PREPARATION AND CHARACTERIZATION OF GREEN COMPOSITE USING ALKYL CHAIN DERIVATIVE MODIFIED LIGNIN

S.H. Kim, S.T. Oh, H.Y. Jeong and J.S. Park*

Department of Biosystem & Biomaterials Science and Engineering, Seoul National University, Seoul, 151-742 Korea

* Corresponding author (jongshin@snu.ac.kr)

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1 Introduction

Lignin has Enormous potential as a raw material for polymer industries. However, lignin has not been utilized as a raw material in spite of its many advantages because of their brittleness and difficulty to process.

Chemical modification of lignin is an important area of lignin research. Two types of polymers were used for the blending with chemically modified lignin.

Lignin comes to be an Amphiphilic property due to its unique molecular structure. The Solubility Parameter of lignin is between hydrophilic polymers and hydrophobic polymers. Polymers that have similar Solubility Parameter can be blending well each other such as the relation of water and alcohol.

On the other hand, Polymers have a different Solubility Parameter can't be blending well such as the relation of water and oil. Thus phase separation would be happened

Until today, two main problems exist in lignin research area. One of them is brittleness, due to the large amount hydroxyl functional group at the end of the lignin molecular structure. The other one is phase separation as same as explained above.

However, it has been produced by several research groups to be able to make thermoplastics containing a large amount of lignin. Furthermore modified lignin was prepared to increase the interfacial force with other synthetic polymers.

In this research, two types of modification agent were used. To give a hydrophilicity, γ-Butylolactone was used. And to give a hydorphobicity, Tetrahydrofuran was used. (Fig. 1)

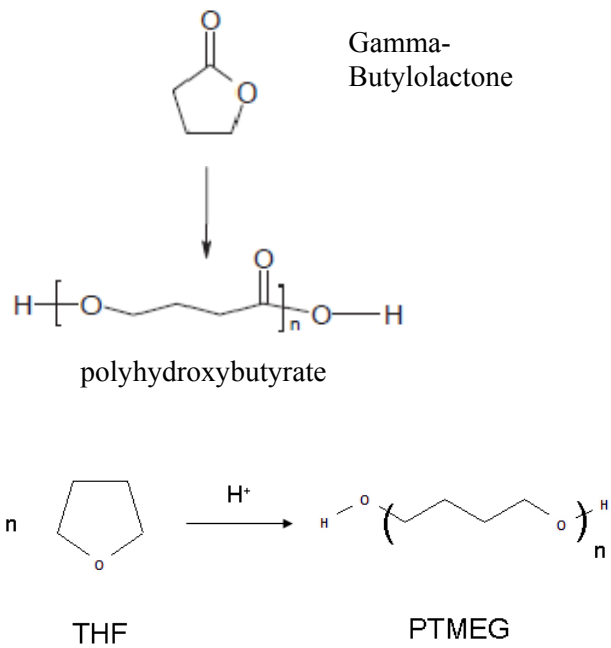

Fig. 1. Polymerisation of γ-Butylolactone and Tetrahydrofuran

These two alkyl chain derivative agents, had polymerized with lignin, to blocking OH group of lignin. At the same time, it needed to rearrange Solubility Parameter for make Solubility Parameter of modified lignin analogous with blended polymer.

As it can be extrapolating by the molecular structure, polymerized gamma butylolactone have a highly hydrophilic property. On the other hand, polymerized Tetrahydrofuran have a highly hydrophobicity. Lignin and alkyl chain derivative had combined as a glycosidic bond, under strong acidic condition. (Fig. 1)

2 Experimental

2.1 Materials

Caprolactone, Tetrahydrofuran and Gamma butylolactone were prepared for chemical modification of lignin. Sulfuric acid was used as a chemical modification catalyst. Lignin was purchased by MeadWestVaco, SKL (Tg - 67.54°C, MW - 1200).

Chemically modified lignin was blended with Polypropylene and Polyethylene terephthalate for general plastic. Modified lignin and synthetic polymers were prepared with different weight ratio of 25:75, 50:50, 75:25.

2.2 Characterization of modified lignin blended matrix

2.2.1 *Thermal Properties*

Thermo-gravimetric analyzer (Q500, TA Instruments, USA) was used for investigating the thermal properties of Modified lignin .

