Futurum
Tsukuba Science Journal

Vinylon Prepared in Spring Water and Vinylon/Polyethylenedioxythiophene Composite

Composite

Kyoka Komaba, Hiromasa Goto*

Department of Materials Science, Faculty of Pure and Applied Sciences,
University of Tsukuba, Tsukuba Ibaraki 305-8573, Japan.
*Correspondence: gotoh@ims.tsukuba.ac.jp

ABSTRACT

In this research, we prepared vinylon synthesized in spring water from Zao. Furthermore, vinylon/poly(3,4-ethylenedioxythiophene) (PEDOT) composite was prepared with vinylon synthesized in spring water. The compounds thus synthesized in this study were evaluated with infrared absorption (IR) spectroscopy measurements and scanning electron microscopy (SEM) observations.

Keywords: Composite, conductive polymer, spring water.

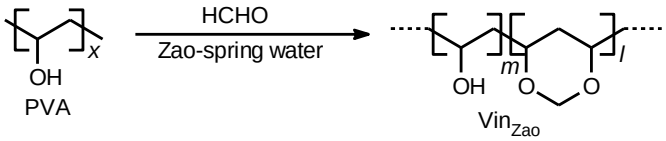
Introduction

Hot spring water contains many kinds of minerals like Ca, Mg, Al, and ions such as SO_4^{2-}, Cl^-, and HSO_4^- [1]. pH of the hot spring water depends on place and time [2].

In this research, vinylon was synthesized in the spring water obtained from Zao, Japan. Spring water was used as both acid catalyst and solvent during the reaction. Furthermore, vinylon/poly(3,4-ethylenedioxythiophene) (PEDOT, a conducting polymer) composite was synthesized with vinylon thus prepared in this study.

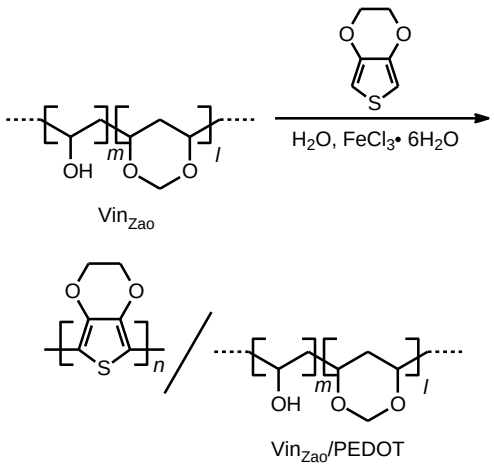
Experimental

Synthesis



Scheme 1. Synthesis of Vin_{Zao} (vinylon) in the presence of Zao-spring water. PVA: polyvinylalcohol.

First, vinylon was synthesized in Zao-spring water (pH = 2.0, 60 mL) from polyvinylalcohol (PVA, 2.0 g) with a small volume of formaldehyde (Scheme 1). Vinylon was first synthesized by Sakurada in 1939. Polyvinylalcohol was formalized with H_2SO_4, Na_2SO_4, HCHO and H_2O in the study. H_2SO_4 was used as an acid catalyst. Na_2SO_4 was used to prevent softening of fiber by formalization. H_2O was employed as a solvent [3]. Therefore, the acid component of the Zao-spring water played a role of acid catalyst and a solvent.



Scheme 2. Synthesis of Vin_{Zao}/PEDOT. PEDOT: poly(3,4-ethylenedioxythiophene).

This polymer (vinylon) is abbreviated as Vin_{Zao}. Then, Vin_{Zao} thus prepared (0.02 g) and 3,4-ethylenedioxythiophene (EDOT, 0.2 g) were added into the distilled water (1 mL) and stirred. After two days, $FeCl_3 \cdot 6H_2O$ (0.2 g) was added into the mixture over night (Scheme 2). The precipitate was collected by filtration and the solvent was removed under vacuum to afford a black solid.

Results and discussion

Molecular Structure

Figure 1 shows infrared absorption (IR) spectra for EDOT (monomer), Vin_{Zao} and Vin_{Zao}/PEDOT composite. EDOT exhibited bending vibration of C–H in aromatic ring with α carbon at 890 cm^{-1}. While, Vin_{Zao}/PEDOT showed no signal derived from the monomer at 890 cm^{-1}. Vin_{Zao}/PEDOT shows C=O and C=C stretching vibration at 1697 and 1539 cm^{-1} due to the vinylon structure, respectively. The signal at 1150cm^{-1} and 1165 cm^{-1} is derived from the C-O-C stretching vibration of vinylon in Vin_{Zao} and Vin_{Zao}/PEDOT, respetively. These results confirm that the synthesis of Vin_{Zao} and Vin_{Zao}/PEDOT was achieved.

