

EFFECT OF COUPLING AGENT ON THE INTERFACIAL PROPERTIES OF 3D RAMIE/POLYPROPYLENE COMPOSITES

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Introduction

In consideration of the environmental pressure, there is an urgent need to develop environmentally friendly materials from renewable resources.

With acceptable mechanical strength, good acoustic and safety performance and lightweight, ramie composites have potential applications in automotive areas[1].

Polypropylene (PP), as a matrix, has advantages of relatively low processing temperature which will not damage the reinforcement of nature fibers in the fabrication of composites.

Three dimensionally reinforced composites are introduced to prevent delamination in laminated composites. Among all the 3D structures, 3D orthogonal woven composites are constructed with three sets of yarns, namely warp, weft and Z yarns, interlaced in three mutually orthogonal directions[2].

In this work, three types of 3D ramie/PP composites with different coupling agents were fabricated. For comparison, mechanical properties and morphology properties were tested. Finally, FTIR analysis was also done to check the coupling agents effect.

Experimental

Materials

Ramie yarns of 1150 tex consisting of 6 threads (Dongting ramie Co., Ltd. Hunan province CHN) were used as warp yarns. Hybrid yarns made of 160 tex polypropylene filaments (Hongtai Plastics Co., Ltd. Yixing City CHN) and 550 tex ramie fiber yarns which consist of 3 threads (Dongting ramie Co., Ltd. Hunan province CHN) were used as filling yarns. Cotton yarns of 350 tex were used as z-yarns. The 3D fabric was woven on the 3D automatic weaving machine in Donghua University. Polypropylene resin (Hongtai Plastics Co., Ltd.

Yixing City CHN) were used as the matrix. Thermocompression molding method was used to form the 3D composites. To increase the adhesion properties of ramie fiber and PP, A-151 silane coupling agent (Maotong Industrial Co., Ltd. Shanghai CHN; Longsil 4C) was applied.

Mechanical performance test

Tensile tests and flexural tests were conducted on an WDW-20 universal material testing machine. Tensile tests were performed at a strain rate of 10 mm/min and a gauge length of 115 mm. Flexural tests were performed at a crosshead speed of 3 mm/min and a span length of 80 mm. The scanning electron microscopy (SEM) observation was conducted with an scanning electron microscope (JSM—5600LV) with an accelerating voltage of 20 kV.

The spectral analysis was conducted with a NEXUS—670 FTIR Spectrometer.

Results and Discussion

Three types of samples were prepared. Sample A was the ramie/PP composite with the fabric untreated. Sample B was the ramie/PP composite with the fabric soaked in the 95% distilled water and 5% A-151 SCA solution. Sample C was the final ramie/PP composite with the fabric soaked in the 95% ethanol and 5% A-151 SCA solution.

It can be found from Table.1 that the tensile strength of Sample A has almost the same value with Sample B, however, the tensile strength of Sample C has 20% higher tensile strength than A and B. For flexural properties, Sample C has 15% higher flexural strength than Sample A and B. Therefore, it could be concluded that 95% ethanol and 5% A-151 SCA solution could help improve the adhesion between fiber and polypropylene matrix..

Fig.1 shows the SEM morphology of tensile fracture surface

of the three types of samples. It can be seen that polypropylene as matrix scattered sparsely on the surface of ramie fibers at the fracture surface(A). And in the surface(B), the area of matrix adhering between fibers remained at a low level. However, thanks to SCA and ethanol treatment much more matrix has been found on the surface of ramie fibers and between fibers. Hence, it is not surprising that the mechanical properties of Sample C show better results than Sample A and B due to better dispersion of matrix. It is probably because the ethanol dispersed the saline coupling more evenly than does water and thus resulted in more contact area between SCA and fibrics without damaging cellulose structure.

Table.1 Mechanical properties of 3-D ramie/PP orthogonal woven composite.

Sample	Tensile strength(Mpa)	Flexural strength(Mpa)
A	26.06±2.31	38.82±2.80
B	25.96±2.23	39.43±2.71
C	31.12±1.64	45.60±2.03

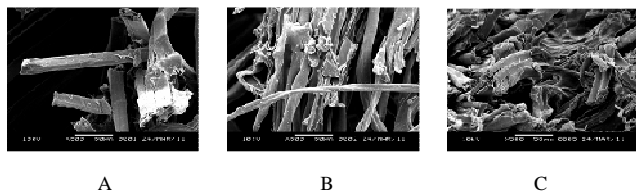


Fig1. SEM photographs of tensile fracture surface

(A) untreated, (B) 95% water and 5% A-151 SCA solution, (C) 95% ethonal and 5% A-151 SCA solution

Fig.2 shows FTIR spectrums of the three sample fabrics. The absorption peaks at approximately 1000 indicating Si-O-C bond appear in the spectrum of B and C, while is not conspicuously shown in the spectrum of A. This showed that Si-O-C bonds were formed in the samples of B and C. Another variance that the line declined slightly at the wavenumber of 3020 in spectrum of A compared to spectrums of B and C indicated the existence of C=C bonds in the samples of B and C. Hence, it can be concluded that silane coupling agent has been grafted onto the surface of the cellulose fibers. As is well known,

the silanols could be formed after the hydrosis of silane. Then the reaction between the silanols and the hydroxyl group would form stable covalent bonds through which the hydrocarbon chains could be grafted onto cellulose to improve chemical affinity[3].

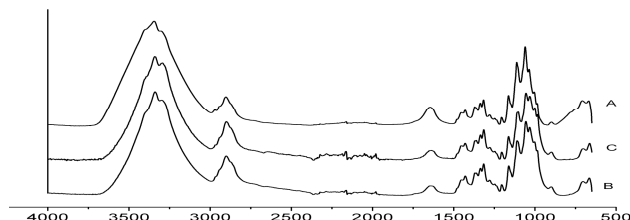


Fig.2 FTIR spectrums

untreated(A), 95% water and 5% A-151 SCA solution treated(B) and 95% ethonal and 5% A-151 SCA solution treated composite (C)

Conclusions

Three types of 3D ramie/polypropylene composites have been fabricated using the thermocompression molding method. The tensile and flexural strengths of Sample C which was treated with SCA and ethanol solution show highest values. SEM photos indicated the improved adhesion between ramie fiber and PP matrix of Sample C. Finally, the FTIR spectrums show that SCA was combined with cellulose, which agreed well with the mechanical properties results.

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