Research on Inhibition Effect of MDF Pyrolysis Condensate Liquids against Two Kinds of Fungi

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Abstract

Medium density fiber board pyrolysis condensate liquid with nitric compounds in it can be used as fungal inhibitor. Fungal experiments to test the fungicidal effectiveness against white rot fungus *Coriolus versicolor* and brown rot fungus *Gloeophyllum trabeum* of medium density fiber board pyrolysis condensate liquids obtained under different pyrolysis conditions were carried out. In the experiment, wood vinegar and bamboo vinegar were served as reference for comparison. Liquids components were analyzed by gas chromatography mass spectrometry. The result showed that medium density fiber board pyrolysis condensate liquids had obvious inhibition to both of the fungi. The inhibition rate was up to 52.64% against *Coriolus versicolor* and up to 27.02% against *Gloeophyllum trabeum.* The antifungal activity of medium density fiber board pyrolysis condensate liquid was better than wood vinegar and bamboo vinegar. Gas chromatography mass spectrometry analysis showed that there are more nitric compounds and less acids, phenols and ketones in medium density fiber board pyrolysis condensate liquid than wood vinegar. According to the results of fungal experiments and components analysis, pyrolysis condensate liquids had better antifungal effects with more nitric compounds. Pyrolysis condensate liquid of waste medium density fiber board will be a valuable material to develop with good antifungal effect.

Key words: MDF, pyrolysis liquids, antifungal activity, GC-MS analysis.

Introduction

Wood products play important role in our lives. According to statistics of State Forestry Bureau, the production of wood-based panel of 2011 is 1.6543×10^8 m^3, a 7.7 % increase as compared with that of 2010. In this situation, how to deal with the waste wood-based board becomes an issue that should be focused (Chen et al. 2007). Pyrolysis is believed to be a promising and effective way to reuse waste wood-based board and is friendly to the environment. However, the pyrolysis process of waste wood-based board is not the same as conventional biomass. Adhesive in waste wood-based board influences the pyrolysis process and products (Girods et al. 2007).

According to previous studies, the liquid products of pyrolysis of wood and bamboo have extensive applications. Wood vinegar has been found to have the function of promoting plant growth, antibacterial, anti-corrosion and can be used for wood preservation (Wang et al. 2004). There are some differences between medium density fiber board (MDF) pyrolysis condensate liquid and wood vigenar in composition and propeties. The pyrolysis liquids of MDF are weak alkaline because of the existence of nitrogen-containing compounds (Mu et al. 2011). The liquids can be used as basic solvents and additives in pesticides and in many other ways. A study on characteristic and bio-efficiency of the pyrolysis liquids from wood, particleboard, plywood and fiberboard showed that the inhibition of these liquids on the fungi were different due to different compositions (Nakai et al. 2007).

In this paper, fungal experiments to test the fungicidal effectiveness against white rot fungus *Coriolus versicolor* and brown rot fungus *Gloeophyllum trabeum* of MDF pyrolysis condensate liquids obtained under different pyrolysis conditions were carried out. In the experiment, wood vinegar and bamboo vinegar were served as reference for comparison. Liquids components were analyzed by gas chromatography mass spectrometry (GC-MS). This study could be a basic research for a further study of the possible application of the pyrolysis liquids.

Materials and Methods

Preparation of Samples

Adhesive contained in MDF was mainly urea formaldehyde (UF) resin. MDF pyrolysis liquids samples were obtained from pyrolysis at final temperature fixed at 300℃, 400 ℃, 500 ℃, 600 ℃with the heating rate of 100 ℃/h and 150 ℃/h respectively. MDF(500/150) referred to MDF pyrolysis condensate liquid obtained at final temperature of 500 ℃ with heating rate of 150 ℃/h in the following paragraphs. Wood vinegar and bamboo vinegar were provided by manufactory.

Fungal Experiments

Potato dextrose agar (PDA) medium was autoclaved for 15 min at 121 ℃, 103.4 kPa. Then the pyrolysis liquid was diluted in PDA medium to a concentration of 0.5%. The mixture was poured into Petri dish (80 mm diameter) and left in Horizontal laminar flow table for cooling. The Petri dish was then centrally inoculated with a 5 mm fresh plug of fungi (7 days old). Petri dish with PDA medium only was used as control. Three replicates were set up for all tests and controls. All cultures were incubated in a incubator at 25℃until the growth of the fungi in the controls had reached the edge of the Petri dishes.

The colony diameter was measured and the inhibition was calculated according to the following equation:

$$I=[(C-T)/C]\times 100\%,$$

where I is the inhibition(%), C is the colony diameter of mycelium from control Petri dishes(mm) and T is the colony diameter of mycelium from the Petri dishes containing the liquids(mm) (Kartal et al. 2011).

