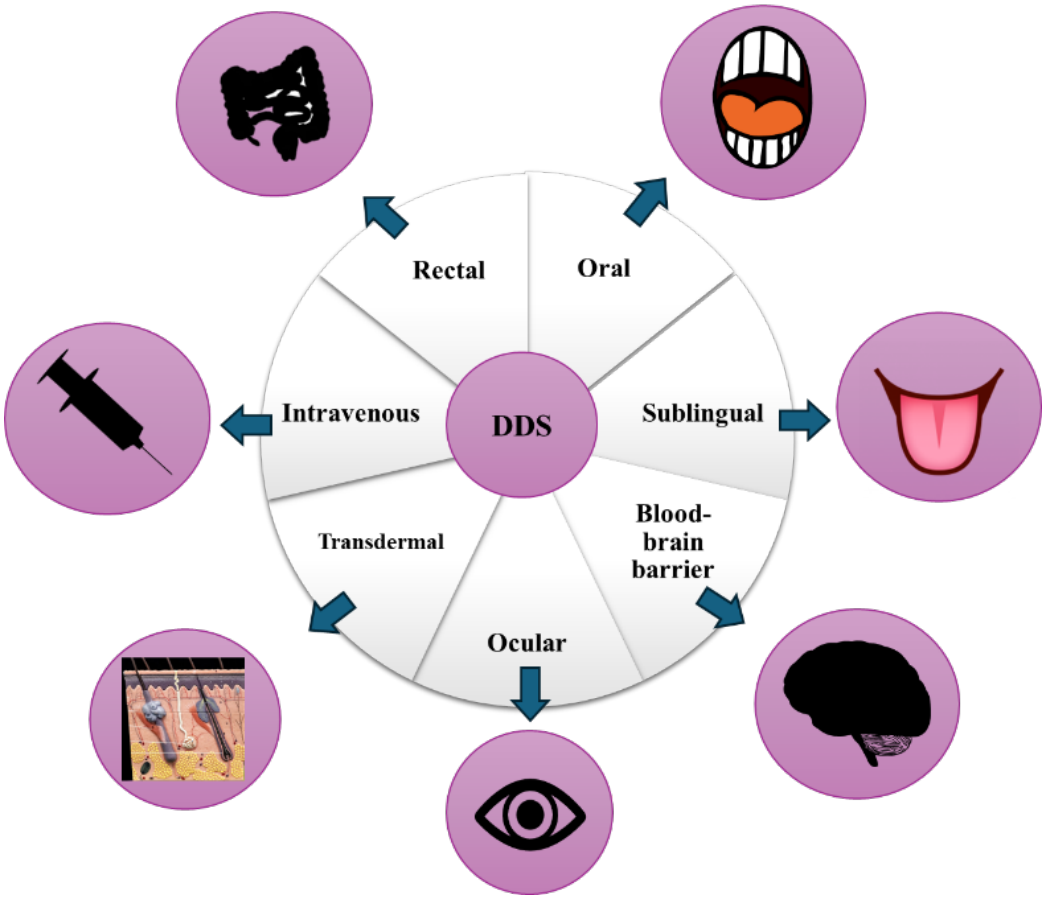


Figure 4. Drug delivery routes. Created based on information from [58-60].

Thus, as a result, an advanced delivery system that can overcome these challenges is needed. In this context, electrospun fibers offer several advantages, including reduced toxicity compared to conventional dosage forms, high drug-loading capacity due to the density of the fibers, and the ability to form complex structures suitable for various applications in drug delivery systems. Additionally, these fibers facilitate the simultaneous administration of multiple therapies, enabling both immediate and extended-release delivery [61,62].

Acting as a barrier, skin is susceptible to damage [63]. Wound healing (Figure 5) is a complex process divided into four phases (hemostasis, inflammation, proliferation, and remodeling) in which immune, endothelial, and fibroblast cells are involved [64-67].

