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Advancing Nanofiber Research: Assessing Non Solvent Contributions to Structure using Coaxial Electrospinning

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Introduction

Nanofibers play a vital role as precursors for fabricating a wide array of products spanning environmental and energy sustainability, biomedical, and healthcare applications. The nanofiber characteristics, such as porosity, domains, and interfaces, are strongly influenced by the phase separation behavior among polymers, solvents, and nonsolvents in the liquid jet during the nanofabrication process. However, the precise control and understanding of these phenomena at the level of individual nanofibers still need to be improved due to the need for more current technologies to provide sufficient spatial and temporal resolution. To address this challenge, we employed coaxial electrospinning with a nonsolvent core to manipulate phase separations in situ on single nanofibers. The introduction of inner nonsolvent-induced phase separation, facilitated by the utilization of a nonsolvent liquid core, led to the formation of polymer nanofibers exhibiting significantly enhanced internal porosity. This advanced fabrication approach paves the way for optimizing nanofiber properties and opens up new avenues for tailoring their performance in a broad range of applications.

Experimental Method

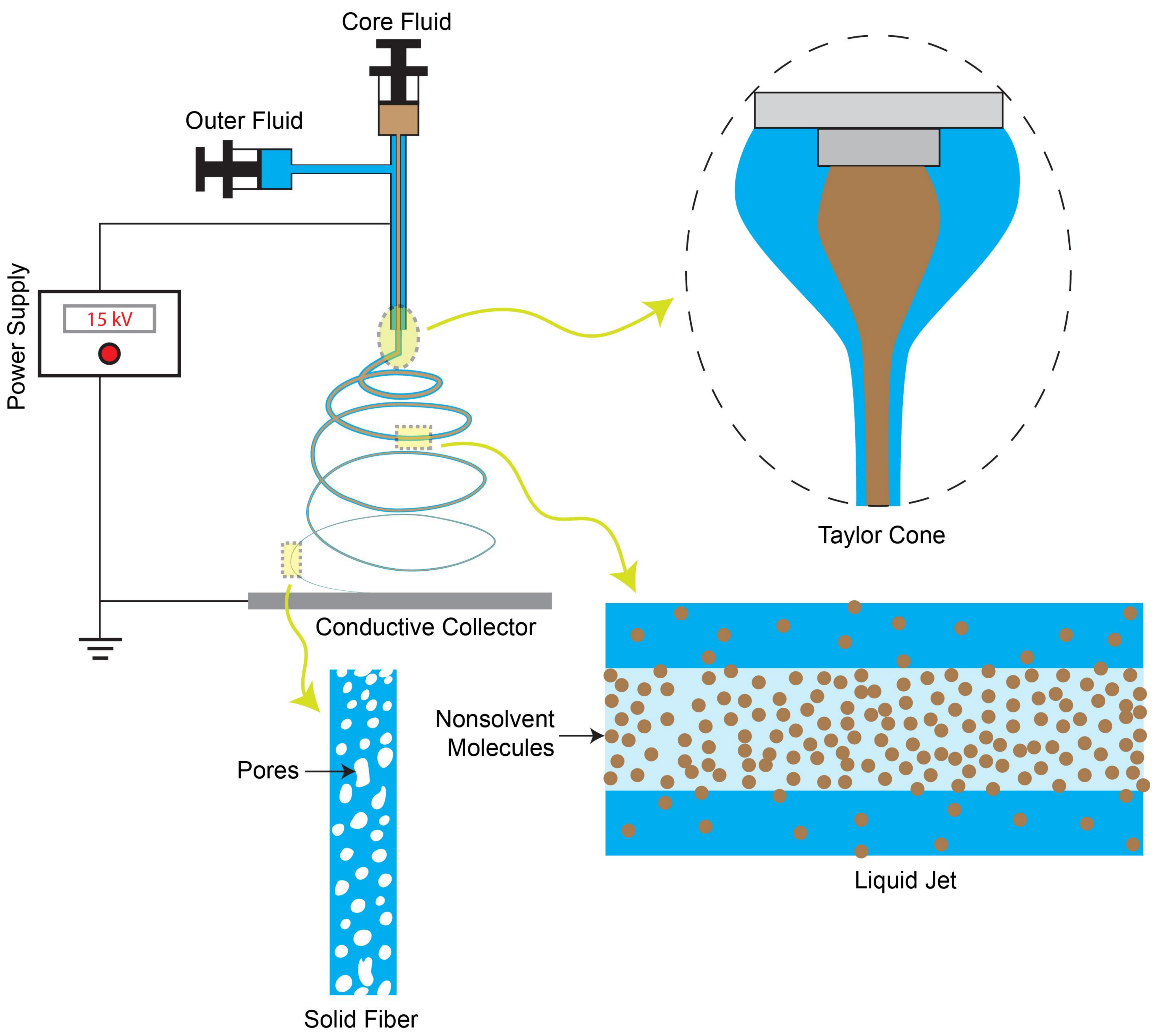

Figure 1. Schematic illustration showing the formation of porous nanofibers via core nonsolvent induced polymer phase separation using coaxial electrospinning technique.

