

## Electrospinning research and products: The road and the way forward

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### ABSTRACT

Electrospinning is one of the most accessed nanofabrication techniques during the last three decades, attributed to its viability for the mass production of continuous nanofibers with superior properties from a variety of polymers and polymeric composites. Large investments from various sectors have pushed the development of electrospinning industrial setups capable of producing nanofibers in millions of kilograms per year for several practical applications. Herein, the lessons learned over three decades of research, innovations, and designs on electrospinning products are discussed in detail. The historical developments, engineering, and future opportunities of electrospun nanofibers (ESNFs) are critically addressed. The laboratory-to-industry transition gaps for electrospinning technology and ESNFs products, the potential of electrospun nanostructured materials for various applications, and academia-industry comparison are comprehensively analyzed. The current challenges and future trends regarding the use of this technology to fabricate promising nano/macro-products are critically demonstrated. We show that future research on electrospinning should focus on theoretical and technological developments to achieve better maneuverability during large-scale fiber formation, redesigning the electrospinning process around decarbonizing the materials processing to align with the sustainability agenda and the integration of electrospinning technology with the tools of intelligent manufacturing and IR 4.0.

### KEYWORDS

Laboratory-to-industry; Electrospinning research; Academia-industry; Macro-products

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