

DESCRIPTION OF DEGRADATION INFLUENCE ON THE PLASTICIZED PVB DURING ITS RE-WORKING BY KNEADING

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ABSTRACT

PVB sheet (type Butacite 3GO) with polymer chains containing butyraldehyde, hydroxyl- and small amount of acetate groups, was tested. These sheets were highly plasticized, with the content of plasticizer 28%. Studied material was tested at different kneading conditions; especially the influence of temperature, oxygen, mechanical energy and created heat of dissipation was studied.

PVB sheet was kneaded at their usual humidity cca 0.5%. Because PVB is known as the material with high hygroscopicity, next tests were done on PVB sheets macerated in water. By this operation the humidity of sheets increases to the content 8.0%. High humidity influenced all observed properties. Simultaneously, samples of PVB sheets re-worked by calendaring and pressing. At the calendaring the sheets were thermally stressed. The calendaring represents shear stress at low temperature. The degradation was evaluated as the change of optical properties, like the light transmittance through the re-worked material, created haze and yellowing. Next evaluated data were the change of mechanical properties – melt flow index and stress-strain behaviour. Summarized data were used for the choice of the optimal conditions for re-working of PVB sheets. The optimal conditions should bring the lowest energetic costs, minimal shear and thermo-oxidative degradation.

Keywords: Polyvinyl butyral, Degradation, Recycling, Kneading, Thermooxidation process

1 INTRODUCTION

Worldwidely, a lot of polymer waste is coming from the lamination and the production of PVB sheets. Unfortunately, the finding of optimal PVB waste re-working conditions is not easy [3]. Polyvinylbutyral is a material, which tends to the degradation, especially thermooxidative degradation of polymer chains at the shear stress. The following decrease of the molecular length brings the lowering of mechanical properties, elongation and viscosity in the melt. Worse mechanical properties of PVB sheet lower significantly its ability to absorb a mechanical energy created at the car crash [1,3]. In order to keep PVB properties after the re-working as higher as possible the optimal re-working conditions were studied, This means to find conditions, when after re-working the decrease of mechanical properties and yellowing are as low as possible. At the same time, the lowest energetic exigency of re-working process was evaluated. To minimize it the hygroscopicity and the following rigidity drop was exploited [3]. However, the higher temperature can bring the hydrolyzation of butyral groups and consequently to change the final re-PVB properties.

Plasticized PVB sheet (Butacite type) with chains containing butyral and hydroxyl groups and small amount of acetate units was tested. The composition of the mentioned random copolymers was in the content cca 80, 18-19 and less than 2 %, partially [1,2]. Tested PVB sheet was highly plasticized with the content 28% of plasticizer triethylenglykol bis(2-ethylhexanoate)thereinafter named 3GO.

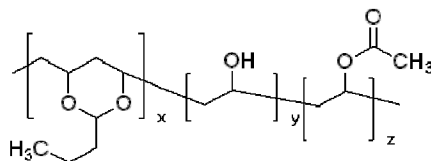


Fig. 1: *Polyvinyl butyral chain structure*

2 PROCEDURES AND THEORY

Studied plasticized PVB sheet was obtained from the company Retrim, the society re-working PVB waste for the commercial producer DuPont. PVB tested on thermodegradation (not chemically and mechanically), was prepared by pressing in the absence of the air. Samples were pressed between PET sheets, the press about 1 MPa and temperatures 160, 190 a 220 °C during 10 minutes.

Next samples were kneaded in the kneader Brabender equipped with two blunders and the rapid ratio 2:3. The chamber had the volume 55 cm³ was heated. The PVB portion was 40 g and mixing time 10 minutes. The variables were temperature (100, 130, 160, 190 and 220 °C), and the rotational speed (40, 60 and 80 min⁻¹). Used PVB samples had the water content 0,5%, resp. 8,0%). The higher water content was achieved by the soaking of PVB sheet in water for 14 days. These samples were named as "wet" PVB.

Due to the high viscosity of plasticized PVB at 70°C it was not possible to re-work these samples on the kneader. So, in this case, the samples were degraded by the shear stress on the laboratory calender with the different speed of rolls heated to 70°C.

Prepared re-worked material was pressed into the desks (1 mm thickness) at 130 °C. Consequently, bodies for mechanical property measurement were cut. Mechanical properties were measured on Alpha Technologies T 2000. The content of water was cca 0,6%.

Melt flow index was evaluated by plastometer M 201 according to the ISO norm. Tempered samples were extruded through the capillary with D=2mm. The relative humidity was 25%, the power of pressing was 100 N at 423 °K

Carl Fischer method was used for the determination of water content. This method is based on the conductometry of water steam vaporized from the sheet into the special solution of iodide and sulphur dioxide in methanol.