2.2.2 *Mechanical Properties*

Universal Testing Machine (LRX Plus, LLOYD Instruments, UK) was used for investigating the mechanical properties of blended matrix. Blended matrixes were mixed with modified lignin and some kind of synthetic polymers that have a good compatibility such as PP, PET.

Use the plastics tensile setup to determine tensile properties of samples. Tensile test speed was 500mm/min condition. This test conforms to BS EN ISO 527-1, BS2782 Part 3 Method 322, ASTM D 882 and other plastic testing standards.

3 Results

Pyrolysis temperatures of modified lignin had increased from 198'C to 264'C. Therefore, it means that the thermal stability of modified lignin was improved remarkably.(Fig.2) It gives a positive effect that alkyl chain modification of lignin within the framework of polymer processability

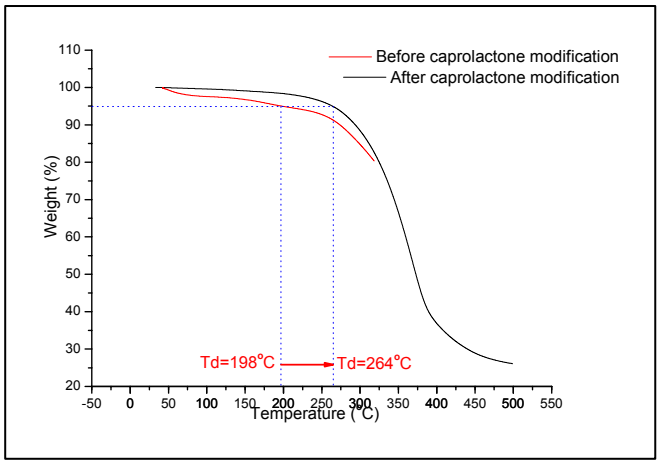

Fig. 2. TGA curve change after PCL modification

But, Polycaprolactone modification of lignin is not an appropriate method. Because it's high weight ratio in the modified lignin of Polycaprolactone about 60%. And Polycaprolactone has a amphiphilic analogous Solubility Parameter.

So, in this research we want to chase two hares at once – Lignin weight ratio increaseed in the modified lignin and rearrangement of Solubility Parameter of lignin to alkyl chain derivative modification.

As a result, tetrahydrofuran modified lignin (THFL) have about half decreased modification agent contents as compared with the polycaprolactone modified lignin. 31.7% (Fig. 3)

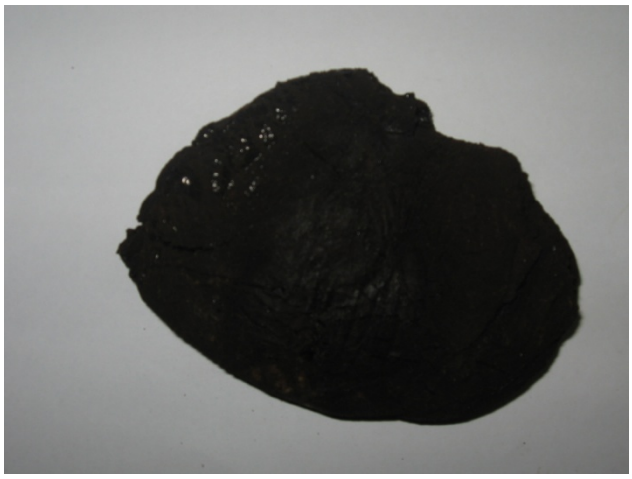

Fig. 3. THF Modified Lignin

In the case of butylolactone modified lignin (BLL) could be reduce the amount of butylolactone contents to 41.5%. (Fig. 4)

Fig. 4. Butylolactone Modified Lignin

All of the mechanical properties of THFL-PP had increased. It is because increased interfacial force between THFL and Polypropylene had held strong of polymeric chain of Polypropylene.

But, In the case of THFL-PP, the mechanical properties of 75:25 modified lignin : synthetic plastics matrix were decreased remarkably, while ones of 50:50 modified lignin : synthetic plastic matrix were a little decreased. THFL 75% sample had no elongation. So, it couldn't measurable. (Fig.5)

In the case of BLL-PET, elongation increased with the concentration of BLL, and the strength increased with the concentration of PET. Since the mechanical properties of polymer mixture follows the "Rule of Mixture". The mechanical properties of BLL-PET seemed to be a proportional behavior according to the BLL contents. In the case of BLL 75% sample had no elongation. So, it couldn't measurable as same as THFL 75%.

