Sodium Alginate Extraction From Brown Seaweed (*Turbinaria Conoides*) And Its Structural Property As Bipolymer Electrolyte

Nurhadini
Department of Chemistry, Faculty of Engineering, Universitas Bangka Belitung
Bangka, Indonesia
nurhadini@ubb.ac.id

Ristika Oktavia Asriza
Department of Chemistry, Faculty of Engineering, Universitas Bangka Belitung
Bangka, Indonesia
ristika@ubb.ac.id

Anggraeni
Department of Biology, Faculty of Agriculture, Fisheries and Biology Universitas Bangka Belitung
Bangka, Indonesia
anggieib@gmail.com

Yudi Setiawan
Departement of Machine Engineering, Faculty of Engineering
Bangka, Indonesia
yudiubb@yahoo.co.id

***Abstract*—This research was conducted to extract sodium alginate from *Turbinaria conoides* and its structural property as biopolymer electrolyte. The existence of brown seaweed (*Turbinaria conoides*) is abundant in Bangka Belitung Islands. The main content of brown seaweed is alginate that it can be used as biopolymer electrolyte. Sodium alginate extraction process in *Turbinaria conoides* was carried out at 60°C with 5% Na_2CO_3 and the yield of sodium alginate was 13%. Sodium alginate is successfully extracted in *Turbinaria conoides*. Sodium alginate was characterized using FTIR. The results showed that sodium alginate extract had similar spectrum and same main fuctional group with commercial sodium alginate. Characterization structural property of biopolymer electrolyte by FTIR-ATR.** the increasing NaI percentage in sodium alginate made shift of peak toward higher wavenumber**. These shifting indicated increasing of interaction between NaI with polymer chain in alginate and degree of salt dispersion in polymer**

Keywords*— sodium alginate, biopolymer electrolyte, DSSC, Turbinaria conoides

I. INTRODUCTION

Environment-friendly and sustainable energy is promising for future energy resources. One of these energy resources is solar cells that it converts sunlight become electrical energy. DSSC become alternative solar cell due to low cost, simple fabrication, and easy to obtain materials. Thin and flexible *Dye sensitized solar cell* (DSSC) received more attention for much application. DSSC manufacturing technology is increasing to develop its efficiency[1]. DSSC efficiency is affected by type, preparation condition and surface area of electrolyte [2]. Mostly liquid electrolyte is used in DSSC because it has higher conductivity than other type electrolyte. However, it can lead to leakage, low stability and volatile and toxic solvents [3]

Polymer electrolytes can minimize leakage and solvent evaporation problems, high stability and shape flexibility. Synthetic polymer electrolyte is widely used in polymer electrolyte but it is not biodegradable[2].Conversely, biopolymer electrolytes are biodegradable, reliable processes, nontoxic, and abundant resources. Therefore, developing natural polymer into good ionic conductivity biopolymer electrolytes are now main consideration and research. Type of biopolymer is dominated by polysaccharides in electrolyte development to increase DSSC efficiency. Alginate, carrageenan and chitosan are natural resources derived and have been applied as biopolymer electrolyte [4][5][6].

Alginate is polysaccharides derived from brown seaweed which is very interesting because it has properties biodegradable, nontoxic, high ionic conductivity and abundant especially in Bangka Belitung Islands. Further, alginate is easily extracted process from brown seaweed. Biopolymer based alga have been studied by Sing (2016). Gel polymer made from sodium alginate and plasticized glycerol with CH_3COOH had ionic conductivity 3.1 10^{-4} S/cm. Yang (2014) synthesized polymer electrolytes from cross-linking alginate and PVA had ionic conductivity 0,091 S/cm [7].

Properties of biopolymer electrolyte determine DSSC efficiency. It can dependent on counter cations of iodides salts in biopolymer host. Structural properties explain interaction between polymer and salts. This paper will be studied about effect of NaI in alginate as polymer host on structural properties and it will be characterized by FTIR-ATR.