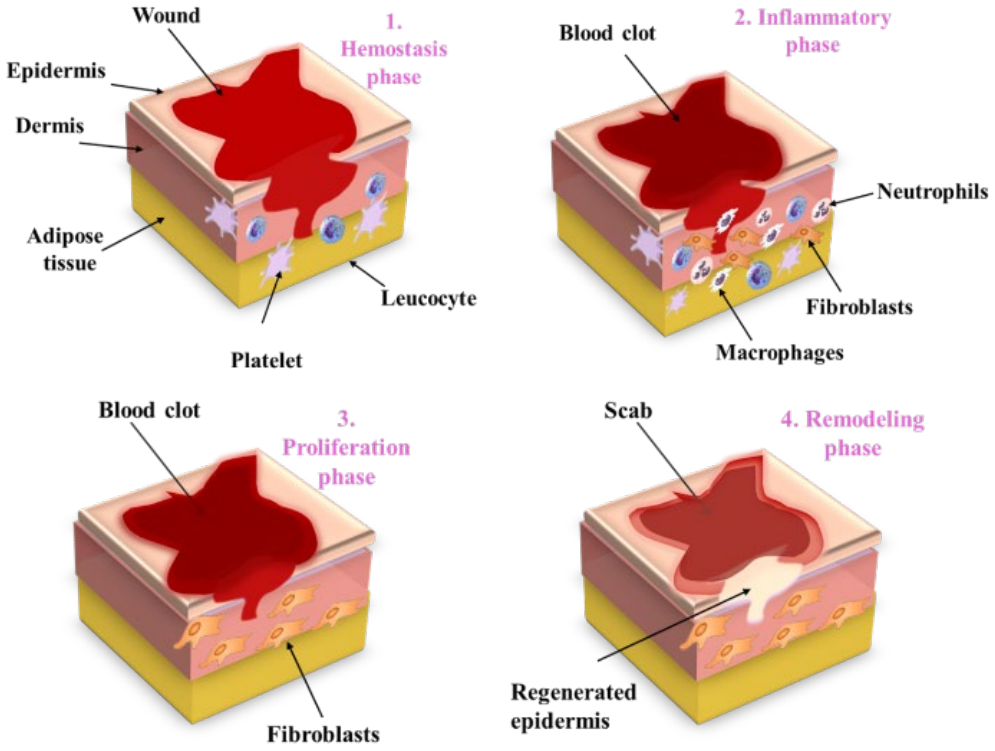


Figure 5. Wound healing process. Created based on information from [64-67].

To aid this natural process and accelerate healing, wound dressings of various sorts can be employed. To create advanced wound healing strategies, electrospun fibers can be involved. Electrospun fibers have been shown to have advantageous wound-healing properties because of their similarity to ECM, which promotes cell growth and proliferation, reducing inflammation and relieving pain through drug release [68-70]. Also, the porosity of electrospun materials can lead to efficient absorption of exudate from the wound surface, forming an ideal environment for tissue regeneration. At the same time, the large surface area of the fibers can allow the loading of active substances and growth factors to facilitate the process. Electrospun fibers can be loaded with different active substances or biomolecules to facilitate wound healing. Thus, fibers have been loaded with different therapeutic agents such as (curcumin, ciprofloxacin, tetracycline, diclofenac, or gentamicin), nanoparticles with an increased antimicrobial effect (titanium dioxide - TiO_2, silver nanoparticles - AgNPs, zinc oxide - ZnO, cerium oxide CeO_2), natural substances (essential oils), but also growth factors [68,71].

Regarding medical implants, the material choice is of great importance to ensure optimal outcomes. In this respect, electrospun fibers exhibit a series of advantages. Thus, these fibers are designed to have a better resemblance to the ECM of the tissues in which the implantation will be performed by regulating the porosity and pore size by the high specific surface area and

surface-to-volume ratio, which helps cell adhesion, proliferation, and differentiation [72]. The electrospinning technique can be used to obtain three-dimensional scaffolds that closely resemble the tissue, which is an important consideration for their implantation [73]. Also, the choice of materials makes electrospun fibers important in the design of implants, thus determining optimal properties specific to the tissue where the implantation is performed. Electrospun fibers are easily functionalized; they can be loaded with antimicrobial agents, growth factors, and drugs, thereby enhancing the healing effects of implants [40,74]. This aspect also targets therapy, promoting both tissue regeneration and the prevention of infection at the implant site [75,76].

