

Extraction of Sodium Alginate from *Charophyceae* Algae [†]

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[†] Presented at the 26th International Electronic Conference on Synthetic Organic Chemistry, 15–30 November 2022; Available online: <https://sciforum.net/event/ecsoc-26>.

Abstract: This study examined the rheological properties of alginates, one of the main products obtained from algae. These polysaccharides are widely used in fields such as pharmaceuticals, medical technology, cosmetics, food, agriculture and the textile and paper industries. Therefore, sodium alginate was obtained from waterweed (*Charophyceae*) in the following experiment. The structure and composition of the sodium alginate were analyzed using physical and chemical research methods: IR spectroscopy and XRD.

Keywords: algae; sodium alginate; *Charophyceae*; IR spectroscopy; XRD

1. Introduction

In recent years, the use of algae as a biomass resource for biorefineries has become very promising [1], and they have attracted great interest as excellent sources of nutrients. Polysaccharides are the main constituents of algae. Thus, they have many beneficial effects on human health, and much attention has been paid to the isolation and characterization of polysaccharides from algae [2].

Alginates are mainly used in industry for their stabilizing, thickening and emulsifying properties, and depending on specific properties such as the gel strength, porosity or biocompatibility, they are expanding to applications such as the use of biomaterials for tissue engineering and bioprinting [3]. Alginates are analogs of pectin in land plants [4]. According to their structure, they constitute a linear copolymer of β -D-mannuronic acid (M) and α -L-gulurone connected with (1–4) [5].

2. Materials and Methods

2.1. Infrared Spectroscopy (IR)

IR spectroscopy analysis was conducted at 400–4000 cm^{-1} wavenumbers and a 4 cm^{-1} resolution using an INVENIO S (Bruker, Germany) equipped with a diamond ATR cell.

The IR spectra of the isolated sodium alginate showed a standard curve and pure sodium alginate curve. Both spectra showed similarities, according to which the IR spectra of the isolated sodium alginate and the standard showed a mannuronic acid functional group at wavenumber 896 cm^{-1} , uronic acid group at wavenumber 1058 cm^{-1} , OH functional group at wavenumber 3226–3454 cm^{-1} , and CH_2 stretching at wavenumber 2895–2967 cm^{-1} .

2.2. X-ray Diffraction (XRD)

Sodium alginate was characterized by powder X-ray diffraction using a Shimadzu instrument, XRD-6100 model. It was seen that *Charophyceae* algae have an amorphous structure with a peak of $2\theta = 22.76^\circ$ (the crystallinity index was 32.54%).



Citation: Khaydarova, S.S.; Siddikova, S.Q.; Khaitbaev, A.K. Extraction of Sodium Alginate from *Charophyceae* Algae. *Chem. Proc.* **2022**, *12*, 59. <https://doi.org/10.3390/ecsoc-26-13639>

Academic Editor: Julio A. Seijas

Published: 16 November 2022

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3. Results and Discussion

3.1. Separation of the Compounds from the Composition of the Algae

The main structural elements of algae cell walls are polysaccharides. They consist of mixtures of neutral or acidic, linear and branched polysaccharides. These polysaccharides are usually extracted using hot water [6], which is a popular and convenient method, but the disadvantages of the method are that it requires a great deal of time and has a high temperature and low extraction efficiency. In general, extraction methods involve the removal of interfering substances (e.g., low-molecular-weight compounds, lipids, and colored substances from the alginate sample) using a methanol/chloroform mixture (1:1) [7]. In addition, 2% formaldehyde, one of the most widely used extraction methods, binds the color pigments present in the cell wall for 24 h at room temperature (25 °C) [8].

3.2. Extraction

First, the collected *Charophyceae* algae were cleaned and dried. A total of 20 g of dried seaweed was extracted with 2% formaldehyde, and as a result, the lower-molecular-weight compounds of the plant were removed. The seaweed was then washed with distilled water and subjected to extraction using 0.2 M H₂SO₄ for 4 h. After a certain time, it was washed again with distilled water, and the extraction was continued using 5% (pH 12.4) sodium carbonate. The resulting extract was centrifuged, and the dissolved fraction was collected and precipitated with ethanol. Then, the sediment fraction was filtered, washed twice in acetone and dried in a 40 °C drying oven. The product yield was 22.5%.

4. Conclusions

In total, 4.68 g of sodium alginate was extracted from *Charophyceae* algae using an extraction method. Thus, it was 22.5% compared to the dry mass amount of waterweed. All the experiments were performed in triplicate, and the extraction time (2, 3, 4 h), temperature (40, 60, 80 °C), concentration of the alkali (3% (pH 12.0), 4% (pH 12.2), 5% (pH 12.4)), and the amount of ethanol (1:1; 1:2; 1:3) were studied.

Sodium alginate's structure and composition were analyzed using physical-chemical research methods and IR spectroscopy (OH—3226–3454 cm^{−1}, CH₂—2928 cm^{−1}, man-nuronic acid functional group—896 cm^{−1} and uronic acid—1058 cm^{−1}) and XRD (crystalline index: 32.54%).

Author Contributions: Conceptualization, S.S.K. and A.K.K.; methodology, S.S.K.; software, S.S.K.; validation, S.S.K., S.Q.S. and A.K.K.; formal analysis, S.S.K.; investigation, S.S.K.; resources, S.S.K.; data curation, S.Q.S.; writing—original draft preparation, S.S.K.; writing—review and editing, S.S.K. and A.K.K.; visualization, A.K.K.; supervision, S.S.K.; project administration, S.S.K.; funding acquisition, S.S.K. and A.K.K.; All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: We would like to express our gratitude to Toshov Kh. S, Department of Optical Spectroscopic Analysis of “Molecular and Cell Biotechnology”, Interuniversity Scientific Laboratory, who assisted in the analysis of the polysaccharide samples by means of IR spectroscopy and X-ray diffraction (XRD).

Conflicts of Interest: The authors declare no conflict of interest.

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