Electrospinning of hybrid lipid-polymer fibres for cultured meat applications

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Electrospinning is a versatile technique to produce scaffolds mimicking the extracellular matrix of native tissue and has received considerable attention recently in cellular agriculture and alternative meat manufacturing. Among the different materials employed, charged proteins and polymers are the most highly relevant to food applications. However, their electrospinning remains a significant challenge due to their intrinsic properties such as high viscosity, surface tension, and strong hydrogen bonding capacity. These characteristics hinder effective chain entanglement, fibre formation, and cross-linking, limiting the development of stable fibrous structures. Nevertheless, given their role in supporting tissue integrity and influencing cellular behaviour, the incorporation of biomimetic polymers into cultured meat systems offers a promising approach to enhancing tissue functionality and improving overall product quality.

In this study, we present how hybrid electrospinning of lipid nanoparticles with biomimicking polymers facilitates the production of hierarchical scaffolds with tuneable functional and mechanical properties. Positively charged lipid nanoparticles, exhibiting distinct internal structures, were combined with a negatively charged biopolymer. This design aimed to promote electrostatic interactions between the nanoparticles and the biopolymer fibres and so enhance fibre formation and stability.

We have applied a thorough rheological and particle size analysis to find the optimum conditions where electrospinning can produce highly stable fibres with high cross-linking capacity, leading to maximum mechanical integrity. Beyond structural performance, cellular interactions — such as attachment within the fibrous matrix — will be emphasised to demonstrate the material's potential for supporting cell attachment and growth.

Our findings demonstrate that our hybrid mixture significantly enhances the electrospinnability of charged biopolymers through improved cross-linking and structural reinforcement.