GC-MS Analysis

Samples prepared from pyrolysis liquids were qualified by GC-MS. A column (RTX-5) with a diameter of 0.25 mm and length of 30 m was maintained at 50 °C for 5 min, then the temperature was raised to 280 ℃at a heating rate of 10 ℃/min and held at 280 ℃for 20 min. Nitrogen was used as carrier gas. The injection (injection volume of 1.0 μl) was performed at 280 ℃in the split mode (20:1). The mass spectrometer was operated in the electron ionization (EI) mode with ionization energy of 70 eV.

Results and Discussion

Bio-efficiency of Pyrolysis Liquids

The inhibition effects of MDF pyrolysis condensate liquids against white rot fungus *Coriolus versicolor* and brown rot fungus *Gloeophyllum trabeum* are shown in Figure 1 and 2 with wood vinegar and bamboo vinegar as contrast. The result showed that MDF pyrolysis condensate liquids had obvious inhibition to both of the fungi. The inhibition effects on *Coriolus versicolor* of all the three kinds of pyrolysis liquids were better than that on *Gloeophyllum trabeum*.

The inhibition rates against white rot fungus *Coriolus versicolor* and brown rot fungus *Gloeophyllum trabeum* of pyrolysis liquids obtained under different pyrolysis conditions are shown in Figure 3 and 4. The antifungal activity of MDF pyrolysis condensate liquid was

better than wood vinegar and bamboo vinegar with the inhibition rate up to 52.64% against *Coriolus versicolor* and up to 27.02% against *Gloeophyllum trabeum.* For MDF, pyrolysis liquids obtained at final temperature of 500℃ and 600℃ had better antifungal effects than those obtained at temperature of 300 ℃and 400 ℃which could be attributed to more anti-fungal functional groups generated at that condition.

Figure 1 The inhibition effects against Coriolus versicolor of different kinds of pyrolysis condensate liquids

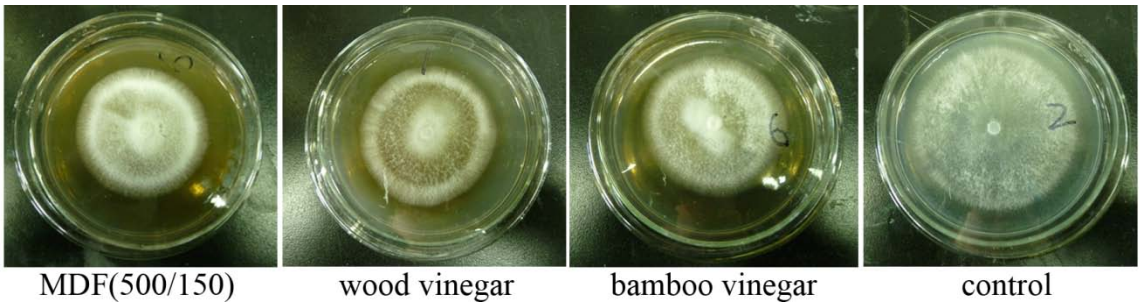

Figure 2 The inhibition effects against Gloeophyllum trabeum of different kinds of pyrolysis condensate liquids

Inhibitory effects in vitro of filtrates from biomass slurry fuel production on the growth of brown-rot and white-rot fungi suggested that higher concentrations of the filtrates are critical for inhibition and the filtrates contain some components such as phenolic compounds from lignin degradation for induction of antifungal activity against brown-rot fungi only (Kartal et al. 2004). In our experiment, the antifungal activity of MDF pyrolysis condensate liquids were better than wood vinegar and bamboo vinegar to both of the fungi. The inhibition effects on white-rot fungus of all the three kinds of pyrolysis liquids were better than that on brown-rot fungus.

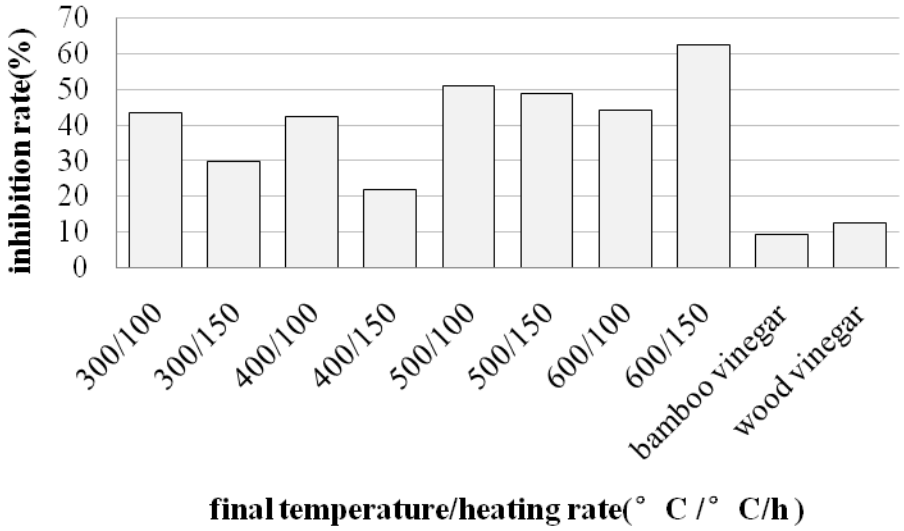

Figure 3 The inhibition rates against Coriolus versicolor of MDF pyrolysis condensate liquids obtained under different pyrolysis conditions

