Multifunctional polymer particles and fibers by electrohydrodynamic co-jetting

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Nano- and microparticles have been successfully utilized in a variety of research areas, such as diagnostics, drug delivery or regenerative medicine. Compositional flexibility, tunability, and versatility of polymer particles has been accomplished by progress in particle fabrication methods. In particular, the complementary control of internal (bulk) and external (surface) features has been increasingly recognized as important design parameters for multifunctional particles.

In the past, particles have been fabricated with several distinct methods. In particular, electrospraying of polymer solutions is a straightforward method to fabricate nano-/microparticles as well as fibers by applying high electrical voltage to polymeric solutions. Building on these processes, electrohydrodynamic (EHD) co-jetting involves two or more capillary needles in a side-by-side configuration that allow different polymer solutions to be processed in parallel. Under the laminar flow regimen encountered in these systems, biphasic droplets are formed at the outlet point of the adjacent needles. Application of an electric field to the nozzle leads to a stable Talyor cone at the tip of the biphasic droplet. The Taylor cone builds the basis of a jet that forms as a result of continuous stretching of the polymer thread. The rapid acceleration favors atomization of the charged jets and significantly increases the surface area. Thus, instantaneous solvent evaporation as well as solidification of the non-volatile components restricts occurs.

Initial work has been focused on water-soluble polymers because environmentally friendly water-based jetting systems typically exhibit lower toxicity, which are important for biomedical applications. More recently, EHD co-jetting of organic-soluble polymers have been used to fabricate anisotropic microstructures. In particular, the EHD co-jetting of organic solution of poly(lactic-co-glycolic acid) (PLGA) has been successfully used to prepare biodegradable bicompartmental particles and fibers. Because of their biodegradability, these particles may constitute promising building blocks for biohybrid materials or find potential applications in drug delivery and tissue engineering. The systematic investigation of EHD co-jetting of PLGA reveals that the jetting solution and process parameters can control compartmentalization, shape, and size.

Multicompartmental particles feature dissimilar materials and combine orthogonal sets of properties in the same particle. Selective surface modification of parts of the surface can create surface patterns. The precise nano- and microscale control of the architecture of biodegradable materials is required for many biomedical applications, including controlled drug delivery, regenerative medicine, or simultaneous imaging and diagnosis applications.