Processability , Morphological and Mechanical Properties of Wood Fiber Reinforced Recycled Polyolefin Composites

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Wood fiber reinforced recycled polyolefin composites were prepared in this study. Tensile , flexural and Izod impact strength were performed in order to evaluate the mechanical properties of the resulted composites. Results show that the tensile strength of recycled HDPE increased from 16.5 MPa to 21.5 MPa after being reinforced with 30wt% wood fiber (WF). Tensile modulus of 30wt% WF/Recycled HDPE composite increased from 798 to 1499 MPa, as compared with the unreinforced recycled HDPE. Flexural strength of recycled HDPE increased with the increasing of wood fiber content. Flexural strength and modulus of 30wt% WF/Recycled HDPE composite were 34.4 MPa and 1150 Mpa , respectively. However , those of the unreinforced recycled HDPE were 25.3 MPa and 675 MPa respectively.

The processability was studied at 150, 160 and 170°C, respectively. Results showed that the melt viscosity of 10wt% wood fiber reinforced recycled HDPE decreased from 350 Pa·s to 150 Pa·s as the temperature increased from 150 to 170°C at the shear rate of 800 1/s. The silane treated composites reduced the melt fracture as can be observed from the surface morphologies of the extruded rod.

Introduction

Recycling is proposed as a desirable way to reduce the amount of waste deposited in landfills and minimize exploitation of natural resources. Plastic materials contribute about 20-25% by weight to total waste in Taiwan which are composed mainly of polyolefins , PET , PS , and PVC.

There is a good potential for the use of natural fibers as reinforcing fillers in thermoplastics. The main advantage of these fibers are their low cost , low density , and resistance to breakage during processing[1] 。In addition , these fibers offer an excellent opportunity to utilize an abundant source of such materials available from nature.

The reinforcing fibers play an important role in strengthening the composites by effective

transfer of stress between the fiber and matrix. The compatibility of hydrophobic polymer and hydrophilic cellulose fiber can be enhanced by the modification of polymer or fiber surface[2][3].

In the present investigation，the effect of wood flour content on the mechanical properties of composites of wood flour with recycled HDPE was studied. Silane coupling agent was used to improve the bonding between polymer and wood fiber. The effect of coupling agent on the mechanical properties of the composite was examined.

The processability (e.g. viscosity) of the composite during melt mixing and molding plays an important role in determining the ultimate properties of the composite products [4]. This study summarizes some of experimental results of rheology and morphology of wood fiber reinforced recycled HDPE composite. Comparisons of morphology and rheological properties conducted between modified composites and unmodified ones.

Materials and Methods

Materials

Recycled HDPE Recycled from the bottom cap of the PET bottles，density：0.954g/cm^3，MFI：2.4 g/10min，Tm：132.5℃.

Wood flour Supplied by CELLUFLEX (German)，a kind of the pulverized raw cellulose，the grain size was 150μm，aspect ratio(L/D) of the fiber was 6.0.

Coupling agent 3-aminopropyltriethoxysilane，$H_2NCH_2CH_2CH_2Si(OCH_2CH_3)_3$，supplied by Sila-Ace Co.(Japan)，product number s-330.

Preparation of Composites

Wood flour was dried in a vacuum oven at 90℃ for 2hr was mixed with recycled HDPE chips in a plasticating extruder (single screw). Extrudates were cut into small pellets. Test specimens are injection moulded at moulding temperature 140-160℃.

Properties Measurement

Mechanical properties of test specimens were measured on an Instron (Model 4468) Tensile test procedures were followed ASTM D638-82. Flexural properties were followed ASTM D790. Izod impact strength values was using an TMI instrument (Model 43-01) according to ASTM D256. All tests were performed at ambient temperature of 25±2℃.

Rheological properties were studied using a Capillary Rheometer (GÖTTFERT RHEO TESTER 1501) following ASTM D3835-96，at different temperature 150、160、170℃，and at different shear rate from 20 to 800 1/s.

Tensile fractured surfaces of the composites were investigated using a Scanning Electron Microscope (SEM) ，TOPCON (Model sm-300).

Results and Discussion

Tensile Properties Results of the tensile properties are presented in Figure 1. Addition of wood fiber to the recycled HDPE matrix showed a significant increase tensile strength and modulus of the composites (the highest one of modulus is 88%). The silane treated composites exhibit greater tensile strength(19.9 MPa at 20wt%) than the untreated one (20.7 MPa at 20wt%)。The increase in elongation at break is attributable to the addition of silane coupling agent to the composite. This is accompanied by an increase in the toughness or ductility of the composite.

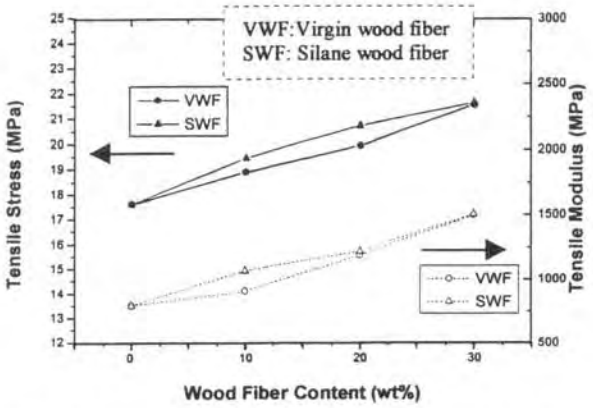


Fig 1 Comparison of the tensile properties of wood fiber reinforced recycled HDPE composites with (SWF) or without(VWF) silane coupling agent treatment.

