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LETTER TO THE EDITOR

Adhesion Characteristics of Different Reins with Aluminum Foils

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This paper investigated the adhesion charactics between aluminum foils and phenol resin, polyvinyl acetate emulsion and mixed reins by FT-IR and XPS. The results showed that O in the hydroxyl and C-O in the reins could formed the chemical bonding (C-O-Al) with special forms of aluminum ions. The formation of chemical bonding could improve the bond strength and properties of multi-layered structural plywood made from veneers and aluminum foils. Therefore the paper provides a scientific foundation for potential application prospects of Wood/ Aluminum composites.

I Introduction

Nowadays many kinds of wood-based composites with new function, new structure and green materials have been studied by researchers and industrial companies, widely used in packaging, furniture, architecture and other aspects (Turku et al. 2016, Sommerhuber et al. 2016, Peng et al. 2018, Ge et al. 2018, Li et al. 2017, Jiang et al. 2017, Peng et al. 2017). The development and research of wood based composite materials is the one of the main research fields in wood science and technology (Gao et al. 2017). The multi-layered structural plywood made from veneers and aluminum foils was the novel wood-based composite in recent years (Yang et al. 2011, Liu et al. 2017). The physical and mechanical properties were improved significantly with the presence of aluminum foils (Xia et al. 2017). Wood and aluminum foil were the two different kinds of materials, the bond strength and materials performances depend partly on the composite adhesive (Olakanmi et al. 2016). The special adhesive must have reactive groups and toughness to bond wood and aluminum foils (Kaboorani et al. 2011). It can wet surfaces with the lower surface energy (Baldan 2004, Li et al. 2007) Many researches focused on the processing and toughness of the resins by adding flexibilizer, coupling agent and different surface pretreatments to improve the composite properties (Yang et al. 2011, Xu et al. 2016). In this paper, polyvinyl acetate emulsion, phenol resin and the mixture were cured and on the surface of aluminum foils respectively. Adhesion charactics were characterized by FTIR and XPS (Gostynski et al. 2017, Mi et al. 2019, Atzei et al. 2014, Guo et al. 2013).

II Materials and Methods

Materials: Aluminum foils of 0.27 mm thickness with 50 mm*40 mm width, polyvinyl acetate emulsion (PVAc) with solid content 43% and pH 6.1, phenol resin (PF) with solid content 48% and pH 8.9 and distilled water.

Methods: Phenol resin and mixed resin were coated uniformly on the surface of aluminum foils after surface pretreatment. Then surface analysis was done by FTIR spectrum and XPS. (Leena et al. 2016, Olakanmi et al. 2014, Lunder et al. 2002, Zamani Zakaria et al. 2017, Wei et al. 2017, Wang et al. 2014, Kumar et al. 2017, Fu et al. 2006).

III Results and Discussion

FTIR spectrum analysis: As the Fig. 1 showed that the -OH peak of PF and PVAc was at 3447 cm^{-1}, 3446 cm^{-1}(Ge et al. 2017). But the peak was disappeared on the surface of aluminum foils. Though the -OH peak of mixed reins was weak, it was not present on the surface of aluminum foils. The result indicated possible bond between reins and the aluminum foils. The appearance of new strong peak of -C-O- on the surface of aluminum foils indicates that the group of $-CH_2-OH$ may form chemical bond (-C-O-Al). 1597 $cm^{-1}$and 1430 cm^{-1} are the peak of- C=C- on the surface of aluminum foils. The moving to low value peak area of them suggests the chemical bond of phenol hydroxyl groups and hydroxymethyl with aluminum foils

