High-throughput microgel biofabrication via air-assisted co-axial jetting for cell encapsulation, 3D bioprinting, and scaffolding applications

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Microgels have recently received widespread attention for their applications in a wide array of domains such as tissue engineering, regenerative medicine, and cell and tissue transplantation because of their properties like injectability, modularity, porosity, and the ability to be customized in terms of size, form, and mechanical properties. However, it is still challenging to mass (high-throughput) produce microgels with diverse sizes and tunable properties. Herein, we utilized an air-assisted co-axial device (ACAD) to continuously produce microgels in a high-throughput manner. To test its robustness, microgels of multiple hydrogels and their combination, including alginate (Alg), gelatin methacrylate (GelMA) and Alg–GelMA, were formed at a maximum production rate of ~65 000 microgels s^{-1} while retaining circularity and a size range of 50–500 μm based on varying air pressure levels. The ACAD platform allowed single and multiple cell encapsulation with 74 ± 6% efficiency. These microgels illustrated appealing rheological properties such as yield stress, viscosity, and shear modulus for bioprinting applications. Specifically, Alg microgels have the potential to be used as a sacrificial support bath while GelMA microgels have potential for direct extrusion both on their own or when loaded in a bulk GelMA hydrogel. Generated microgels showed high cell viability (>90%) and proliferation of MDA-MB-231 and human dermal fibroblasts over seven days in both encapsulation and scaffolding applications, particularly for GelMA microgels. The developed strategy provides a facile and rapid approach without any complex or expensive consumables and accessories for scalable high-throughput microgel production for cell therapy, tissue regeneration and 3D bioprinting applications.