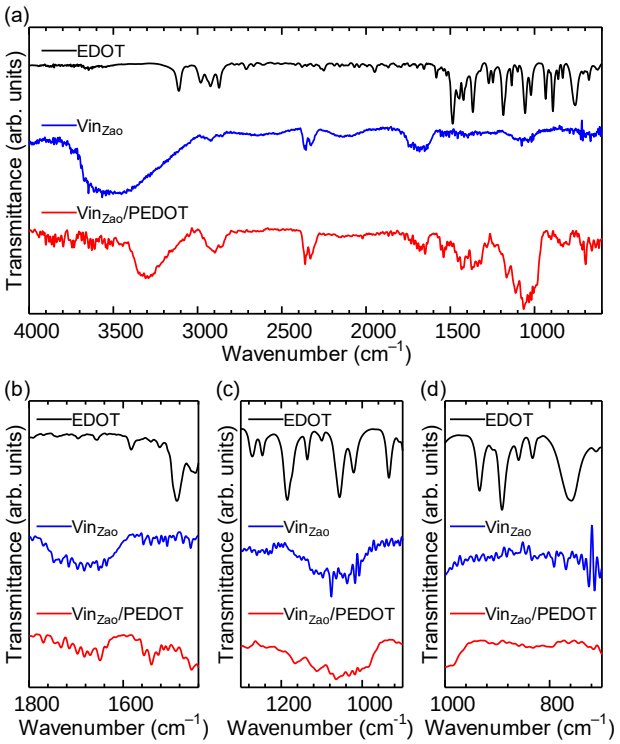


Figure 1. Infrared absorption spectra for 3,4-ethylenedioxythiophene (EDOT, monomer), Vin_{Zao} and Vin_{Zao}/PEDOT. (a): full scale. (b):1800 –1440 cm^{-1}. (c):1300–900 cm^{-1}. (d):1000 –700 cm^{-1}. Vin_{Zao}: vinylon prepared in Zao-spring water.

Composite

Surface images

Figures 2,3 show SEM images of non-Au coated Vin_{Zao} and Vin_{Zao}/PEDOT, respectively. Vin_{Zao} has roughness structure (Figure 2a,b). While, Vin_{Zao}/PEDOT displays less roughness (Figure 3a). Magnification image of Vin_{Zao}/PEDOT evaluated that Vin_{Zao}/PEDOT has porous structure on the surface (Figure 3b,c).

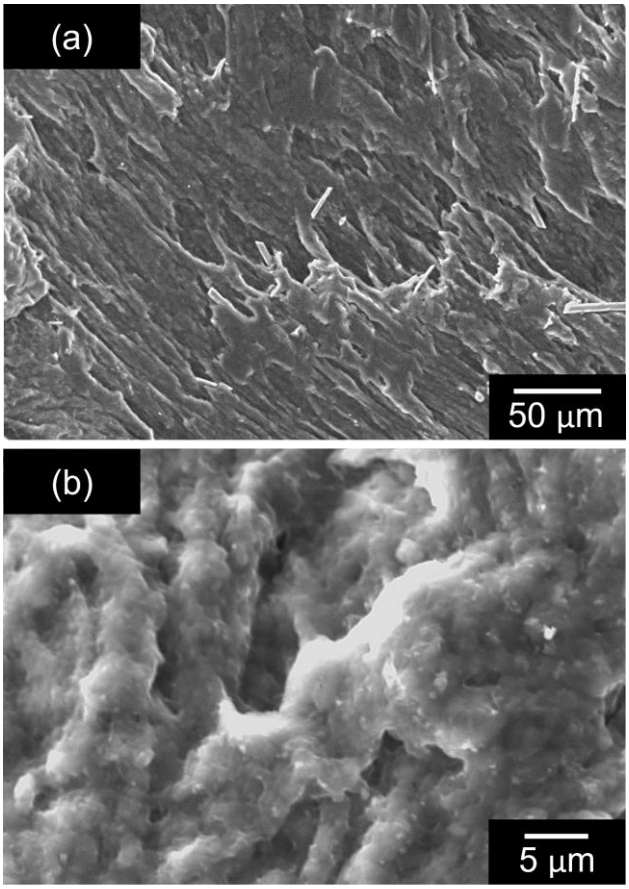


Figure 2. Scanning electron microscopy (SEM) images of Vin_{Zao}. (a): Low magnification. (b): High magnification.

