Futurum
Tsukuba Science Journal

Composite

Polyaniline/Lignin Composite Prepared by Oxidative Polymerization

Ryosuke Kikuchi, Hiromasa Goto*

Division of Materials Science, Faculty of Pure and Applied Sciences, University of Tsukuba, Tsukuba, Ibaraki 305-8573, Japan

ABSTRACT

We synthesized polyaniline/lignin composite through oxidative polymerization reaction. We measured electrical conductivity and thermogravimetric analysis in a different ratio of lignin and polyaniline. From these results, heat-resisting property was improved with lignin.

Keywords: polyaniline; sodium lignin sulfate; composite; absorption spectra; electro conductivity

Introduction

Polyaniline (PANI) is a conducting polymers. PANI is easily synthesized in water. However, low solubility may drawback of PANI for applications. Formation of polyaniline composites can improve processability. PANI/alginic acid composite can be dissolved in water because alginic acid arrange 3-D structure of PANI from compact coil to expanded coil [1]. In this research, we employ sodium lignin sulfate as a surfactant for formation of composite with PANI to provide good solubility.

Experimental

Polymerization

As a control sample, polyaniline doped with sulfuric acid was synthesized for comparison with PANI/lignin composite. Six polyaniline composites (PANI-SLS) were synthesized with following method. Aniline, distilled water, sulfuric acid or sodium lignin sulfonate (SLS) were placed ion an Erlenmeyer flask with magnetic stirring bar. The flask was cooled with ice bath, and stirred for over 3 h. Then, ammonium persulfate (APS) in the water solution was added drop by drop with a Pasteur pipette to slowly progress polymerization of aniline. After stirring for a day, the solution was separated with suction filter. The black solid remained on the filter was transferred to another Erlenmeyer flask and was washed with distilled water, and methanol with several times. Further filtration was carried out. The PANI thus obtained was dried under reduced pressure to yield powder form.

Results and discussion

FT-IR measurement

Figure 1 shows FT-IR spectra of PANI, PANI/SLS composites, and SLS prepared with KBr method. For PANI/SLS composites, the characteristic peaks due to quinonoid and benzenoid structure of PANI, are observed at around 1600 and 1500 cm^{-1}, respectively. C-N stretching vibration are obseerved at 1140 and 1300 cm^{-1}. Increase of concentration of SLS in the polymerization, signals at around 1037 cm^{-1} appeared. The signal associates with -C-O- (primary -OH) stretching, which is characteristic band of the SLS. This result indicates that a series of PANI-SLS contains both PANI and SLS. The resultant PANI is in a form of doped (oxidized) state.

Received: 10 January, 2017. Accepted. 13 January, 2017.

*E-mail: gotoh@ims.tsukuba.ac.jp

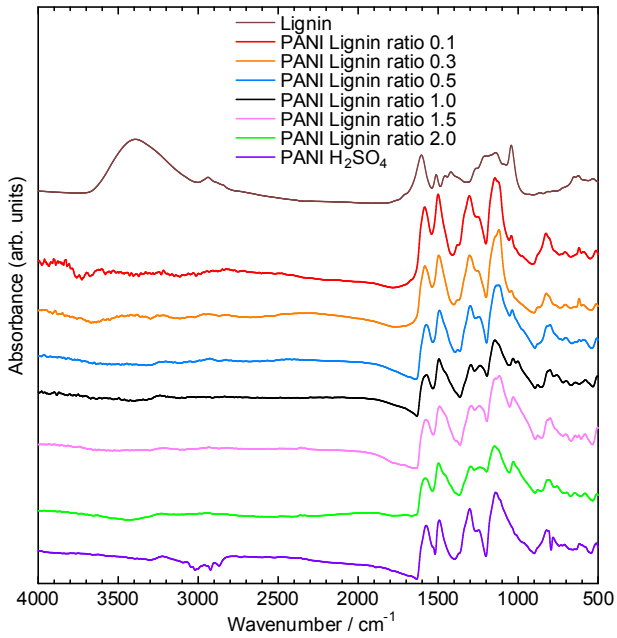

Figure 1. IR absorption spectra of Polyaniline (PANI) film, PANI sodium lignin sulfonate (SLS) series films and SLS film.

Electrical conductivity

Figure 2 shows electrical conductivity of PANI (H_2SO_4) and a series of PANI-SLS composites. The composites show lower conductivity compared with PANI (H_2SO_4) due to low doping level. Electrical conductivity plots vs. PANI-SLS ratio displays maximum. The PANI based composite obtained in the condition of SLS/aniline = 1 in weight shows the highest conductivity in the series. In the range of PANI/SLS ratio is 0.1-1.0, SLS plays a role of acid dopant for polyaniline. In the range of SLS/aniline is 1.0-2.0, SLS shows no conductivity. This can be due to the fact that excess amount of SLS to PANI depress the electrical conductivity of the resultant composite.

