

INFLUENCE OF CONTAINED ADHESIVES ON THE PYROLYSIS CHARACTERISTICS OF WOOD BIOMASS

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Abstract: In recent years the use of plywood and laminate lumber as construction material has been increasing rapidly. The wood waste, containing synthetic polymer, such as adhesives, is expected to become a large quantity of material during the next 15~20 years. Although the demand for quality waste wood is increasing, waste wood material mixed with plastics or containing adhesives has low recycling value, and in most cases it is discarded. Therefore, it is necessary to develop techniques for processing it effectively. One technique for creating gaseous and liquid fuel out of wood is pyrolysis. The study investigated the outcome of pyrolysis in which synthetic polymers (plastics and adhesives) and wood biomass from construction materials were mixed at temperatures ranging from 300°C to 500°C at standard pressure and in a nitrogen atmosphere. Taking a compreg as samples, the pyrolysis characteristics of wood biomass mixed with synthetic polymer were studied using a thermogravimetric analyser (TGA). In the TGA measurement, wood containing adhesives was found to have a lower peak temperature of heat weight loss compared with wood not containing adhesives. It was demonstrated this experimental result is caused when the decomposition reaction of cellulose was influenced by adhesives.

1. Introduction

Japanese detached houses are mainly built of wood. At present the majority of these buildings are demolished and the plot redeveloped within 20-30 years. In recent years, plywood and laminate lumber are more commonly used than solid timber to build houses. This is because it has become possible to employ plywood and laminate lumber which is now produced strong enough to be used as structural members requiring strength and durability, for purposes such as pillars and beams, due to the improvement of adhesive technology for wooden materials. The production of structural plywood has increased about threefold in the last ten years and the production of laminate lumber has doubled. On the other hand, particleboard is a structural element made of finely crushed wood mixed with adhesives and then hardened. It is often used in cheap furniture and for the flooring of apartments. Among wooden boards, particleboard is the most widely produced. Particleboard is mostly made from wood waste and can already be described as a recycled material. In the future, further use of such recycled material is projected. However, such material mixed with plastics (physically

mixed or coated on the surface) and material with adhesives (especially adhesives containing nitrogen) has low recycling value, so most of them are discarded as final waste. It is therefore desirable to develop techniques for processing the materials more effectively. One of the techniques employed to manufacture gaseous and liquid fuel from wood is pyrolysis.

In 2006, Zhou et.al. researched the Thermogravimetric characteristics and kinetics of plastic and biomass blends during co-pyrolysis. According to their research, the high temperature region associated with co-pyrolysis of wood and plastics is described as interactive [1]. Marin et.al. inquired into the characteristics of the product in the co-pyrolysis of a mixture of wood biomass and synthetic polymers [2-4]. In addition to this, there are a number of other reports on this topic but there is little research on the pyrolysis characteristics of a mixture of wood and adhesives. In 2007, Nakai et.al. discovered that tar residue following pyrolysis of particleboard contains a component that is effective in preventing decay and insect damage [5]. There is no description of the pyrolysis characteristics of the mixture of wood and adhesives.

We conducted a pyrolysis experiment using approximately 70kg of samples comprising particleboard. We observed that particleboard (PBP) tends to take less processing time than the original wood (PBR) [6]. Our experiment showed that it is faster to process wood containing adhesives. On the other hand, when TGA measurement of PBP and PBR was performed, it turned out that the pyrolysis peak weight loss temperature of PBP is lower than PBR by 30°C. Therefore, investigation was made of the pyrolysis characteristics of wood containing adhesives, using a sample with which TG measurement of the adhesives content is possible. This is the report of each result of TG/DTA measurement of wood containing adhesives, the original wood and adhesives.

2. Experiments

2.1 Materials

The samples employed were Laminated Veneer Lumber compreg [7] (CPP) and material wood of compreg (CPR) and cellulose. The material wood of compreg was birch. The veneer of the birch raw material was pasted up with phenol resin adhesive. The CPP included 30% of phenol resin adhesive (PF). The composition of the CPP are shown in Fig.1. These samples were used after being ground finely to 150µm diameter or less. The cellulose in use was purchased from commercial chemical shop (Sigma-Aldrich Chemie CAS No.9004-34-6).

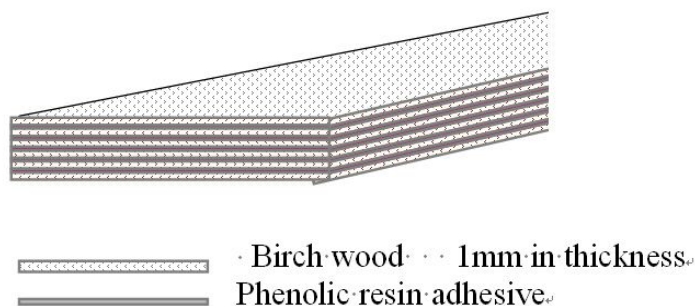


Fig. 1 Structure of compreg

2.2 Apparatus

TG/DTA measurement was performed in order to analyze the fundamental pyrolysis characteristics of the sample. The equipment is Shimadzu DTG-60, Japan. The pyrolysis was also carried out in the TG/DTA.

