ANALYSIS OF PHYSICOCHEMICAL PROPERTIES OF AMMONIUM ALGINATE

Nina Tarzynska, Anna Bednarowicz, Zbigniew Draczynski, Cesar Hernandez,
Dominik Sikorski, Izabella Krucinska
Lodz University of Technology, Department of Material and Commodity Sciences and Textile Metrology
nina.tarzynska@edu.p.lodz.pl

Key Words: ammonium alginate, sodium alginate, viscosity of spinning solutions, FTIR

1. INTRODUCTION

Alginates are naturally occurring polysaccharide copolymers consisting of ß-D-mannuronic acid (M-block) and α-L-guluronic acid (G-block) residues joined together by glycosidic linkages. [1] These blocks occur in different proportions and in different locations along the chain. Possible deployments are MM, GG, GM. [2]

Alginates from seaweed stems are usually characterized by a higher content of guluron blocks, while alginates from seaweed leaves are characterized by a higher content of mannuronic blocks. [3,4] In case of guluron blocks, the stereochemical structure of two repeating structural units allows to create space and close the divalent metal ions, e.g. calcium, to form an "egg-box" structure. In this structure, it is difficult to exchange calcium ions for sodium ions and it is possible to retain water. Gels that are formed from alginate with a higher content of guluronic acid blocks are defined as hard gels. [5] However gels made of alginate with a predominance of manurone blocks are soft gels. This structure allows to absorb water between the polymer chains and simplifies the exchange of ions.

Alginate fibers can be divided into many types, due to the type of their material: alginic acid, zinc alginate, copper alginate, sodium alginate, calcium alginate, ammonium alginate. [6] However, calcium alginate or sodium-calcium alginate is the most commonly used to produce alginate fibers. Typically, they are spun by the wet method, from aqueous solutions at a concentration of 4 to 8%. [7] Then in the coagulation bath, sodium ions are exchanged for calcium ions. The composition of this bath depends on whether the fiber produced contains alginic acid, calcium alginate or other alginate derivatives.

2. MATERIALS AND METHODS

2.1. Preparation of ammonium alginate

Ammonium alginate was made by modifying alginic acid with vapor ammonia. Various exposure times were applied (1h, 2h, 3h, 4h, 5h, 24h, 96h).

2.2. Fourier-transform spectroscopy

In order to confirm the modification, FTIR analysis was carried out.

2.3. Preparation of polymer solutions

The ammonium alginate solution was made by dissolving powdered ammonium alginate in distilled water. The solution was stirred for the first 4 hours using a mechanical stirrer -

Heidolph RZR-1 Control, after which the solution was left for 24 hours at room temperature to allow self-venting.

2.4. Investigations of apparent viscosity of polymer solutions

Measurements of apparent viscosity were carried out on a Anton PaarRheolabQC viscometer at 20 ° C. From the obtained test results, the graphs of the apparent viscosity dependence as a function of the shear rate on a double logarithmic scale were created.

3. RESULTS

3.1. Fourier-transform spectroscopy

After the modification process, the disappearance of the carboxyl groups is visible at a maximum at 1725 cm^{-1} (fig. 1). After modification, a peak appears at 1580 cm^{-1}, which proofs the -$COONH_4$ group appeariance.