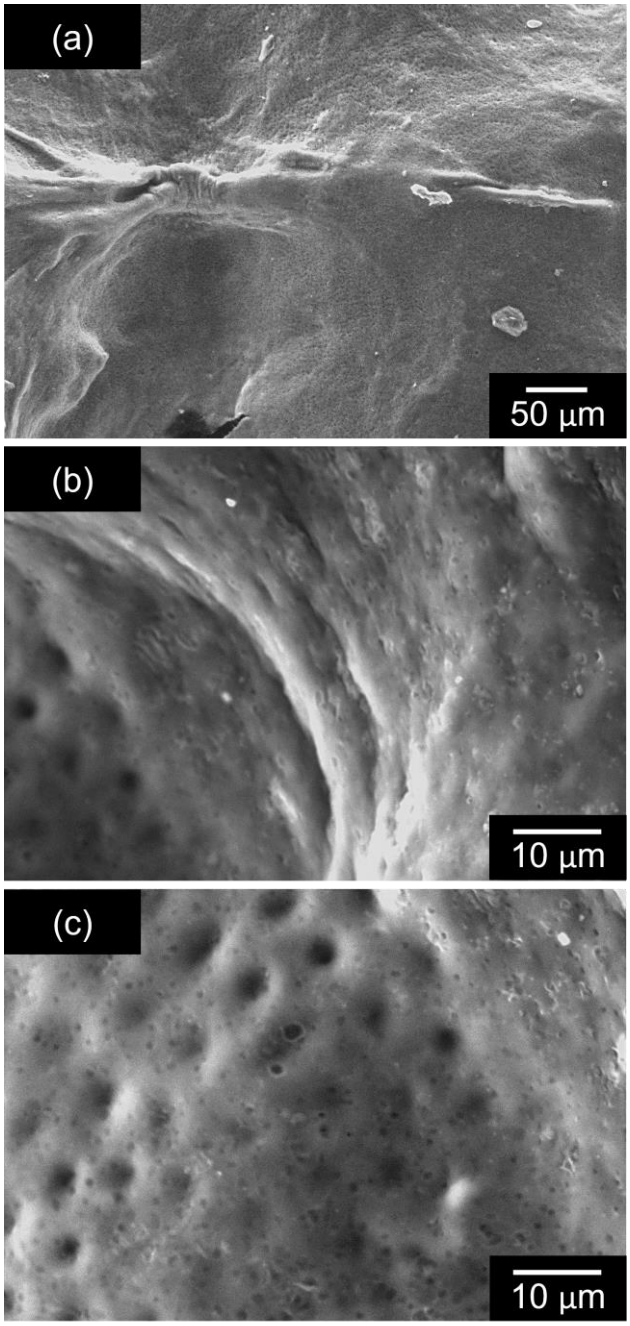


Figure 3. SEM images of Vin_{Zao}/PEDOT. (a): Low magnification. (b,c): High magnification.

Conclusions

Preparation of vinylon synthesized in Zao-spring water, and composite formation of the vinylon with PEDOT were successfully achieved. PEDOT as a conducting polymer was coated the entire surface of the vinylon.

Acknowledgements

The volcanic spring water for reaction solvent was kindly gifted by Zao Onsen Tourism Association. The authors would like to thank Glass Workshop of Central Workshop of University of Tsukuba for fine glass works.

References

[1] Ciężkowski, W., Chowaniec, J., Górecki, W., Krawiec, A., Rajchel, L., Zuber, A. Mineral and thermal waters of Poland. Przeglad Geologiczny. 58 (2010).

[2] Yamamoto, H., Kikawada, Y. Temporal variation in water chemistry of Bandaiko hot spring in Kusatsu hot springs through the past five decades and its change accompanying eruption of Mt Moto-Shirane in 2018, Proc. 72th Ann. Cong. Jpn Soc. Hot Spr. Sci., 80th Ann. Cong. Taiwan, 72, 73 (2019).

[3] Sakurada, I. THE SAKURADA LABORATORY, The Commemoration volume for the silver jubilee, 84-91 (1951).

Received: 28 January, 2021
Accepted: 2 February 4, 2021