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Abstract

Electrospinning with Green Solvents: Overcoming Constraints While Tailoring Nanofibrous Structures †

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The production of nanofibrous membranes through electrospinning has traditionally relied on highly effective organic solvents such as dimethylformamide (DMF), chloroform (CHL), and dichloromethane (DCM). Despite their efficiency in dissolving polymers and ensuring processability, these solvents are toxic and potentially carcinogenic, raising serious concerns for both human health and the environment. This long-standing technical scientific lock-in has restricted the widespread adoption of sustainable alternatives and hindered the development of safer nanostructured materials for biomedical and environmental applications.

In this work, we demonstrate the complete replacement of hazardous solvents with low-toxicity systems, including acetone, acetone/ethanol, and acetone/water mixtures, all fully compliant with current EU regulations. Morphological analyses performed on polycaprolactone (PCL) and polylactic acid (PLA) nanofibrous membranes reveal that green solvent systems not only allow the preservation of standard electrospinning parameters but also enable the generation of a wide range of fibrous morphologies, from bead-only to beads-on-string and fully continuous fibers. Importantly, this structural versatility highlights the ability to modulate fiber size and surface features without requiring disruptive changes in the processing setup.

Overall, the findings demonstrate that the transition to green solvent systems effectively overcomes the constraints imposed by traditional toxic solvents. By enabling fine morphological control and expanding application versatility, this approach paves the way for the design of nanostructures that are not only high-performing but also safe, environmentally sustainable, and aligned with the growing demand for greener technologies in advanced material science.

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