Also, in terms of biocompatibility, the choice of materials is important. Thus, electrospun fibers may be capable of supporting various cellular activities, including cell adhesion, proliferation, and differentiation [77]. Modifying the fiber surface can enhance these activities and improve the interaction between the scaffold and tissue [78]. The degradation rate of fibers may be a key factor for their successful use in targeted applications. Too rapid degradation can lead to inadequate tissue regeneration, while longer degradation can lead to an inflammatory response. To avoid the latter, electrospun fibers are generally functionalized with anti-inflammatory agents to minimize immune responses [38,78]. This prevents the human body from rejecting the implants [75,76].

Electrospun fibers are considered a breakthrough innovation in medical implants due to their exceptional properties [40]. In terms of their use in medical implants, they could be used in several fields. The fibers can be used in vascular grafts and stents, as they mimic the structure of blood vessels, which helps prevent thrombosis and promotes cell growth [74]. Using biodegradable polymers is necessary and can lead to limited tissue interventions [78]. In bone tissue engineering, fibers have been used to create scaffolds that incorporate growth factors to enhance bone regeneration by accelerating osteogenesis. For wound healing, they have also been loaded with antimicrobial agents, leading to improved skin healing [72,74-76].

Another interesting application is for tissue engineering. Tissue engineering (TE) represents a multidisciplinary domain that combines various fields, including biology, medicine, chemistry, and pharmaceutics, as well as engineering, to innovate and develop functional tissues. This is achieved by utilizing supports, biomaterials, biologically active ingredients, and cells to restore the function of damaged tissues [79,80]. So, TE can be classified into two main categories: *ex vivo* and *in situ*. *Ex vivo* TE uses stem cells that are isolated from the patients and then placed in a scaffold to create an appropriate environment that promotes proliferation and differentiation into the desired tissue, while *in situ* TE involves scaffolds made

of biocompatible materials implanted directly into the defect without the need for cells. Both methods have advantages and disadvantages. *Ex vivo* TE involves high costs, inadequate cell proliferation, and, most importantly, rejection of the implant by the patient's body, while *in situ* TE avoids implant rejection by the patient's body, but poor mechanical properties of the newly formed tissue, as cell differentiation cannot be controlled, represent this method's drawbacks [79,81].

Electrospun nanofibers became widely used in tissue engineering as scaffolds because of their mechanical properties and porosity, creating a favorable environment for cell adhesion, growth, and proliferation similar to ECM [82,83]. Studies have reported the utility of various electrospun fiber formulations for developing scaffolds for applications in skin [84,85], bone [86,87], and nerve tissue engineering [88,89].

Regarding the specific case of electrospun PET- and rPET-based materials, they are utilized in various domains, including medical applications [90]. Thus, many studies have focused on the potential of PET in biomedical components (e.g., catheters, vascular grafts, and heart valves) [91]. As bacterial infections represent a significant public health concern, the use of PET and rPET for fabricating membranes with antimicrobial potential has garnered recent attention [92].

Despite its versatility, low cost, and extensive applications in biomedical fields [93], this technique still faces limitations regarding solvent toxicity, fiber quality, scalability, and theoretical modeling that hinder its industrial translation [30,93-95]. One significant challenge in the electrospinning process is the lack of control over fiber deposition, which makes it difficult to achieve precise structures. Additionally, the classical method limits the obtaining of complex nanofibers' composite materials because it does not allow the incorporation of multiple materials in a single fiber system [95]. Widespread use of toxic organic solvents in the process represents another significant drawback of electrospinning. Thus, biologically active compounds are prone to not being incorporated into electrospun fibers when using these solvents. This, together with possible solvent residues and environmental safety risks, may limit the applicability of fibers in the medical field [30,35,95].