Results

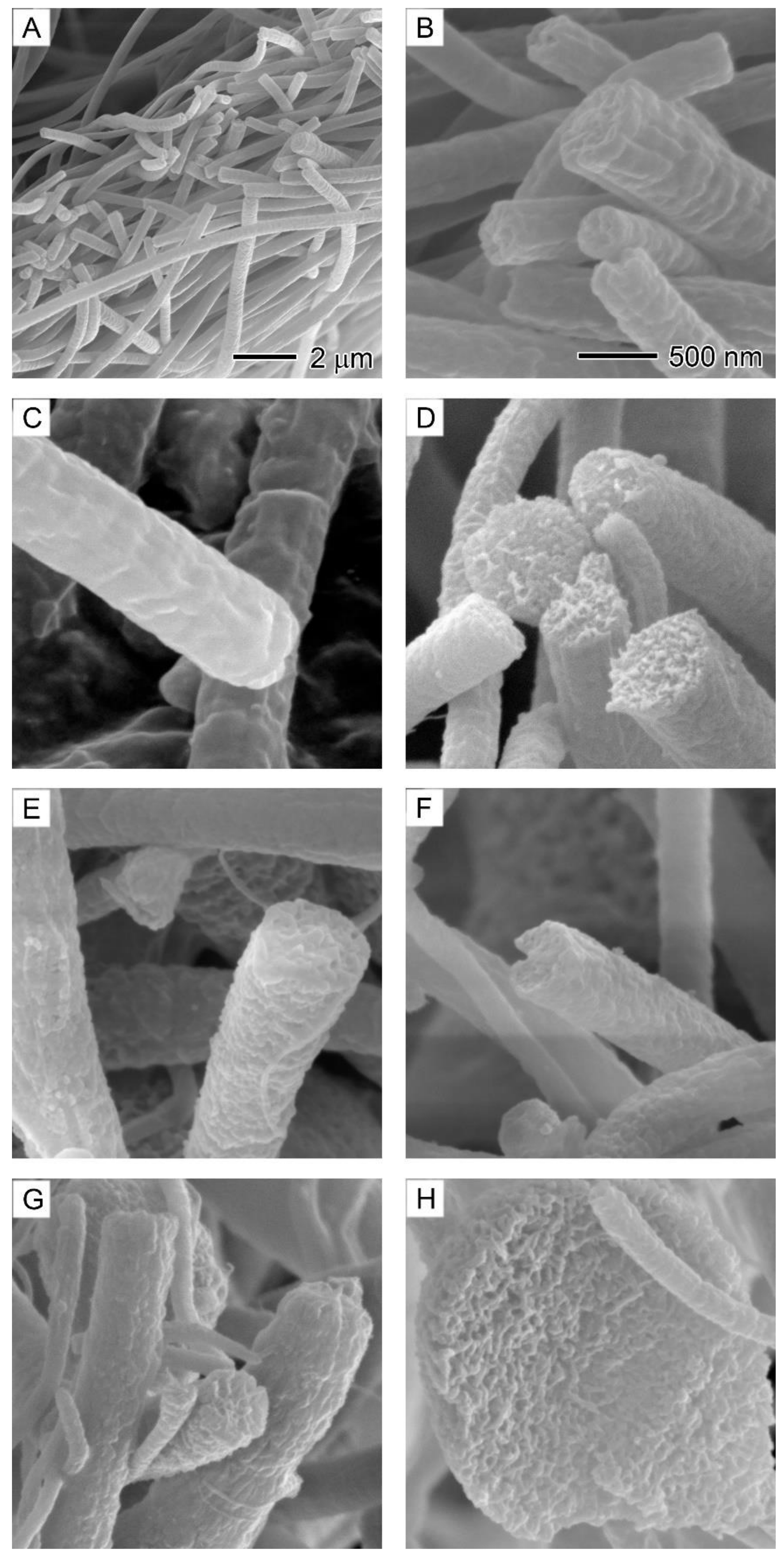

Figure 2. SEM images showing the surface morphology and internal structure of polyacrylonitrile nanofibers obtained at different core nonsolvent (1/20 v/v water/DMF) injection rates.

