Annals of Warsaw University of Life Sciences – SGGW
Forestry and Wood Technology No 72, 2010: 79-82
(Ann. WULS-SGGW, For and Wood Technol. 72, 2010)

Properties of pressure-sensitive adhesives using special filler

[1)]IGOR NOVÁK, [2)]JÁN SEDLIAČIK, [1)]ŠTĚPÁN FLORIÁN, [3)]JÁN MATYAŠOVSKÝ, [4)]DANICA ČERVINKOVÁ
[1)]Polymer Institute of the Slovak Academy of Sciences, Bratislava, [2)]Technical University, Zvolen, [3)]VIPO, a.s., Partizánske, [4)]VÚSAPL, a.s. Nitra, Slovakia

Abstract: *Properties of pressure-sensitive adhesives using special filler.* The paper deals with pressure-sensitive adhesives and with their electrical properties. The main aim is to verify adhesive and electrical properties of isotropic electrically conductive PSA composites on the base of poly acrylates filled with silver-coated electrically conductive inorganic particles, i.e. plated basalt particles or wollastonite fibres. Coated fibrous wollastonite filler is more appropriate for obtaining strong adhesive joints, because it has better strength parameters of the adhesive joint than PSA containing silver-coated basalt.

Keywords: pressure-sensitive adhesives, filler, electric conductivity,

INTRODUCTION

The pressure-sensitive adhesives (PSA) with electrical properties are widely used in light-current electro technical engineering [1]. The polymer matrix of this sorts of PSA contains some dispersed line, as a rule the submicron electrically conductive particles which are metallic, metal-coated or carbonaceous [2-11]. The electrically conductive PSA substances are necessary for production of modern electrical and electronic components in the field of electromagnetic shielding, computer production or cosmic technology. The preparation of valuable electrically conductive PSA is rather complicated because of contradictory requirements put forward. The concentration of electrically conductive filler in PSA must be reasonably low for obtaining appropriate electrical conductivity and PSA must show suitable cohesive properties.

This contribution is concerned with adhesive and electrical properties of isotropic electrically conductive PSA composites on the base of poly acrylates filled with silver-coated electrically conductive inorganic particles, i.e. plated basalt particles or wollastonite fibres.

EXPERIMENTAL PART

The following materials were used for modifying the rheological and adhesive properties of PSA: statistical (styrene-2-ethylhexyl acrylate) copolymer containing 14 wt. % of styrene (Eastman, USA), wollastonite fibres (mineral fibres based on calcium silicate) Nyglos 12 (Nyco, Belgium) with the diameter of fibres = 12 μm and aspect ratio = 13; basalt particles (ca 40 μm) having an irregular spherical shape (Slovakia). The strength of adhesive joint of PSA composites was found out by testing of adhesive butt joints. The butt joint was prepared by fixation of two aluminium discs of 40 mm diameter furnished with uniform deposit of PSA composite and annealed at 100 °C as well as exposed to 0.3 MPa pressure for 20 sec. Both aluminium discs bonded with PSA composites were placed in special holders equipped with a swinging joint mechanism providing for destruction of adhesive joint in the direction of tensile load. The mechanism including bonded discs was put into jaws of a 5 kN universal testing machine Instron 4301 containing a computer software for evaluation of the results of measurements. The adhesive joints were evaluated by means of tensile tests, the rate of motion of dynamometer cross head being 10 $mm.min^{-1}$.

The silver-coated inorganic (basalt and wollastonite) fillers were prepared using a method of electroless plating [3, 4, 8].

RESULTS AND DISCUSSION

Results obtained by measuring electrical and adhesive properties of conductive PSA composites containing silver-coated inorganic particles or fibres are given in Figs. 1 and 2.

Fig. 1 represents a volume electrical resistivity of the conductive PSA composite on the base of poly acrylate filled with plated inorganic particles or fibres (silver-coated basalt particles or wollastonite fibres). The curve a in Fig. 1 gives the concentration dependence of the volume electrical resistivity of PSA composite for plated basalt particles. It appears that curve a starts to keep certain stability up to the content of about 50 wt. % of plated basalt particles in PSA composite. Provided this concentration of plated particles is reached a percolation conversion sets in PSA composite. This change is evident if the concentration of 65 wt. % of plated basalt particles in composite is attained. While the value of volume electrical resistivity of non-filled polymer is 12.9 it decreases to 4.1 at 65 wt. % of plated basalts particles owing to percolation concentration of conductive filler and continues to decrease to 1.0 at 70 wt.% of this filler in PSA. If we replace the plated basalt particles by plated wollastonite fibres exhibiting smaller dimensions (the size of irregular spherical particles of basalt was 40 μm, whereas the average diameter of wollastonite fibres was about 12 μm), the percolation concentration can be reached at considerably lower concentration of plated wollastonite fibres (Fig. 1, curve a), when compared with plated basalt particles (Fig.1, curve b). Provided the wollastonite is used, the percolation concentration after the 35 wt. % concentration the significant reduction of the logarithm of volume electrical resistivity from 12.9 to 4.0 takes place. If the content of silver-coated wollastonite in PSA continued to increase, the value of volume electrical resistivity decreased to 0.2 (for 50 wt. % of the filler in PSA).