2.3 Experimental Method

About 5mg of the sample was heated up to 550°C at a constant rate of increase in temperature of 10°C/min and was maintained at the maximum for 10min. The TG/DTA was under 50ml/min N₂ flow.

3. Results and Discussion

The TG/DTG curves of CPP and CPR are shown in Fig. 2. In CPP and CPR, weight loss progresses slightly more quickly with CPR at first but at 174 °C, in turn, CPP loses weight more rapidly. This is considered to be the influence by disassembly of the phenolic resin adhesive (PF) contained in CPP. It reverses again at 353 °C and afterwards, the rapid weight loss of CPR continues to 390 °C. As for CPP, weight reduction slows down at 350 °C. The pyrolysis of the wood components is completed at around 350°C. It is believed that the condition where the pyrolysis residue of wood and the pyrolysis residue of PF which is a thermosetting resin decomposed slowly towards the end. The residue recovery yields of CPP and CPR were 33% and 12% respectively. The peak weight loss temperature of CPP and CPR is 331 °C and 372 respectively, and CPP is lower than CPR by 41 °C.

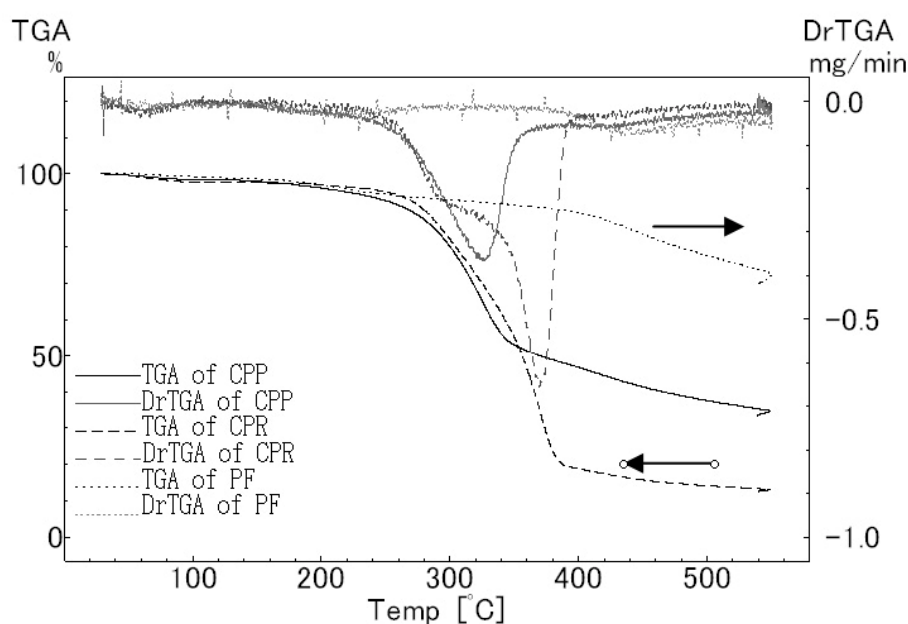


Fig. 2 The TG/DrTG curve of CPP, CPR, PF

Next, the same operation was performed on DTA and the graph is shown in Fig. 3. Endothermic reaction [70-100°C] occurred due to evaporation of moisture. Slight endothermic reaction occurs at around 190 °C of the DTA curve of CPP, which is considered to originate in decomposition of PF. Endothermic reaction of CPP which appears at 330 °C originates neither CPR nor PF. CPR has a big endothermic reaction at 374 °C, but CPP doesn't. The endothermic reaction of CPR occurred at 370 °C. Although the same reaction as CPP occurred at 330 °C, it is not accompanied by the big endothermic reaction. It is thought that 370 °C and 330 °C are the peak weight loss temperatures of CPP and CPR, respectively, and the main component of wood material itself decomposed at this point.

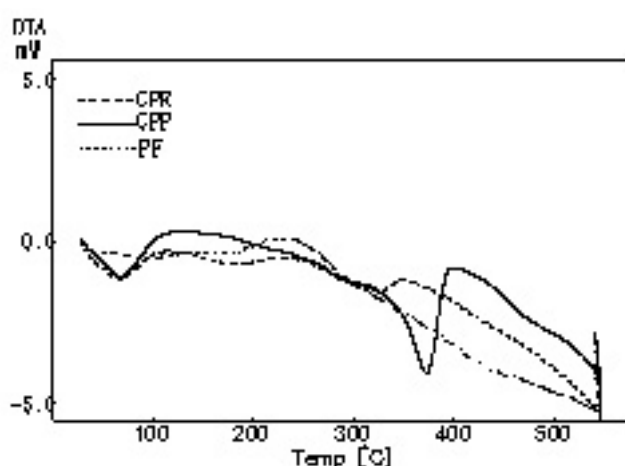


Fig. 3 The DTA curve of CPP, CPR, PF

The percentages of the cellulose, hemicellulose, and lignin which are the main composition components of wood are about 50%, about 20~30%, and about 20~30%, respectively. The pyrolysis of cellulose with the highest content is an endothermic reaction [8].