Alternative electrospinning methods were developed to overcome these limitations. Coaxial, multiaxial, and side-by-side electrospinning enable the synthesis of core-shell, Janus, and porous fibers, thereby improving their structure and functionality, and facilitating drug delivery, cell protection, and tissue-like electrical properties [35,95,96]. Besides the mentioned alternatives, three-dimensional (3D) nanofibers represent a new generation method for

obtaining scaffolds that are suited for cell incorporation, drug and nutrient diffusion, and promote new tissue formation due to their increased porosity, which guides cellular behavior [94,95,97]. However, further research is still needed to optimize and develop this promising technique for improving fiber quality and industrial manufacturing.

3. Importance of the Proposed Theme

Nanotechnology is an interdisciplinary field that underpins innovations and developments in various fields, including medicine and the environment. In this sense, developing advanced therapeutic opportunities, obtaining medical devices with improved properties, and reducing the risk of infections can enhance the quality of medical services and, consequently, improve patients' quality of life.

Using a technique such as electrospinning makes it possible to obtain fibers with nanometric dimensions, allowing the use of a wide variety of polymers during the process. The nanofibers obtained have the potential to be used in various applications, including medical applications, and to promote the recycling of materials such as PET. Additionally, it is a cost-effective method for full development, which presents the advantage of controlling material properties during fiber production, such as structure, morphology, and fiber size, by varying parameters during the process. However, the technique requires improvements to overcome some of its current drawbacks, including the use of potentially toxic solvents, excessive voltage, obtaining uniformly distributed fibers, and scaling up the technique for industrial use, while also simplifying the new electrospinning techniques as much as possible. The sections of this paper highlight the potential of electrospun fibers for use in a wide range of biomedical applications, leading to new therapeutic strategies that will revolutionize the medical field and ultimately improve the efficacy of therapies and healthcare, with a direct impact on the quality of life of patients.

In addition, obtaining recycled materials with potential applications in this field can also help address another global problem, namely the significant accumulation of waste. One non-biodegradable material responsible for global pollution is polyethylene terephthalate, a thermoplastic polyester widely used in packaging. Recycling PET is urgently needed to alleviate the global plastic waste crisis and conserve natural resources. Its applications can also be found in the medical field. Thus, the electrospinning technique is employed to produce PET

and rPET-based electrospun fibers that promote the sustainability and recycling of the world's current pollutants.

4. Personal contributions

The use of electrospinning in the fabrication of nanofibers based on PET and rPET is an emerging process that underpins the possibility of processing and reusing these two materials, which may lead to new opportunities that simultaneously promote the development of new materials and recycling.

By leveraging interdisciplinary nanotechnology, which integrates chemical, physical, and biological fields, this thesis seeks to underscore the significance of PET recycling and its potential medical applications through the optimization of process parameters to achieve uniform nanofibers. Obtained PET and rPET-based nanofibers were functionalized with antimicrobial agents, resulting in innovative materials that can enhance healthcare settings and medical devices, emphasizing antimicrobial efficacy and biocompatibility while addressing plastic waste concerns.

(i) Zinc Oxide-Loaded Recycled PET Nanofibers for Applications in Healthcare and Biomedical Devices

The first study addressed in the doctoral thesis aimed to develop electrospun membranes made of recycled polyethylene terephthalate nanofibers loaded with zinc oxide nanoparticles, evaluating their antimicrobial properties and potential use in biomedical applications. In this regard, electrospinning technology was used to transform rPET into nanostructured membranes with the following characteristics: interconnected, overlapping, and randomly oriented fibrous networks, using well-established parameters (e.g., needle diameter, needle-to-target distance, voltage, temperature, and humidity) and varying only deposition rate. Thus, the obtained fibers were used as deposition substrates for ZnO nanoparticles, using a dual-solution immersion process.