II. EXPERIMENTAL

A. Sodium Alginate Extraction

Brown seaweeds (*Turbinaria conoides*) were collected from Bangka Island. Then, it was washed to remove impurities (salt, plastics, sand and other organism) and dried in the air. Next, it was soaked for 1 hour in 2% H_2SO_4 solution, that ratio of seaweed and H_2SO_4 solution was 1:20 (w/v). Brown seaweed was neutralized with the deionized water, soaked for 30 minutes in 0,5% NaOH and

Copyright © 2019, the Authors. Published by Atlantis Press.
This is an open access article under the CC BY-NC license (http://creativecommons.org/licenses/by-nc/4.0/).

then neutrlized once again (adjusted pH 7). The brown seaweed was placed in 1000 mL two-neck flask, was refluxed at 60 ºC for 2 hour with 5% Na_2CO_3, that ratio of seaweed and Na_2CO_3 solution was 1:20 (w/v). The mixture was filtered and added 10% H_2O_2 until the solution adjusting to yellow. The filtrate's pH was adjusted to 1-2 with 10% H_2SO_4 and allowed to settle for 30 minutes. These result was alginic acid gels. And then the alginic acid gels was dissolved with 10% NaOH adjusting homogeneous. The solution was poured slowly into isopropyl alcohol solution under stirring. Then the mixture was allowed to settle for 30 minutes until sodium alginate fiber is formed. The sodium alginate fiber was centrifuged for 10 minutes at 4000 rpm to separated fiber with filtrate. At the end, the sodium alginate fiber was dried and pulverized so the sodium alginate powder was formed [8][9].

B. Syntheses of Polymer Electrolyte

Biopolymer electrolyte was prepared by dissolving alginate and NaI in water and stirred for 6 hour until homogenous. Biopolymer electrolyte membrane were made in alginate mass 0,5 gram with 5%; 10%; 15% and 20% NaI (b/b). Biopolymer electrolyte solution was filtered by using Whatman paper. Biopolymer electrolyte membrane was prepared by casting biopolymer electrolyte solution in petry dish and dried at 37ºC in incubator. The thin biopolymer electrolytes were characterized by FTIR-ATR.

III. RESULT AND DISCUSSION

A. Analysis of FTIR Sodium Alginate from Turbinaria conoides

*Turbinaria conoide*s is one of brown seaweed species. It is consist of polysaccharide, protein and fatty acid etc. Main functional group in *Turbinaria conoides* before treatmeant is presented in Figure 1.

Broad band at 3264 cm^{-1} was assigned to hydrogen bonded (-O-H) stretching related to polysaccharide and protein compound. The peak at 2942 cm^{-1} and 2146 cm^{-1} were attributed to C-H bond related to protein compound. The peak at 1949 cm^{-1} and 868 cm^{-1} were attributed to C=C and C-H vibration related to aromatic ring.

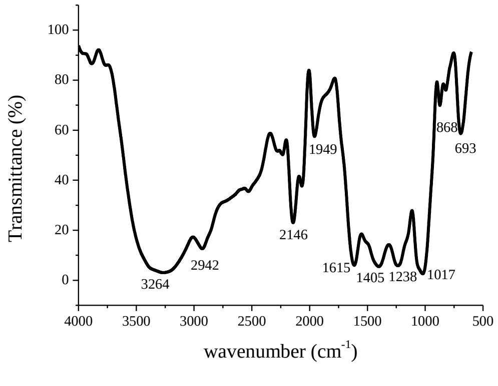

Fig. 1. FTIR spectrum of *Turbinaria conoides*

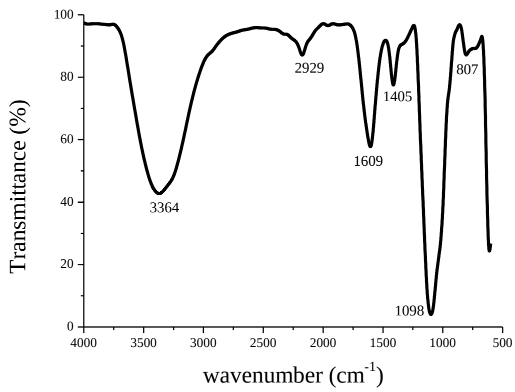

Fig. 2. FTIR-ATR spectrum of sodium alginate from *Turbinaria conoides*

The peak at 1615 cm^{-1} and 1405 cm^{-1} were assigned to asymmetric and symmetric stretching of carboxylic vibration related to alginate compound. The peak at 1238 cm^{-1} was attributed to sulfur group (S-O-) associated to fucoidan compound. The peak at 1017 cm^{-1} is assigned to C-O stretching vibration associated to polysaccharide and fucoidan compound [10]

The yield alginate extract from *Turbinaria conoides* is 13% which is higher than for alginate from *Sargassum sp.* However it was lower alginate from other *Turbinaria* species. FTIR-ATR spectrum of sodium alginate from *Turbinaria conoides* is presented in Fig. 2.

