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FROM DYNAMIC STRUCTURES TO FUNCTIONAL MATERIALS

Gelation in Biomedical Applications – The Functional Roles of Self-Assembling Peptides in Re-programming Biopolymers

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The development of advanced biomaterials was followed by a growing demand for hydrogels that mimic the properties of soft tissues to promote regeneration and allow minimally invasive treatment. Existing supramolecular systems are often limited by poor mechanical robustness, while covalent systems feature permanently cross-linked networks that hinder their ability to replicate the dynamic cell-matrix interactions in native tissues. Therefore, these materials are often unable to support important biological processes including cell migration, matrix remodelling and adaptive tissue regeneration.

Nanofibril-forming self-assembling peptides (SAPs) show great potential as extracellular-matrix-like scaffolds, providing dynamic cell environments mimicing those found in native tissues. Their ability to spontaneously organize into well-defined architectures through non-covalent interactions enables the formation of dynamic materials with tunable mechanical properties. Furthermore, conceptualizing a sequence enables precise control over morphology and functionality.

The integration of SAPs with otherwise bioinert biopolymers, such as agarose, alginate, and hyaluronic acid, provides functionalization with bioactive motifs as well as structural stability to the system, resulting in 3D scaffold hydrogels with optimized mechanical, tunable physicochemical and advanced biochemical characteristics. As a result, tailorable and broadly tunable 3D soft materials with excellent mechanical properties, such as shear-thinning and autonomous recovery of supramolecular crosslinks, were obtained, offering sustainable alternatives to traditional, synthetic polymer-based hydrogels and presenting significant potential for tissue engineering, regenerative medicine, and other advanced biomedical applications.