Techniques such as FT-IR, SEM, TEM, XRD, and thermogravimetric analysis were used to establish the physicochemical properties of electrospun fibers. The antimicrobial effect was assessed by *in vitro* (effect of membranes on planktonic microorganisms' growth, evaluation of

adhesion and biofilm formation, and assessment of antifungal (mold) effect), *in vivo* tests on animal models, and histology tests. SEM characterization reveals the production of unordered fibers (40-100 nm diameter) that form nanostructured membranes at various deposition rates, accompanied by non-uniformly distributed granular nanostructures (10-20 nm). Moreover, TEM characterization reveals the fibrous structure of the membrane and granules on the fiber's surfaces. Also, PET@ZnO membranes were characterized by FT-IR, showing absorption bands characteristic of PET at 1713 cm^{-1} (C=O stretching), 1240 cm^{-1} (C–O asymmetric stretching), and 1093 cm^{-1} (C–O symmetric stretching) and Zn–O bond at 436 cm^{-1} and 722 cm^{-1}. The absorption band for Zn–O is more intense for the 10 mL/h deposition rate of electrospun fibers, which suggests the increased incorporation of ZnO nanoparticles into the PET matrix. These results also suggest that the electrospinning process does not influence the polymer's intrinsic chemical structure. Moreover, XRD patterns for the PET@ZnO membranes confirm the presence of both PET and ZnO phases. Thermal analysis indicates that the samples initially lose ~6% of their mass up to 340 °C, possibly due to solvent evaporation and minor changes in the polymer. At temperatures between 249–250 °C, the polymer melts, while at temperatures between 340–500 °C, most of the sample mass loss occurs due to the oxidation of the resulting fragments and the degradation of the polymer backbone. At temperatures between 460 and 470 °C, multiple exothermic peaks can be observed when carbon residues are fully burned. At 500 °C, a small mass loss occurs due to surface changes in ZnO.

In vitro tests indicate that PET@ZnO membranes provided a strong inhibitory effect on Gram-positive bacteria (*S. aureus*) and Gram-negative bacteria (*Ps. aeruginosa*), yeasts (*C. albicans*), and mold (*A. niger*), also highlighting the antibiofilm ZnO properties. Furthermore, no cytotoxic effect was observed on amniotic fluid stem cells (AFSCs). In vivo testing on mice showed no side effects, such as inflammation, abscess, or toxicity, after PET@ZnO membrane implantation.

(ii) In Vitro and In Vivo Evaluation of rPET/Cu-Alg Nanofibers for Anti-Infective Therapy

The second study involved the development of rPET-based nanofibers enhanced with copper-alginate for wound dressing applications, emphasizing antimicrobial efficacy and biocompatibility. Electrospinning technology was used to obtain rPET nanofibers, followed by post-functionalization with alginate and copper chloride.

Techniques such as FT-IR, SEM, and XRD were employed to characterize the physicochemical properties of PET@Alg/Cu electrospun fibers. *In vitro* (cell proliferation - MTT method, evaluation of cellular oxidative stress), *in vivo* (tests on animal models, biochemistry, immunochemistry, immunofluorescence, and histology tests were performed. SEM micrographs provided information about the structural features of PET@Alg/Cu and confirmed that fibers (50-200 nm diameter) are randomly oriented, with significant curvatures along their axes. This can be explained by the asynchronous deposition of fiber segments due to inherent instabilities (e.g., asymmetric oscillations). Moreover, SEM highlighted the PET fibrous morphology with an additional alginate coating on the fiber surface, and the thickness observed indicated the successful integration of the alginate layer into the fibrous membrane. FT-IR analysis of PET@Alg/Cu provided spectra highlighting the absorption bands specific to the alginate layer covering fibers. Furthermore, the uniform alginate coating on PET fibers is associated with the shifts that are observed at 1409–1579 cm^{-1}, suggesting the potential ionic interactions and hydrogen bonding between alginate and copper. XRD shows the specific semi-crystalline nature of the PET substrate with characteristic diffraction peaks. *In vitro* tests indicate that PET@Alg/Cu membranes provided a high antimicrobial effect on Gram-positive bacteria (*S. aureus*) and Gram-negative bacteria (*Ps. aeruginosa*), yeasts (*C. albicans*), and mold (*A. niger*), preventing biofilm formation, providing microbial proliferation. The MTT assay indicated that PET@Alg/Cu has no cytotoxic effect, supporting cell viability after exposure, while the GSH assay confirmed minimal oxidative stress.