Flexural Properties Flexural properties are presented in Figure 2. Addition of wood fiber to the recycled HDPE matrix will enhance the flexural strength and modulus(the highest one of modulus is 70%) of the composites. The silane treated composites exhibit greater flexural modulus(1210 Mpa) than the untreated composites(1150 Mpa).

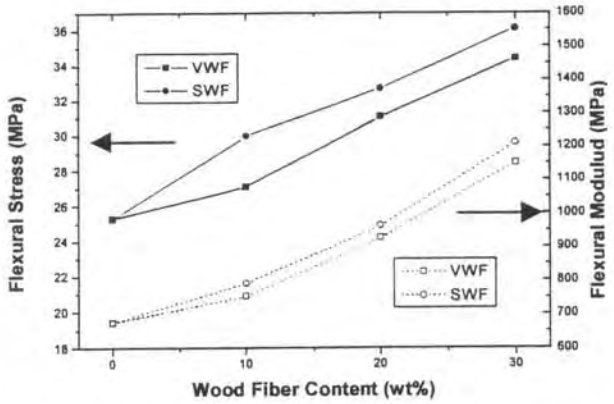
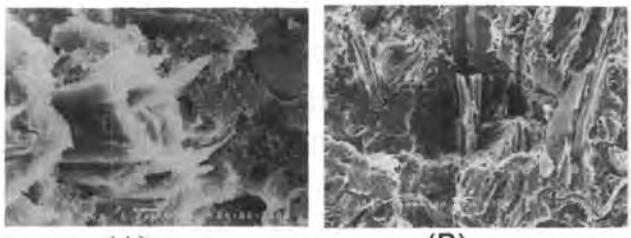


Fig 2 Comparison of the flexural properties of wood fiber reinforced recycled HDPE composites with (SWF) or without (VWF)silane coupling agent treatment.

Morphology of wood fiber/recycling HDPE composites SEM microphotographs of the wood fiber/recycling HDPE composites are shown in Figure 3 。From microphotographs，one can find the silane treated wood fiber reinforced composites exhibit much better bonding between fiber and matrix. It agrees with the better mechanical properties of silane treated composites.



(A) (B)

Fig 3 SEM microphotograph of tensile-fractured surface of 30wt% wood fiber reinforced recycled HDPE composites with silane treatment (A) and without silane treatment (B)

Rheological properties Viscosity of composites versus shear rate at various temperatures are shown in Figure 4. Results showed that the viscosity of the composites decreased with the increasing of temperature. Viscosity of composites versus shear rate at various compositions is shown in Figure 5. Results showed that the viscosity of the composites increased with the increasing of the wood fiber content.

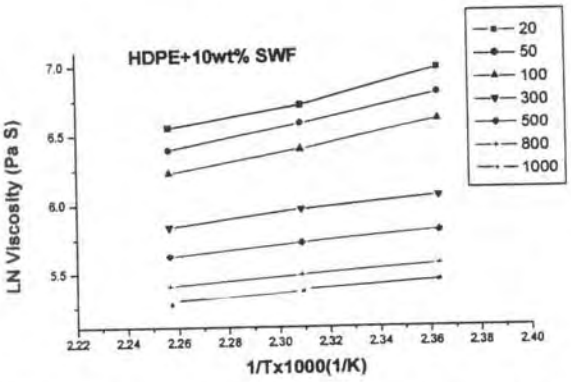


Fig 4 Viscosity of wood fiber reinforced HDPE composites versus shear rate at various temperatures(150 , 160 , 170℃).

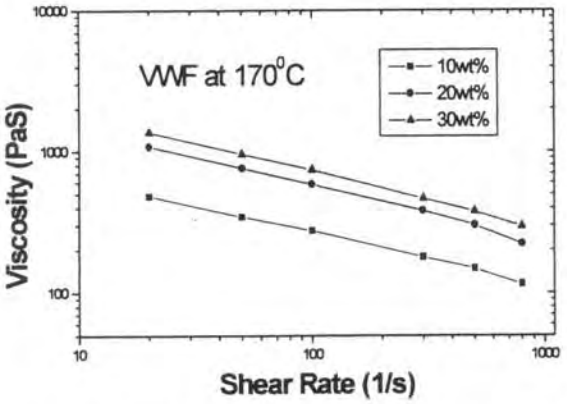


Fig 5.Viscosity of wood fiber reinforced HDPE composites versus shear rate at various virgin wood fiber compositions.

Conclusions

This study demonstrates that wood flour can be successful used as an reinforcing filler in recycled HDPE. Tensile and flexural properties are increasing significantly with the increase of wood fiber content and the addition of silane coupling agent.

The effects of wood fiber content and the addition of modifiers on the processability and morphology structure of wood fiber-filled recycled HDPE composites have been studied.

References

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