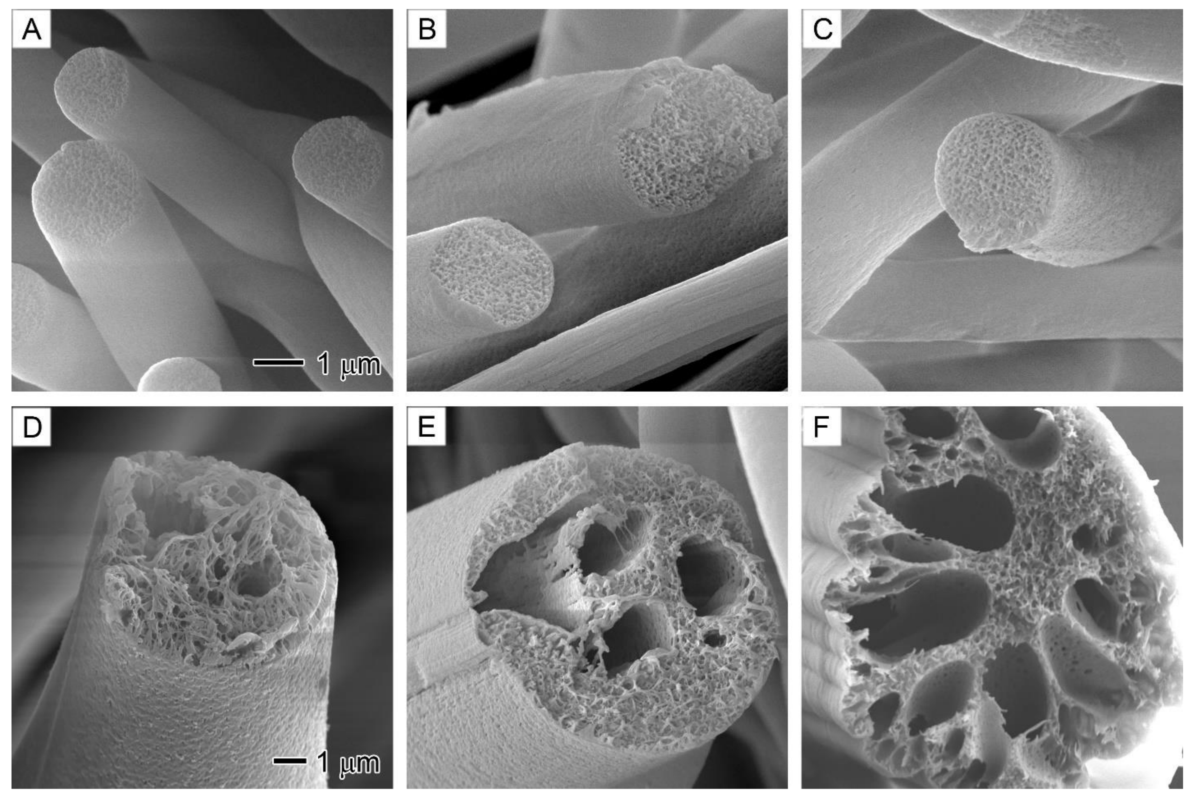

Figure 3. SEM images showing the internal porosity of polystyrene fibers prepared at different core nonsolvent (1/20 v/v water/DMF) injection rates.