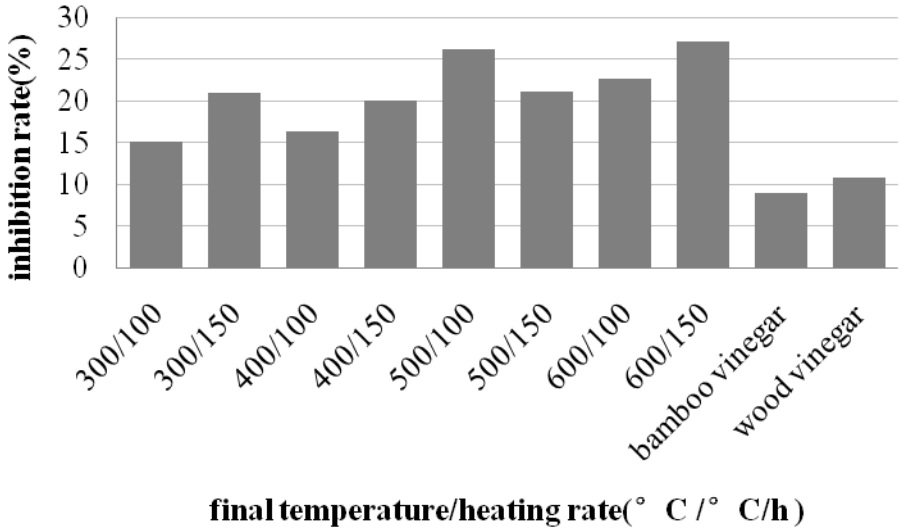

Figure 4 The inhibition rates against Gloeophyllum trabeum of MDF pyrolysis condensate liquids obtained under different pyrolysis conditions

Study of Pyrolysis Liquids Compositions

Main compositions of MDF(500/150) and wood vinegar analyzed by GC-MS are listed in Table 1. MDF pyrolysis condensate liquid contained more nitric compounds, sugars and alcohols than wood vinegar which was rich in acids, phenols and ketones. These linear and cyclic nitric compounds might be generated from decomposition and reaction in the pyrolysis process of UF resin added in the wood-based panel. The distinctive nitric compounds from MDF reveal the chemical interaction between UF resin and wood components. The detailed

chemical reactions now can not be well explained. Such nitric compounds make pyrolysis liquids of waste wood-based composites different from those of general biomass and will influence the utilization of pyrolysis liquids.

Table 1 Main compositions of pyrolysis condensate liquids analyzed by GC-MS

MDF(500/150)	Kinds	Relative content /%	Wood vinegar	Kinds	Relative content /%
Acids	2	34.23	Acids	2	64.46
Phenols	4	4.92	Phenols	5	7.27
Ketones	2	0.63	Ketones	12	9.23
Esters	4	5.14	Esters	4	5.68
Ethers	1	0.57	Aldehydes	2	2.38
Alcohols	1	6.02	Alcohols	1	2.67
Sugars	1	5.24	Sugars	1	0.88
Nitric compounds	11	13.09	Nitric compounds	1	0.72

The pyrolysis process of wood was very complicated, including the thermal degradation of cellulose, hemicellulose and lignin. Wood vinegar contained 16 kinds of ketones, 14 kinds of phenolic and other compounds like esters, aldehydes and alcohols besides the main components acetic acid (Xu et al. 2006). In addition, there are nitric components in wood vinegar like amine, methylamines, dimethylamine and pyridine of trace content (Wang et al. 2004). The result of this paper was in consistent with the mentioned studies and showed that pyrolysis liquids were influenced a lot by the nitric compounds transferred from UF resin.

Pyrolysis condensate liquids with different composition had different fungi inhibition effects. According to the results of fungal experiments and components analysis, we found that pyrolysis condensate liquids had better antifungal effects with more nitric compounds. Acidic environment is suitable for fungal growth. According to previous experiments, the pH of MDF pyrolysis condensate liquid was around 9 with nitric compounds in it while wood vinegar and bamboo vinegar were acidic (Mu et al. 2011). As shown in the antifungal l experimental results, the alkaline pyrolysis liquid had better fungi inhibition effect.

Conclusions

MDF pyrolysis condensate liquids had obvious inhibition to both white rot fungus and brown rot fungus. The inhibition rate was up to 52.64% against *Coriolus versicolor* and up to 27.02% against *Gloeophyllum trabeum.* The antifungal activity of MDF pyrolysis condensate liquid was better than wood vinegar and bamboo vinegar. GC-MS analysis showed that there were more nitric compounds and less acids, phenols and ketones in MDF pyrolysis condensate liquid than that in wood vinegar. According to the result of fungal experiments and components analysis, pyrolysis condensate liquids had better antifungal effects with more nitric compounds. Pyrolysis condensate liquid of waste MDF with good antifungal effect

would be a valuable material to develop.

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