Fig. 2 showed that a broad band at 3364 cm^{-1} was attributed to hydrogen bonded (O–H) stretching. Weak absorption at 2929 cm^{-1} was attributed to C-H bond. Medium absorption at 1609 cm^{-1} and weak absorption at 1405 cm^{-1} were assigned asymmetric and symmetric stretching of carboxylic (C=O) vibration, respectively. Strong band at 1098 cm^{-1} indicate (C-O-C) stretching vibrations of mannuronic acids. The characteristics mannuronic acid residues which is the anomeric or fingerprint region of sodium alginate (950–750 cm^{-1}) was assigned band at 807 cm^{-1}. Summary of wavenumbers and band assignments and from sodium alginate extract (SAE) and sodium alginate commercial (SAC) are presented in Table 1.

TABLE 1. WAVENUMBERS AND BAND ASSIGNMENTS OF ALGINATE

Wavenumbers (cm^{-1})		**Band assignments**
SAE	**SAC**[11]	
3364	3263	O-H
2929	2925	C-H
1609	1595	C=O
1405	1408	C=O
1098	1027	C-O-C

Spectrum of sodium alginate extract is similar to sodium alginate commercial. Furthermore, sodium alginate extract and sodium alginate had same main functional group. Based on FTIR-ATR spectrum indicated sodium alginate successful extracted from *Turbinaria conoides* [11][12][13].

B. Analysis of FTIR-ATR Alginate and NaI

Structural properties of biopolymer electrolyte depended on interaction between biopolymer with salt. Interaction biopolymer with salt is studied by FTIR-ATR characterization. FTIR-ATR spectra in various percentage of NaI in sodium alginate are presented in Fig. 3. Fig. 3 showed that the increasing NaI percentage in sodium alginate membranes made shift of peak toward higher wavenumber.

The peak shifted from 3307 cm^{-1} to 3413 cm^{-1} was assigned O-H stretching vibration. Peak shifted from 1602 cm^{-1} to 1619 cm^{-1} and another peak shifted from 1408 to 1420 cm^{-1} were assigned asymmetric and symmetric stretching of carboxylic (C=O) vibration, respectively. Peak shifted from 1084 cm^{-1} to 1096 cm^{-1} was attributed C-O-C stretching vibration of mannuronic acid. These shifting indicated increasing of interaction between NaI with polymer chain in alginate. Furthermore, the shifting indicated degree of salt dispersion in polymer [11][14][15].

IV. CONCLUSION

Sodium alginate successful extracted from *Turbinaria conoides* with 13% yield and characterization by FTIR. Based on FTIR spectrum, sodium alginate extract is similar to sodium alginate commercial. Furthermore, sodium alginate extract and sodium alginate had same main functional group. Structural property biopolymer electrolyte is investigated by interaction between NaI and sodium alginate. The increasing NaI percentage in sodium alginate membranes made shift of peak toward higher wavenumber.

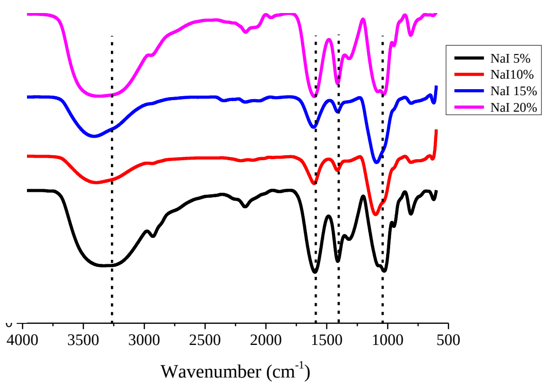

Fig. 2. FTIR-ATR spectra of sodium alginate with NaI variation

ACKNOWLEDGEMENTS

This work has been supported by Universitas Bangka Belitung.