(iii) Electrospun Chitosan-Coated Recycled PET Scaffolds for Biomedical Applications: Short-Term Antimicrobial Efficacy and In Vivo Evaluation

The third study included in the PhD thesis focused on obtaining chitosan-coated recycled PET (rPET@CS) electrospun scaffolds and investigated their antimicrobial activity and *in vivo* biocompatibility. rPET scaffolds were first fabricated via electrospinning at different flow rates (10, 7.5, 5, and 2.5 mL/h) and subsequently coated with chitosan. Techniques such as FT-IR and SEM were used to establish the physico-chemical properties of rPET@CS electrospun fibers, while antimicrobial assay and *in vivo* experiments (biochemistry, histology, immunochemistry, and immunofluorescence) provided information about biocompatibility and antimicrobial effect of rPET@CS. SEM revealed that fiber morphology varied with

electrospinning parameters, while FT-IR confirmed the presence of both rPET and CS. Antimicrobial tests showed that rPET@CS has a significant inhibitory effect against *S. aureus, Ps. aeruginosa,* and *C. albicans* biofilm formation. Subcutaneous implantation of rPET@CS scaffolds induced a transient inflammatory response, with macrophage recruitment and collagen deposition supporting tissue integration.

5. General Conclusions

Given the need to develop new, innovative materials in the medical field to promote the reduction of infections and thus minimize deaths caused by multidrug-resistant bacteria, the use of PET and rPET can represent an innovative and efficient use of PET and rPET to promote recycling and reduction of plastic waste worldwide. PET and rPET are highly available materials, and together with advanced processing techniques, such as electrospinning, may lead to the production of electrospun fibers that could revolutionize the medical field.

In this respect, this doctoral thesis aims to demonstrate the potential of PET-based materials by developing and improving electrospun fibers that meet the optimal conditions for their use in biomedical applications. Based on the conducted studies, it can be concluded that further research is still necessary to validate and explore the application of rPET in biomedical settings and the use of electrospinning in nanofiber formation. In this regard, explorations should focus on the concentration-dependent adverse effects that the presented materials may have. The results suggest the potential for introducing rPETs in biomedical applications in conjunction with other antimicrobial and antibiofilm agents. Additionally, the optimization of the electrospinning protocol plays a crucial role in the development of these materials in the form of dressings (e.g., deposition rate). In addition, long-term evaluation together with exploration of new synergistic bioactive enhancements could lead to promising therapies. The studied materials highlight the versatility and potential of rPET, together with electrospinning, to address critical needs in infection prevention and wound dressing development.

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1. **Grămadă, A.M.**; Niculescu, A.-G.; Bîrcă, A.C.; Holban, A.M.; Ciceu, A.; Balta, C.; Herman, H.; Hermenean, A.; Ardelean, S.; Stoica, A.-E.; et al. Electrospun Chitosan-Coated Recycled PET Scaffolds for Biomedical Applications: Short-Term Antimicrobial Efficacy and In Vivo Evaluation. *Polymers* **2025**, *17*, 1077. https://doi.org/10.3390/polym17081077

2. **Grămadă, A.M.**; Niculescu, A.-G.; Bîrcă, A.C.; Holban, A.M.; Ciceu, A.; Balta, C.; Herman, H.; Hermenean, A.; Stoica, A.-E.; Ardelean, S.; et al. In Vitro and In Vivo Evaluation of rPET/Cu-Alg Nanofibers for Anti-Infective Therapy. *Polymers* **2025**, *17*, 68. https://doi.org/10.3390/polym17010068

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