Multicomponent Supramolecular Hydrogels for Drug Delivery and Cell Culture

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Introduction: Low molecular weight gelators (LMWGs) can self-assemble through non-covalent interactions to form supramolecular hydrogels with potential applications in drug delivery and cell culture[1]. However, single-component systems are often limited by poor mechanical strength, low stability, and sensitivity to environmental conditions, restricting their use in biologically relevant media[2]. This study explores the development of multicomponent hydrogels by combining LMWGs with high molecular weight gelators (HMWGs), including alginate, hydroxypropyl methylcellulose (HPMC), and Pluronic F127. The aim is to enhance structural integrity, tunability, and functionality.

Materials and method: A series of sugar-based and Fmoc-functionalised LMWGs were synthesised and characterised using NMR, mass spectrometry, XRD, SEM, and FT-IR. Hydrogel formation was systematically screened across a wide range of compositions, generating over 170 formulations. Gelation was assessed based on self-supporting behaviour, optical clarity, and reproducibility. Thermal stability was evaluated using $T_{gel\text{-}sol}$ analysis, and selected hydrogels were tested for long-term stability in biologically relevant media, including DMEM, RPMI, and PBS.

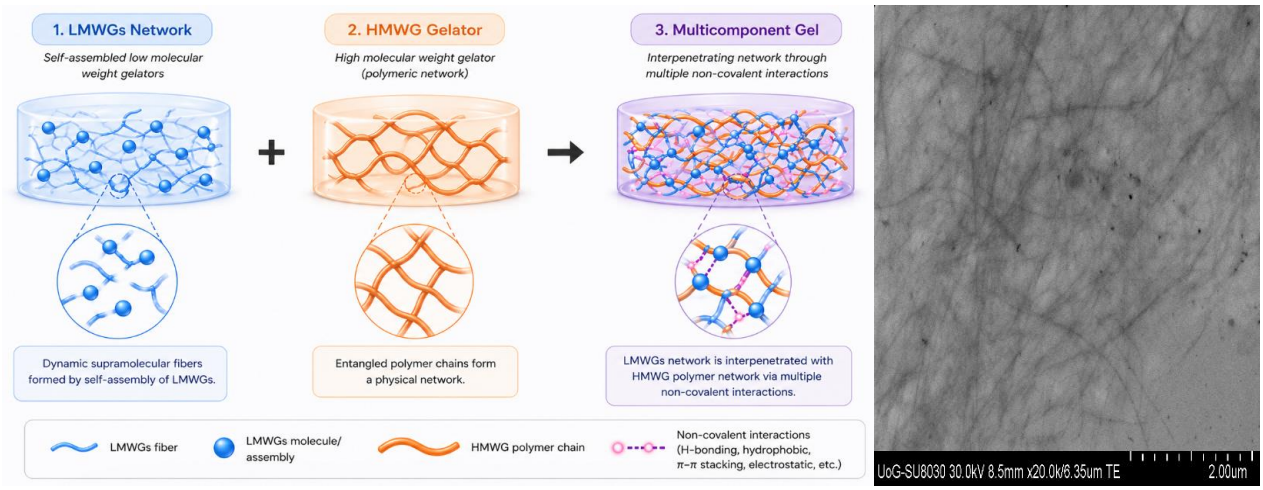

Figure 1. *Schematic illustration of multicomponent hydrogel formation and a representative TEM image (right) for IndomGaln in F127 pluronics showing the interconnected fibrous architecture of the resulting multicomponent hydrogel.*

Results: Fifteen multicomponent hydrogels were identified as optimal candidates, demonstrating consistent gelation and enhanced stability under physiological conditions. Transmission electron microscopy (TEM) confirmed the formation of interconnected fibrous networks, supporting the successful integration of LMWG self-assembly with HMWG polymer matrices.

Conclusion: These results demonstrate that multicomponent design effectively overcomes the limitations of single-component supramolecular gels, producing robust and functional materials suitable for biomedical applications such as controlled drug delivery and three-dimensional cell culture systems.

References

1. Steed, J. W. Supramolecular Gel Chemistry: Developments over the Last Decade. *Chem. Comm.* 2011, *47* (5), 1379–1383.

2. Miguel Amaro-Villegas, PhD Studentship (2023), Medway School of Pharmacy.