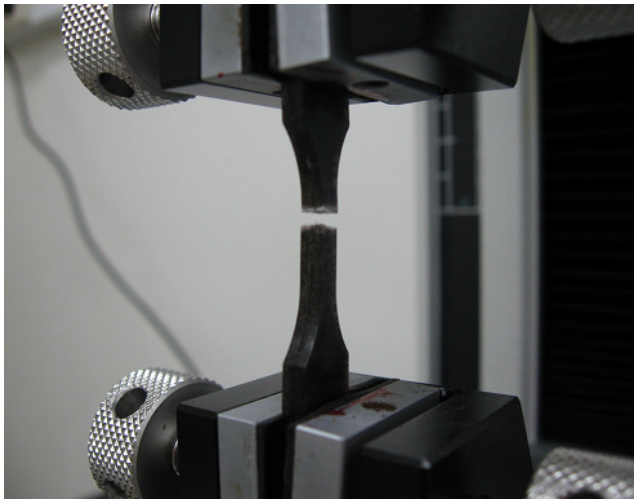

Fig. 5. Tensile test of THFL 75% matrix

Figure.6 shows that the strength of THFL-PP blended matrix increased with THFL content. There was no significant change of tensile strength, although tensile strength of 50%-THFL containing matrix was slightly lower than that of 25% THFL one.

Furthermore, tensile strength of BLL-PET blended matrix decreased with BLL content. Because polyhydroxybutyrate, was a highly elastic property having 1000% elongation which is the polymer of butylolactone

