Sustainable Biomaterials: Alginate and Carrageenan Hydrogels for Healthcare Applications

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Background

Alginate and carrageenan can be sourced sustainably from abundant marine biomass, including invasive seaweed species in Irish coastal waters. Utilising these algae provides a low-cost, renewable feedstock while supporting environmental management, aligning with the principles of the EU Bioeconomy Strategy. Compared with many synthetic and other bio-based polymers, marine polysaccharide hydrogels offer improved sustainability, reduced toxicity, and the potential for scalable, environmentally responsible production, representing a promising pathway for developing next-generation healthcare products.

Aim

To optimise the mechanical performance of seaweed-based hydrogels by varying polymer concentration, crosslinking concentration, and reaction time using heterogeneous ionic gelation.

Methods

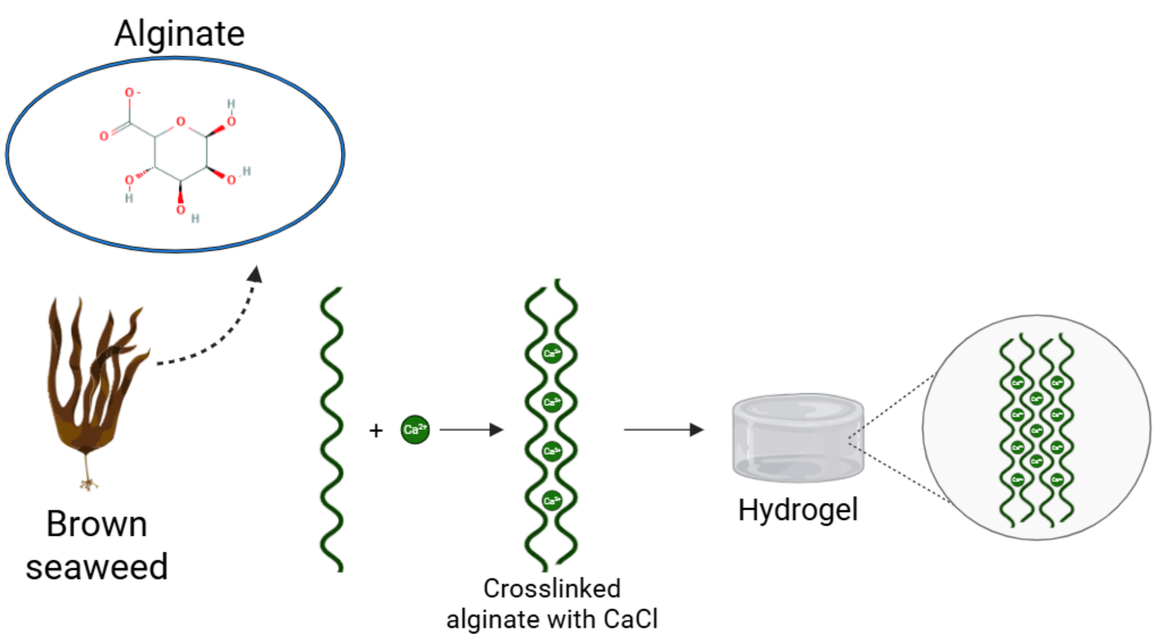


Figure 1*: Alginate hydrogel formation ($CaCl_2$ crosslinking)

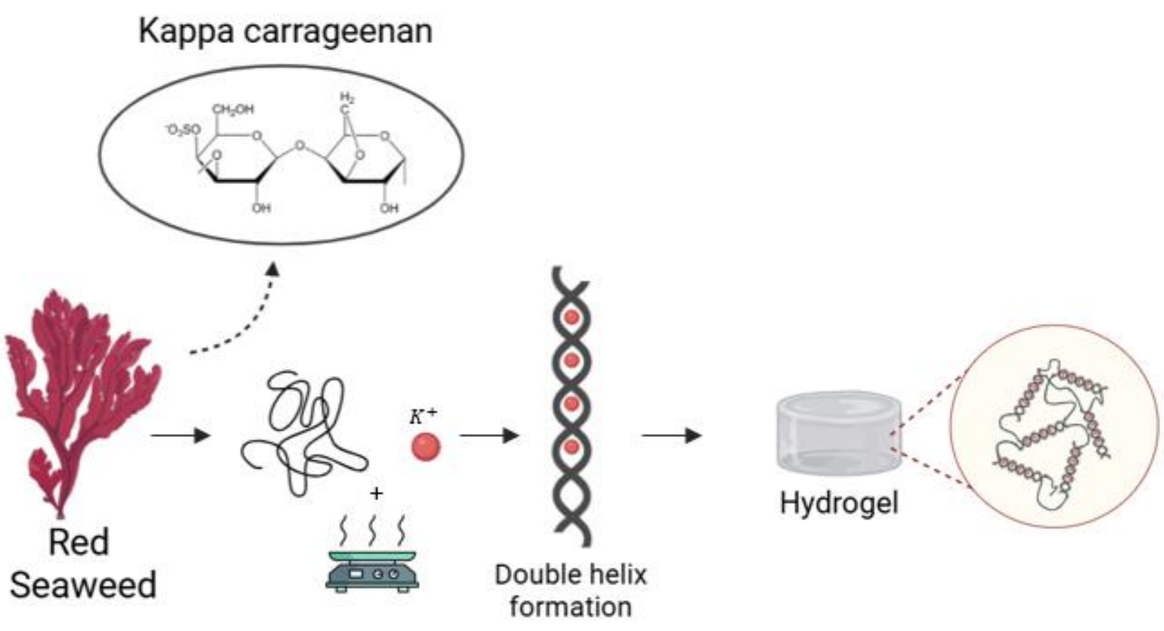


Figure 2*: κ-carrageenan hydrogel formation (KCl crosslinking)