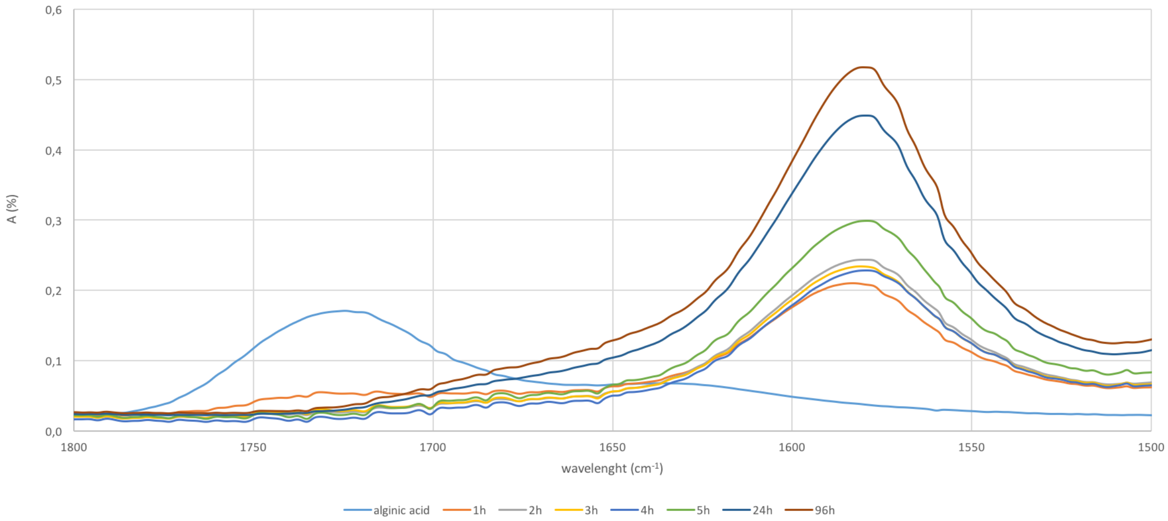

Figure 1. FTIR-ATR spectra of alginic acid and ammonium alginate.

3.2. Apparent viscosity of polymer solutions

The apparent viscosity of the spinning solution should be less than 90 mPa·s to allow the fibers to be detached. Table 1 shows the results of the measurement carried out at 20 ° C for a commonly used 8% solution of sodium alginate and a 12% solution of ammonium alginate.

Table 1. Apparent viscosity of solutions

Solution	Apparent visocosity (mPa·s)
8 % sodium alginate	28,187
12 % ammonium alginate	86,203

The analysis of the results of measuring apparent viscosity presented in the table shows that increasing the ammonium alginate concentration to 12% results in a solution with a viscosity below 90 mPa·s. The use of this alginate derivative in the fiber formation process can result in almost double efficiency of the process compared to the classical derivative of sodium alginate, while maintaining the consistency of the process.

4. CONCLUSION

Modification of alginic acid to obtain ammonium alginate is easy to perform, the effect is visible already after 2 hours of exposure to ammonia. The use of ammonium alginate in the spinning solution instead of the classically used sodium alginate allow to double the spinning process efficiency.

REFERENCES

[1] Wyrębska Ł, Szuster L, Stawska H. Synteza i aplikacja nowych pochodnych wybranych polisacharydów Część I: Przegląd literatury. *Technologia i Jakość Wyrobów* 59. 2014.

[2] Fertah M, Belfkira A, Dahmane E, Taourirte M, Brouillette F. Extraction and characterization of sodium alginate from Moroccan Laminariadigitata brown seaweed. *Arabian Journal of Chemistry* (2017) 10, S3707–S3714. 2014.

[3] Boguń M. Nanokompozytowe włókna alginianowe i kompozyty z ich udziałem do zastosowań w inżynierii biomateriałowej. *Zeszyty naukowe Politechniki Łódzkiej* nr 1062, Łódź. 2010.

[4] Eichhorn S, Hearle J.W.S, Jaffe M, Kikutani T. *Handbook of Textile Fibre Structure, Volume 2 - Natural, Regenerated, Inorganic and Specialist Fibres*.Woodhead Publishing. 2009

[5] Pielesz A. *Algi i alginy – leczenie, zdrowie i uroda*. 2010.

[6] Mather Robert R, Wardman Roger H. *Chemistry of Textile Fibres*. The Royal Society of Chemistry. 2011.

[7] Qin Y. Alginate fibres: an overview of the production processes and applications in wound management. *Polym Int* 57:171–180. 2008.