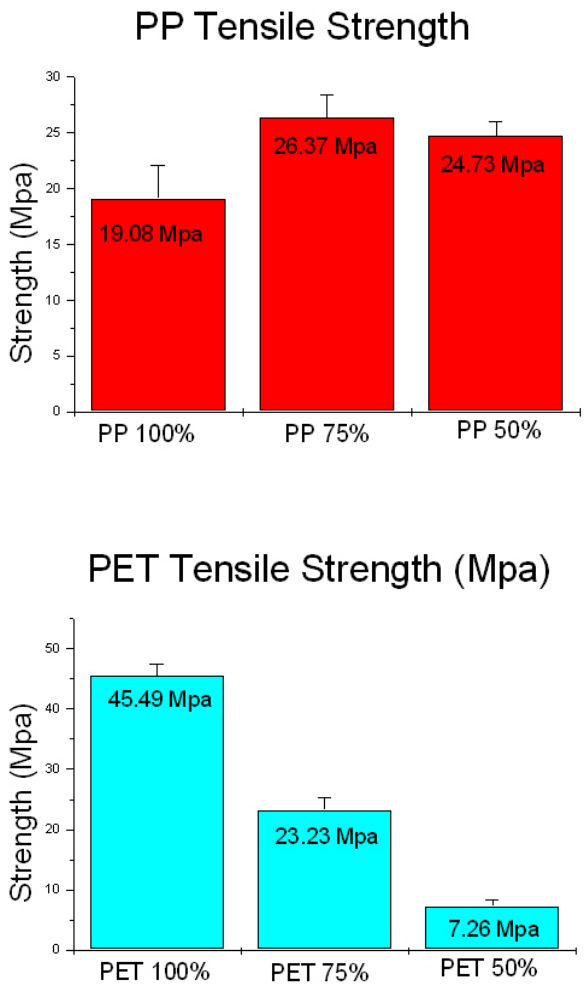

Fig. 6. Tensile Strength of blended matrixes

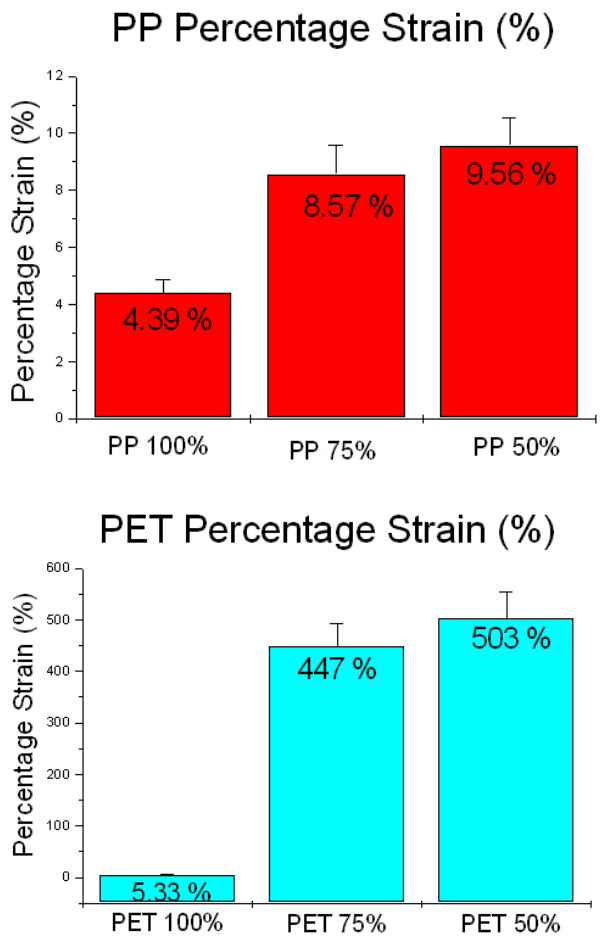

Fig. 7. Percentage strain of blended matrixes

In general Stress-Strain behavior, strain decrease when stress increased. In the case of THFL-PP, it seems a opposite behavior unlike to the general Stress-Strain relationship.

In the case of the BLL-PET, it seems a proper Stress-Strain behavior according to the rule of mixture. (Fig. 7)

Analogous to the tensile strength, the Young's Modulus values were increased with THFL contents, 711 Mpa to 959 Mpa.

In the case of the BLL-PET, Analogous to the tensile strength, the Young's Modulus values were decreased with BLL contents, 1145 Mpa to 126 Mpa. (Fig. 8)

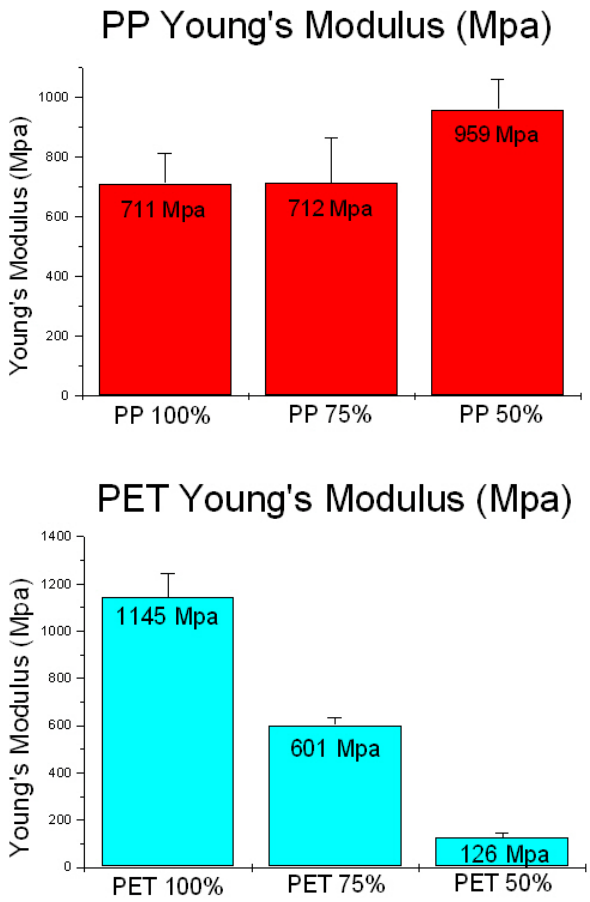

Fig. 8. Young's Modulus of blended matrixes

4 Conclusions

From these results, modified lignin can be used as a blended matrix. In addition, all of these components – Lignin, P4HB, PTMEG were biodegradable, environment friendly materials. It could be concluded that the Green Composite prepared in this study would be a new candidate of raw material for the replace some petro-based synthetic polymers and this product would make an epoch in plastic industries. The general purpose matrix, like PP or PET would be replaced by lignin-based matrix.

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