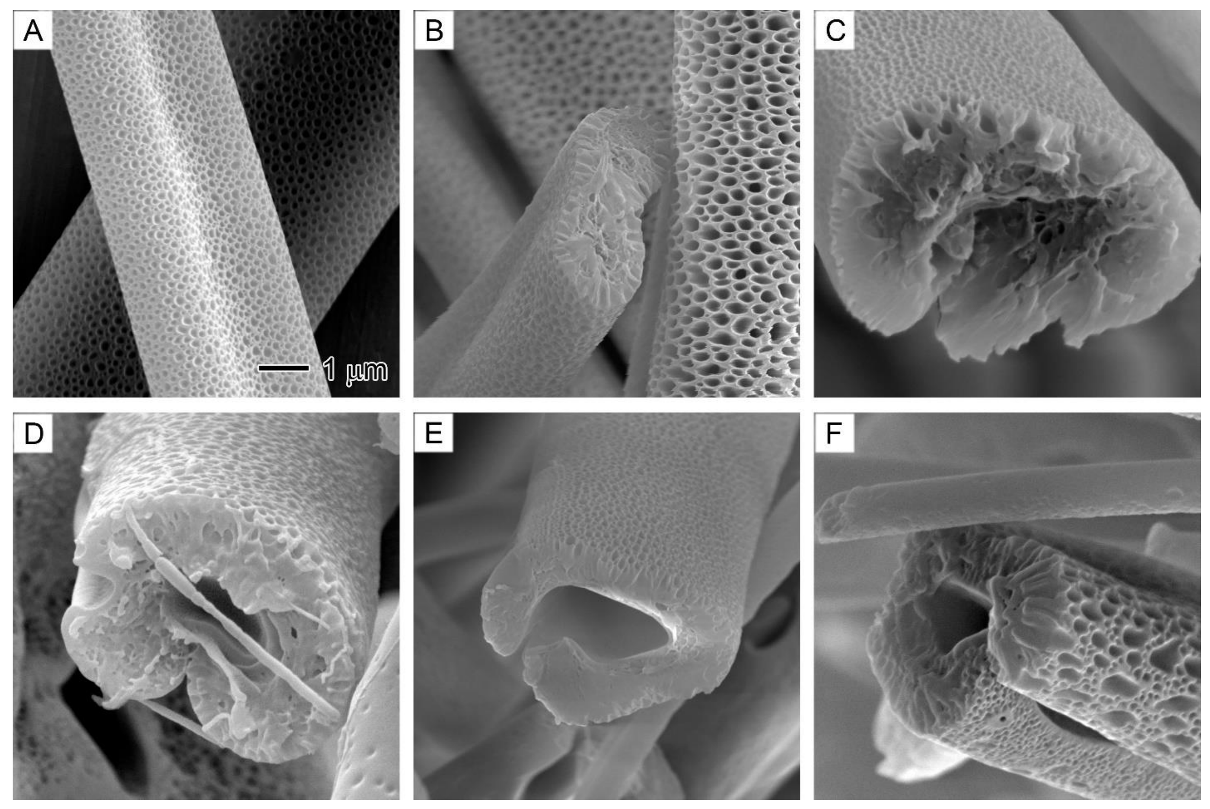

Figure 4. SEM images showing the surface and internal structures of polystyrene fibers prepared using nonsolvent (1/20 v/v water/THF) at different injection rates.

Conclusions

In this study, we have successfully developed an innovative approach for fabricating polymer nanofibers with tunable internal porosity using coaxial electrospinning and core nonsolvent-induced phase separation. By implementing this method, we were able to produce polyacrylonitrile and polystyrene nanofibers with precisely controlled internal porosity by adjusting the core nonsolvent injection rates. Our findings not only enhance the fundamental understanding of phase separation phenomena in individual nanofibers but also provide a versatile and effective strategy for tailoring nanofiber properties to cater to specific application requirements. Moreover, this coaxial electrospinning technique offers a promising platform for further exploration and optimization of nanofiber characteristics, potentially enabling the development of innovative materials and technologies in the future.

Acknowledgments

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