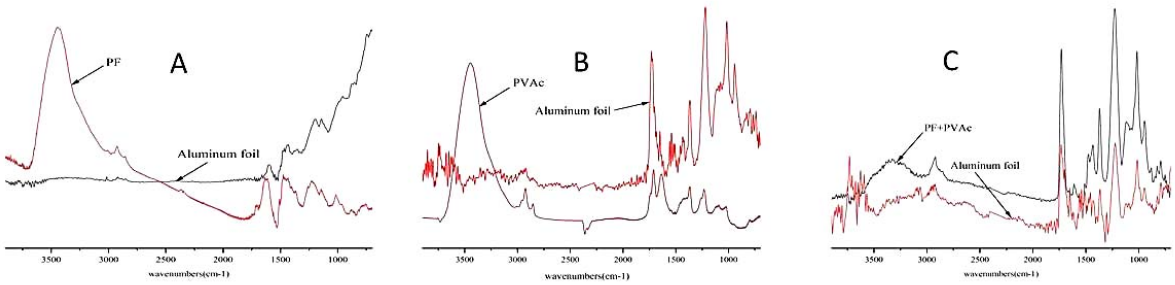

Fig. 1 FTIR spectrum:A)PF; B)PVAc; C)mixed reins respectively

X-ray Photoelectron Spectroscopy: As the survey scan of samples showed, two significant peaks are the C1s and O1s, which are attributed to abundant elements of carbon and oxygen (Fig. 2 A). The intensity of peak of the Al2p and Al2s are weak for the existence of reins on the surface. The Al2p spectrum has two main peaks at a binding energy of 72.9 eV and 74.4 eV, which is associated with aluminum and aluminum oxidation state (Al^{3+}, Al_2O_3, $Al_2O_3 \cdot H_2O$ and AlOOH) (Fig. 2 B). Its active group (-OH) can form coordinate bond with the carbonyl (-C=O) of the reins. Meanwhile the hydrogen bond and dehydration can be formed between them as the formation of Al-O-C- complexes. Because of the strong electron negativity of O atoms, shared electrons shifted to O atoms, and further shifted toward to C atoms at the same time as the Fig. 2 showed. Thus it results in the binding energy of Al2p shifts to the higher binding energy zone (Lee et al. 2013).

The binding energy of 531.5 eV, 531.6 eV and 530.2 eV are the peaks of O1s associated with Al_2O_3, -C=O and -COH. The binding energy of 530.65eV is attributed to O1s of the coordination bond between O of the -COH and Al of the Al_2O_3 (Fig. 2 C). At the same time there are several peaks of O1s forming coordination bond with Al in the range of 530-534 eV (Putz et al. 2017, Konstantin et al. 2018). So the chemical bond (C-O-Al) on the surface of aluminum foils was illustrated by the peaks of O1s for the analysis results of FTIR (Hu et al. 2016).

The binding energy of 284.6 eV and 284.2 eV is the peaks of C1s associated with C-C or C-H of the benzene ring, which indicates the presence of phenol resin (Fig. 2 D). The binding energy of 287.4 eV

and 288.5 eV are believed to the coordination bond between Al in the aluminum oxide and O in the carbonyl (-C=O）and hydroxyl group (-OH), that corresponds to literature results (Charkin et al. 2016). The results also explain the peak displacement of -C-O in the FTIR spectrum analysis. So the chemical bond (Al-O-C-) was proved based on the above analysis.

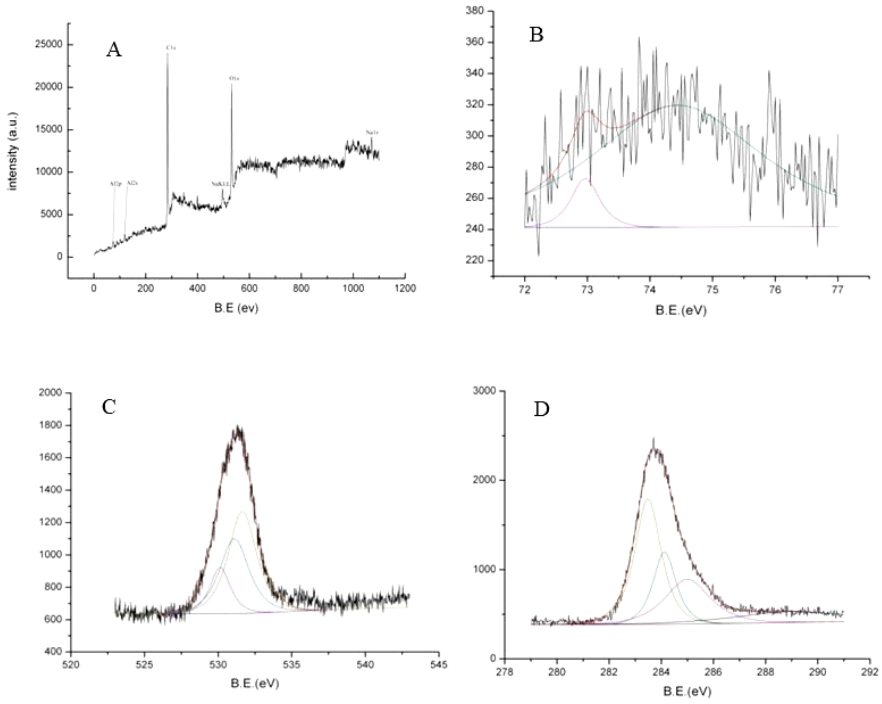

Fig. 2 X-ray photoelectron spectroscopy. A) XPS survey spectra; B) High resolution XPS spectra of Al2p; C) High resolution XPS spectra of O1s; D) High resolution XPS spectra of C1s

IV Conclusions

The results of FTIR and XPS showed that the chemical bond between reins and aluminum foil have been formed. The bond formation may be the C-O-Al by the hydrogen bond and dehydration condensation. The adhesion charactics can accelerate the development of wood ＆aluminum composite materials .

Acknowledgements

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