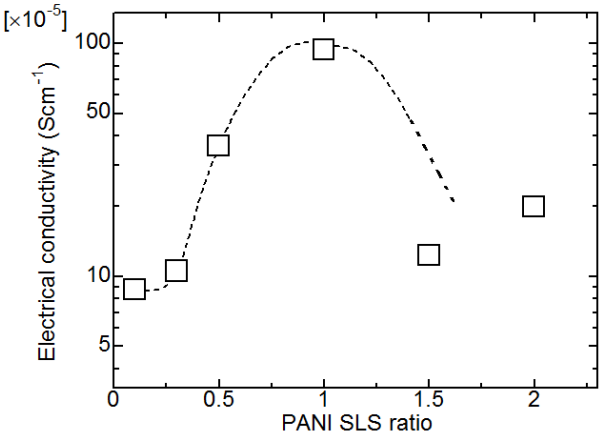

Figure 2. Electrical conductivity of PANI as a function of PANI/SLS ratio in weight.

TG and DTG measurements

Figs 3, 4 show thermogravimetry (TG) and differential thermogravimetry (DTG) curves of PANI, PANI-SLS series and pure SLS. First peak at the all of sample below 100°C is caused by losing of moisture or water remained in sample. Two characteristic peaks can be seen for PANI and PANI-SLS series. The PANI backbone decompose at around 540 °C. No clear difference between PANI and PANI-SLS series was observed less that 400 °C. However, pure PANI shows greater mass reduction than that of PANI-SLS series of composites below 800 °C. The composites containing large volume of SLS show improved thermal stability. Das et al. proposed that occurrence of H-bonding between two polymers provides thermal stability[2].

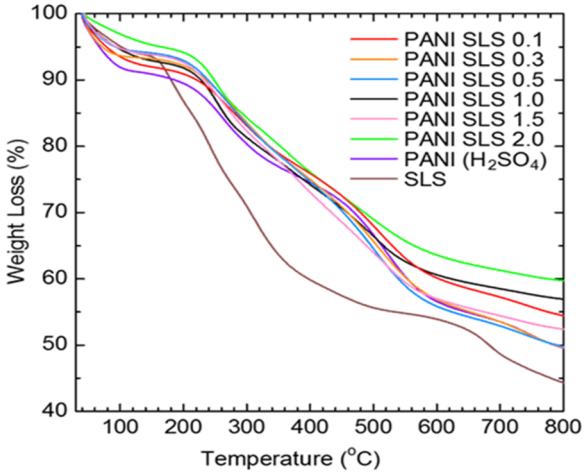

Figure 3. Thermogravimetry (TG) curves of PANI, PANI-SLS series and SLS under argon atmosphere.

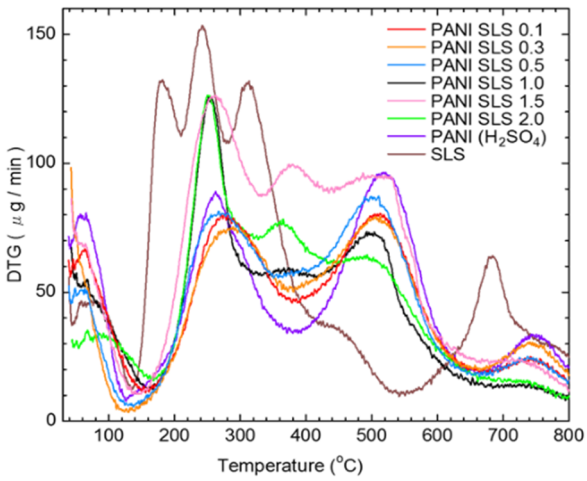

Figure 4. Differential thermogravimetry (DTG) curves of PANI, PANI-SLS series, and SLS under argon atmosphere.

Conclusions

We synthesized polyaniline composite doped with SLS through oxidative polymerization. TG and DTG measurements shows thermal stability of composite. SLS enhanced thermal stability for the composite because of H-bonding between polyaniline and SLS. The composite of PANI/SLS = 50/50 shows highest electrical conductivity in the present study.

Acknowledgments

This research was supported by Chemical Analysis Division Research Facility Center for Science and Technology of University of Tsukuba.

References

1. N. Kuniharu, K. Kawabata, H. Goto, Water soluble polyaniline/polysaccharide composite, Polymerization, carbonization to yield carbon micro-bubbles, *Synth. Met*., 194, 47-51 (2014).
2. Das, B., et al., Synthesis and characterization of polyacrylamide–polyaniline conductive blends, *J. Appl. Polym. Sci*., 69, 841-844 (1998).