3 RESULTS AND DISCUSSION

Mixing on the kneader was carried out at the $\frac{3}{4}$ filling of chamber which provided sufficient amount of oxygen for the possible thermooxidative degradation. Due to this degradation the lowering of PVB chains happened and it significantly influenced the mechanical properties of PVB sheet. With increasing temperature of re-working process it is possible to see clearly the decreasing of viscosity, shear strength and elongation (see Fig.2.)

Samples re-worked by the pressing showed only minimal changes on MFI and mechanical properties. As a result of shear stress degradation the proportional increasing of elongation to the calendaring time was observed (till 250% after 14 minutes).

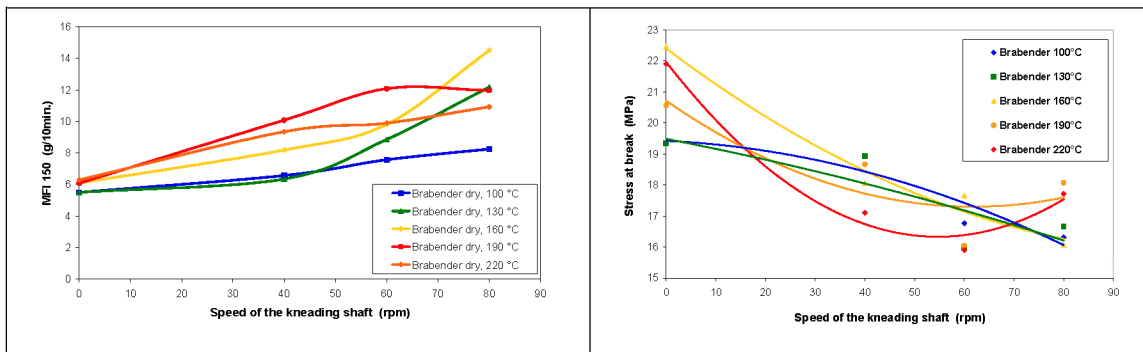


Fig 2: MFI and shear strength at kneading at different conditions

Change of mechanical properties vs. water content

PVB hodoscopy was used for the lowering of energetic exogeneity. Tested PVB sheet contained 8,0% of water. Water in the PVB matrix acts as the next plasticizer lowering the rigidity. The increasing of elongation and MFI was proportional to the water content. Contrary, shear strength went down with the higher water content. Although water vaporized quickly, its influence on the improvement of final mechanical properties was visible (see Fig 3). Arrows point to the values of origine PVB. Also the ideal re-working temperature (150°C) with the lowest degradation is possible notice clearly. This result was also confirmed by the evaluation of yellowing and optical properties.

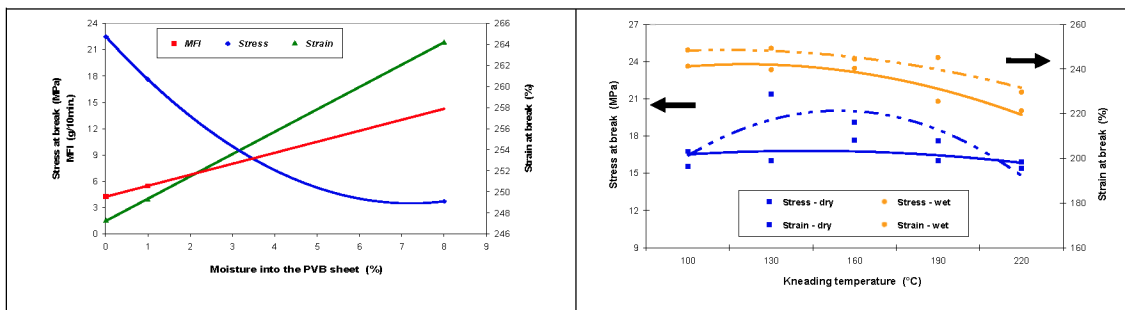


Fig.3: Mechanical properties for "dry" and "wet" PVB samples kneaded at 60 min⁻¹

4 CONCLUSIONS

The optimal PVB re-working conditions with the lowest degradation and energetic exogeneity were studied. The find conditions fulfilling these requests were about 150 °C and rotational speed up to 50 min⁻¹. Higher rotational speed caused lower degradation which was probably the consequence of a slip of blunders and by this a lower efficiency of a kneading process.

REFERENCES

1. M. Tupý, Re-working of PVB waste, Tomas Bata University, Faculty of technology, Plasty a kaučuk, 2008
2. A.K. Dhaliwal, J.N. Hay, The characterization of polyvinyl butyral by thermal analysis, Elsevier - Thermochemica acta, 391 (2002), 245-255
3. J. Zvonicek, Collection of findings close to PVB extrusion process, Non-publish message, Zlin, 1998

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