Gloiopeltis furcata由来フノラン：抽出、化学構造決定及びゲル化の速度論

[課程博士・論文博士共通]

博士学位論文要約
Summary of Dissertation

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論文題目 Title	Funoran from *Gloiopeltis furcata*: Extraction, Chemical Characterization and Gelation Kinetics		

Funoran, a sulfated polysaccharide derived from red algae, possesses diverse industrial applications owing to its non-toxic and biocompatible properties. Its adhesive, thickening, and stabilizing qualities make it valuable in papermaking, textile printing, and food industries. However, understanding its gelation process and extraction methods is crucial for optimizing its utilization in food and medical applications. The gelation mechanism of funoran is influenced by its chemical structure and external factors such as temperature and ions. Variations in extraction methods can yield funoran fractions with differing physicochemical properties, impacting solubility, rheological behavior, and gelation characteristics. Therefore, there is a need to investigate the impact of extraction strategies on funoran properties and elucidate its gelation kinetics for optimal food applications.

- Two extraction strategies were employed to obtain funoran from *Gloiopeltis furcata*: direct hot water extraction (Strategy 1) and cold-water purification followed by hot water extraction (Strategy 2).
- Funoran fractions were characterized for chemical composition using NMR, FTIR…etc., while molecular weight distribution was determined using SEC.
- Rheological measurements were conducted to evaluate the shear thinning behavior and gelation kinetics of funoran fractions.
- Micro-DSC measurements were employed to confirm gelation and assess thermal hysteresis.
- The impact of aging time and temperature on gelation kinetics was investigated through rheological measurements and ^{1}H NMR analysis.

Two strategies were applied to isolate funoran from *G. furcata* by hot water extraction coupled with ethanol and NaCl precipitation technique, which produced four funoran fractions, including two higher molecular weights of funorans and two lower molecular weights of funorans with high contents of Na^{+}. FTIR and NMR techniques proved that all funoran fractions were sulfated polysaccharides with 3-linked β-D-galactose-6-sulfate and 4-linked 3,6-anhydro-L-galactose repeating units as the structural backbone, as well as 2-O-methyl β-D-galactose-6-sulfate attached as substituents. In strategy 2, the ethanolic fraction showed poor water solubility and formed a yellowish, cloudy and highly viscous dispersion, while the salted ethanolic fraction formed a highly transparent and slightly viscous solution that was purified by dialysis. Rheological measurements showed that all funoran solutions exhibited shear-thinning behavior and could form gels on cooling. On reheating, the gels exhibited a much higher melting temperature than the gelation temperature. Despite the lower molecular weight fractions showing a more significant gelation process than the higher molecular weight, suggesting that the presence of a higher amount of Na^{+} remarkably promoted the gelation of funoran. [1].

The cooling and heating rates influence funoran gelation properties and study its gelation mechanism by dynamic rheology and NMR studies. With constant heating rates, the melting point was unaffected by changing cooling rates, whereas higher cooling and heating rates enhance the gel strength and thermal hysteresis. The gelation kinetics mechanism of the funoran solution was elucidated at different quenching temperatures. The rheological measurement results indicated that the funoran solution quenched to lower temperatures resulted in higher G` in the gel state, and faster gelation rate compared with the solution quenched at higher temperatures.

^{1}H NMR results revealed a slow decay in funoran signal intensity at higher temperatures (20 °C) and a fast signal decay at 2 °C. A theoretical model involving second, and first-order reactions was proposed to describe the gelation kinetic process of funoran at different quenching temperatures. It was shown longer helix lengths were required for stable intermolecular association and gel formation at higher temperatures than at lower temperatures [2].

In summary, this study aims to provide a simple way to isolate funoran fractions with significantly different solvation and gel-forming ability from *G. furcata*, which should be useful for promoting the industrial isolation of funoran with different properties. The gelation process in funoran was influenced by temperature and time. From the successful theoretical model with the rheological measurements and ^{1}H NMR results, it is concluded that the gelation rate of the funoran system showed strong time dependency at different temperatures. This research offers valuable insights into the influence of extraction strategies and gelation kinetics on the manipulation and customization of food gels. Such insights can inform the development of improved food formulations and optimize gelation processes in the food industry to meet specific texture requirements and enhance overall product quality.

References

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