TITLE

Zein-Derived Polymer Gels: Design of Crosslinked Networks for Sustainable Soft Materials

TEXT

In the context of the transition towards a circular and climate-conscious materials economy, there is a growing interest in the development of gel-based materials derived from renewable feedstocks[1,2]. Proteins, as abundant natural macromolecules that are frequently available as byproducts of agro-industrial processes, offer a sustainable yet underutilised platform for the design of advanced soft materials[1,2]. However, protein-derived systems characteristically exhibit fragility and suboptimal processability, thereby constraining their functional application as gels and flexible films[2].

The present study explores the transformation of zein, a protein derived from maize that is devoid of nutritional value, into polymer gels via chemical functionalization and radical crosslinking. The acrylation of Zein was carried out to varying degrees in order to introduce polymerizable groups. It was then co-polymerized with an acrylic monomer, resulting in the formation of solid thermosetting gels with a flexible film morphology. These crosslinked networks exhibit characteristics typical of bio-polymer gels, namely a stable 3D architecture, a solvent-free formulation, and mechanical resilience.

Resulting zein-based gels demonstrated the capacity to preserve the intrinsic strength and thermal stability of the protein, while exhibiting significant enhancements in elongation, flexibility, and toughness. It is noteworthy that lower acrylation degrees resulted in enhanced mechanical properties, indicating that mild, non-invasive chemical modifications can optimise gel performance. The influence of biobased crosslinkers was also evaluated in order to further tailor network properties.

These thermoset protein gels demonstrate considerable promise in a range of applications, including sustainable coatings, packaging, and flexible electronics. The design of these materials demonstrates a promising route for the conversion of agricultural residues into robust, solvent-free gel materials that support the broader goals of circular economy and sustainable materials science.

[1] M. Kumar et al. *LWT* **2022**, 154, 112620.
[2] D. Yuan, X. Huang, Q. Meng, J. Ma, Y. Zhao, Q. Ke, X. Kou **2022**, 179, 111557.

KEYWORDS

bio-based gels; protein crosslinking; zein; thermoset networks; circular economy; soft materials; agricultural waste valorization