REFERENCES

[1] Al-Alwani, M.A.M., Mohamad, A.B., Ludin, N.A., Kadhum, A.A.H., Sopian, K. 2016. Dye-sensitised solar cells: Development, structure, operation principles, electron kinetics, characterisation, synthesis materials and natural photosensitisers. Renewable and Sustainable Energy Reviews, 65, 183–213.

[2] Gra¨tzel, M., 2003. Dye-sensitized solar cells. J. Photochem. Photobiol. 2, 145–153

[3] Sequira, C., and Diego, S., 2010, Polymer electrolytes Fundamentals and applications, Woodhead Publishing Limited, United Kingdom.

[4] Nurhadini, Arcana, I.M. 2015. Synthesis Of Polymer Electrolyte Mebranes From Cellulose Acetate/Poly(ethylene oxide) $LiClO_4$ For Lithium Ion Battery Application, The 5th Conference On Mathematic And Natural Sciences, AIP Publishing

[5] Soeda, K., Yamagata, M., Ishikawa, M., 2015, Outstanding features of alginate-based gel electrolyte with ionic liquid for electric double layer capacitors, Journal of Power Sources, 280, pp. 565-572.

[6] Rudhziah, S., Ahmad, A., Ishak, A., Mohamed, N.S., 2015. Biopolymer electrolytes based on blend of kappa-carrageenan and cellulose derivatives for potential application in DSSC. Electrochim. Acta, 72, pp. 133-141

[7] Su'ait, M.S., Rahman, M.Y.A., Ahmad, A. 2015. Review on polymer electrolyte in dye-sensitized solar cells (DSSCs). Solar Energy,115, 452–470.

[8] Mahbub, A.M. 2012. Studi Ekstraksi Alginat Dari Biomassa Rumput Laut Cokelat (Sargassum crassifolium) Sebagai Adsorben dalam Biosorpsi Ion Logam Cadmium (Cd), Skripsi, FMIPA UI, Depok.

[9] Jayanudin, Lestari A.Z., Nurbayanti, F. 2014. Pengaruh Suhu dan Rasio Pelarut Ekstraksi Terhadap Rendemen Dan Viskositas Natrium Alginat Dari Rumput Laut Cokelat (*Sargassum* sp), Jurnal Integritas Proses, 5, 51-55.

[10] Yacou, C., Sandro, A., Carene, B., Gaspard, S. 2018. Chemical structure investigation of tropical Turbinaria turbinata seaweeds and its derived carbon sorbents applied for the removal of hexavalent chromium in water, Algal Research, 34, 25–36

[11] Li, J., He., J., Huang, Y., Li., D., Chen, X., 2015. Improving surface and mechanical properties of alginate films by using ethanol as a co-solvent during external gelation, Carbohydrate Polymers, 123, 208–216

[12] Aristya, I.M.T.W., Admadi, B. and Arnata, I.W., 2017, Karakterisasi Mutu Dan Rendemen Alginat Dari Ekstrak Rumput Laut Sargassum sp Dengan Mengggunakan Larutan Asam Asetat, Jurnal Rekayasa dan Manajemen Agroindustri, 5(1), pp. 81-92.

[13] Subramanian, V., Ganapthy , K., and Dakshinamoorthy, B., 2015, FT-IR, 1H- NMR And 13C-NMR Spectroscopy Of Alginate Extracted From *Turbinaria Decurrens* (Phaeophyta), World Journal Of Pharmacy And Pharmaceutical Sciences, Volume 4, Issue 12, 761-771

[14] Gao, C., Pollet, E., and Averous, L., 2017, Properties of glycerol-plasticized alginate films obtained by thermo-mechanical mixing, Food Hydrocolloids, Volume 63, 414-420

[15] Khanmirzaei M. H., Ramesh, S., Ramesh K. 2015. Effect of different iodide salts on ionic conductivity and structural and thermal behavior of rice-starch-based polymer electrolytes for dye-sensitized solar cell application, Ionics, doi: 10.1007/s11581-015-1385.