Results

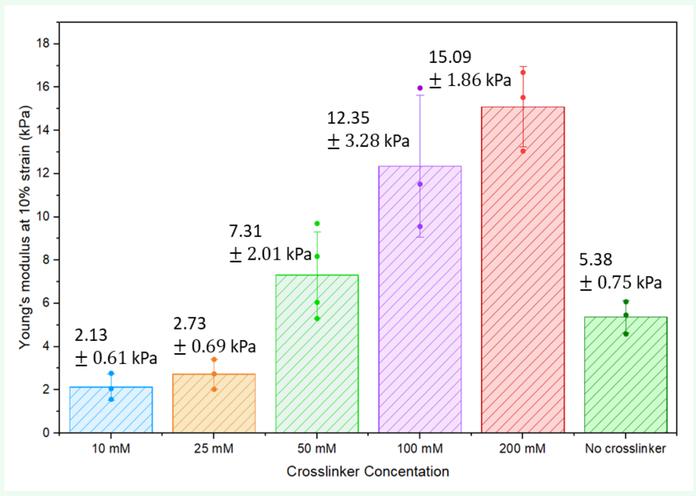


Figure 3: Effect of KCl crosslinker bath concentrations on 1.0% w/v κ-carrageenan hydrogels

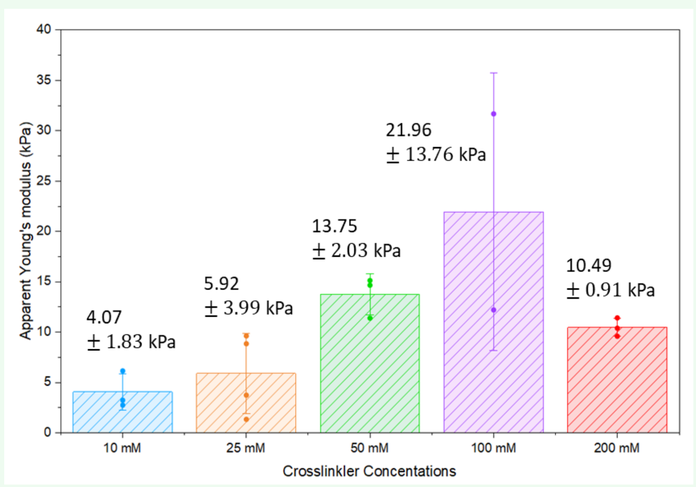


Figure 4: Effect of $CaCl_2$ crosslinker bath concentrations on 2.0% w/v sodium alginate hydrogels

Figure 5: Effect of 100 mM KCl crosslinker bath concentration on various concentrations of κ-carrageenan

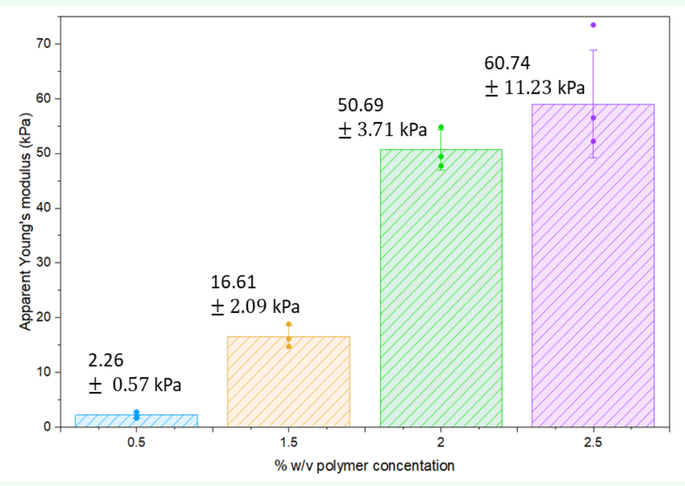
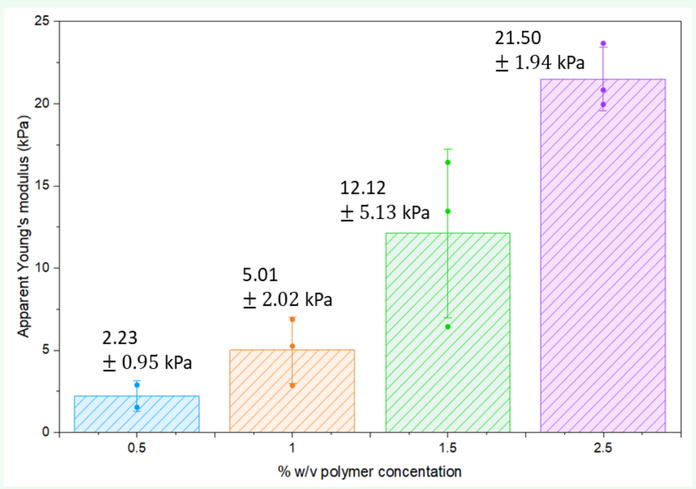


Figure 6: Effect of 100mM $CaCl_2$ crosslinker bath concentration on various polymer concentrations of sodium alginate



Conclusions:

- Mechanical properties are tunable via formulation parameters
- These findings highlight optimal conditions for producing sustainable, mechanically robust hydrogels suitable for healthcare applications

References:

Ren, Y. *et al.* (2024) *Alginate-based hydrogels mediated biomedical applications: A review*. *International Journal of Biological Macromolecules*, 279, 135019

Patel, P. *et al.* (2023) Structure, rheology, and 3D printing of salt-induced κ-carrageenan gels. *Materials Today Communications*, 35, 105807.

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