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To gel or not to gel: Enzymatic desulfation of carrageenans to modify their rheological properties

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PURPOSE OF THE ABSTRACT

Sulfated biomolecules from the marine environment represent an extraordinary natural source of chemical diversity, ranging from small metabolites to complex polymers with an enormous variety of biological and physicochemical properties. Among the commercially most relevant products from red algae, the sulfated biopolymer carrageenan is of particular interest to the food, cosmetics, and pharmaceutical industries as it can exhibit favorable viscoelastic characteristics [1]. The degree and position of sulfation can have a decisive influence on its rheology and thus determines the polymer's commercial use [2]. To expand the application scope of carrageenans, the targeted cleavage of sulfate groups catalyzed by sulfatases can therefore be a promising tool to create novel carrageenan variants with promising new physicochemical properties. However, the range of functionally expressed and characterized carrageenan sulfatases so far remains as insufficient as the understanding of their effect on the rheological behavior of the polymers modified by them.

To address this issue, we screened several putative carrageenolytic polysaccharide-utilization loci of heterotrophic marine microorganisms for sulfatases active on different types of commercially relevant carrageenans. Using this approach, we were able to heterologously express a series of novel sulfatases in their active form that perform the specific desulfation of ι- and κ-carrageenan molecules to α- and β-carrageenan-moieties or several fine-tuned hybrid structures derived from them. We used one of these variants, a universal G4S-sulfatase, for the preparative biotransformation of ι- and κ-carrageenan in the low gram scale, and rheologically analyzed the products to reveal the unique structure-function relationship of the sulfation architecture on the viscoelastic properties of carrageenans. To evaluate the potential of the enzyme for commercial purposes in a proof-of-concept approach, we applied it to the biocatalytic modification of different carrageenans during their extraction from the most industrially important red algal species for carrageenan production, successfully transferring the new rheological properties and laying the groundwork for further intensification.

FIGURES

FIGURE 1

FIGURE 2

KEYWORDS

Biotransformation | Rheology | Marine Enzymes | Polymer Modification

BIBLIOGRAPHY

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