The decomposition reaction of hemicellulose and lignin is an exothermic reaction. Since it is thought that endothermic at 370 °C of CPR is based on the pyrolysis of cellulose, in the case of the pyrolysis of CPP, it is thought that adhesives are serving to inhibit the endothermic reaction of cellulose. It is concluded that CPP requires less quantity of heat for pyrolysis than CPR does.

Further, TG/DTA measurement of cellulose, PF, and cellulose +PF was performed. The mixing rate of cellulose +PF was cellulose: PF = 1:1. The result is shown in Fig.4 and Fig.5. The peak weight loss temperatures of cellulose and cellulose +PF were 323 °C and 325 °C respectively. This shows that PF had not contributed to lower the temperature of the peak weight loss of cellulose. The fall of the peak weight loss temperature of CPP is considered to be caused by the fact that cellulose exists in combination with hemicellulose, lignin, and other wood structure material. The influence of these will be considered in the future.

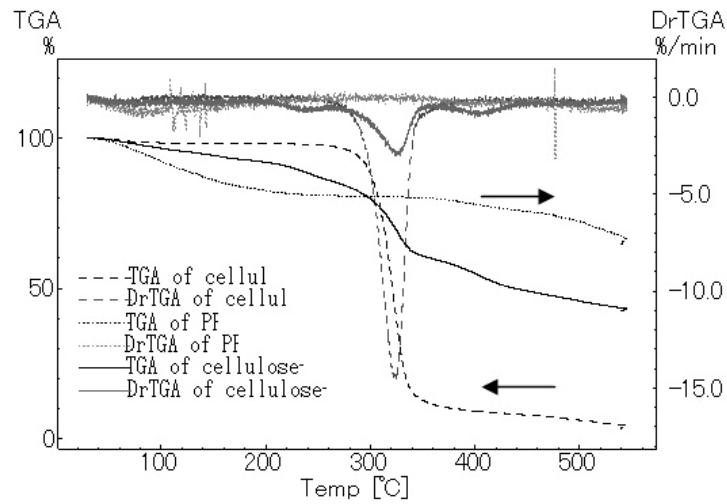


Fig.4 The TG/DrTG curve of CPP,CPR,PF

On the other hand, on the DTA curve (Fig. 5), there is no endothermic reaction in a cellulose +PF sample near 325 °C, which is the peak weight loss temperature of cellulose +PF. This shows that PF inhibits the endothermic reaction of cellulose. Since an exothermic reaction which negates the endothermic reaction of cellulose in PF pyrolysis is not observed, the pyrolysis mechanism of PF and a cellulose mixture will be examined in the future.

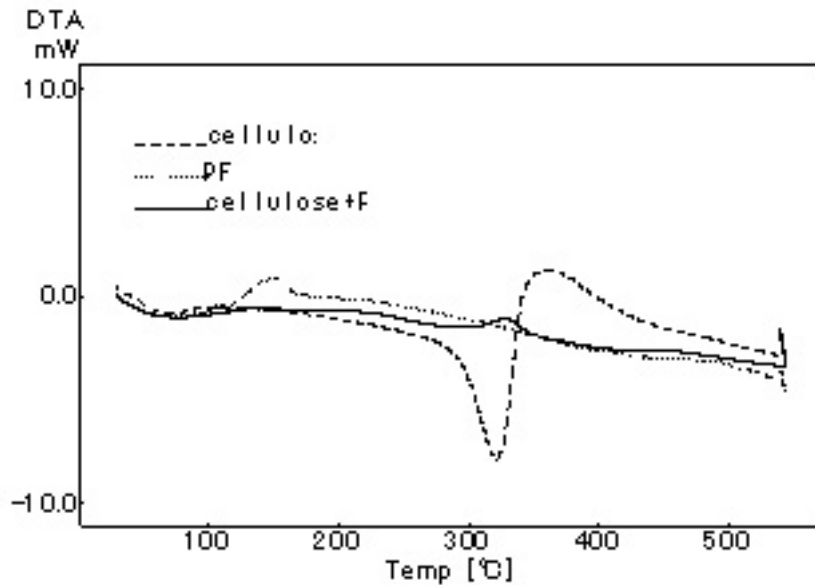


Fig. 5 The DTA curve of cellulose, PF, cellulose+PF

4. Conclusion

The experiment investigated the pyrolysis characteristics of wood containing adhesives, by making compreg into a sample using TG/DTA. At the peak weight loss temperature, TG/DTA measurement showed that CPP was about 40 °C lower than CPR. Although the

endothermic reaction occurred at 370 °C with CPR, the same reaction with CPP occurred at about 330 °C moderately.

In the observation using cellulose as the sample, the fall of the peak weight loss temperature under the influence of PF was not detected, so it is obvious that the endothermic reaction of cellulose is inhibited by the influence of PF. Investigation of the factor of a peak weight loss temperature fall and the elucidation of the inhibition mechanism of the endothermic reaction at the time of cellulose pyrolysis are future topics for investigation.

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