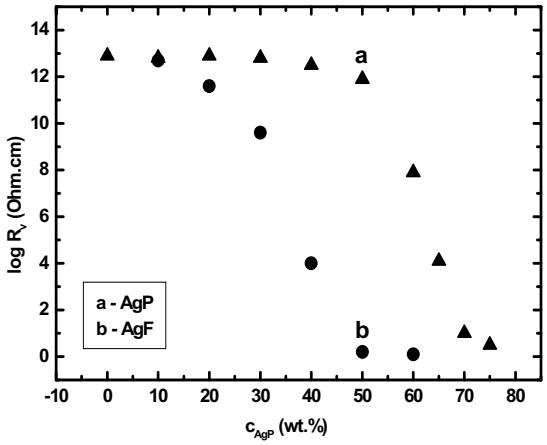

Fig. 1 Volume electrical resistivity of PSA composite vs. content of plated filler: a – silver-coated basalt particles, b – silver-coated wollastonite fibres

Fig. 2 represents the strength of adhesive joint between PSA composite and aluminium for varying content of conductive filler in the systems PSA/plated basalt, plot a and PSA/plated wollastonite, plot b. According to Fig. 2, the strength of adhesive joint drops from the value of 18 x 10^2 J.m^{-2} (non-modified PSA) to 110 J.m^{-2} (70 % filling) for plated basalt and at 50 % filling shows only about 50% of original strength of adhesive joint and to 65 wt. % filling with plated basalt particles the joint strength is reduced more than 4-times (3.9 x 10^2 J.m^{-2}). The situation is different in the case of the plated wollastonite fibres. Because of its bifilar character, this material establishes electrical contact at the lower filler concentrations in comparison with plated basalt particles. The plot b in Fig. 2 shows that the increasing concentration of the plated wollastonite fibres does not produce such considerable change in strength of adhesive joint as observed in preceding case. The strength of adhesive joint equals 14.7 x 10^2 J.m^{-2} for 50 wt. % of wollastonite fibres while the original strength for non-filled PSA system is 17.6 x 10^2 J.m^{-2}. But according to results given in Fig. 1, plot b, the electrical conductivity for 50 wt. % of plated wollastonite fibres is enough. The plated basalt particles exhibited adhesion to aluminium equal to 8.1 x 10^2 J.m^{-2} and electrical resistivity in logarithmic form of 11.9 while the plated fibres of wollastonite exhibited the strength of adhesive joint equal to 14.7 x 10^2 J.m^{-2} and volume electrical resistivity of 0.2 Ohm.cm. Thus these PSA displayed high strength of adhesive joint to aluminium and high electrical conductivity at a given concentration of plated wollastonite fibres when compared with PSA containing plated basalt particles.

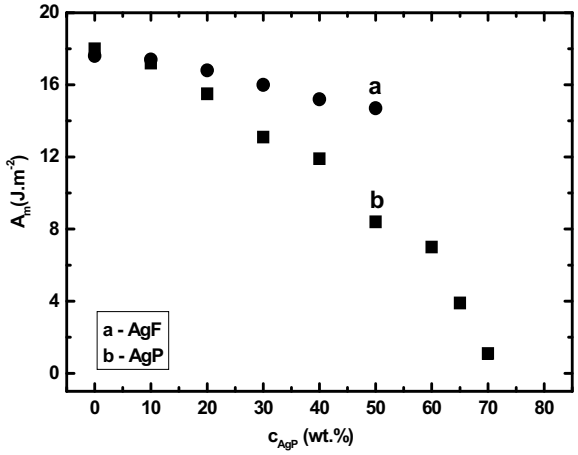

Fig. 2 Strength of adhesive joint of PSA composite to aluminium vs. content of the silver-coated filler: a – silver-coated wollastonite fibres, b – silver-coated basalt particles

CONCLUSION

The electrical properties of PSA on the base of poly acrylate containing plated inorganic particles are dependent on the type and shape of particles of the used filler. Because of low parameters of the strength of adhesive joint in PSA containing silver-coated basalt, the coated fibrous wollastonite is more appropriate for obtaining strong adhesive joints. Like the preparation of electrically conductive PSA containing carbon particles, the preparation of

PSA containing silver-coated inorganic particles requires compromise solution of the problem with reference to selection of adhesive and electrical parameters of the investigated system.

Acknowledgement
The authors are grateful to the Slovak grant agency VEGA (grants No. 2/7103/27 and 1/0517/09) for the financial support of this research.
This paper was processed in the frame of the APVV projects No. APVV-0773-07 and VMSP-P-0044-07 as the result of author's research at significant help of APVV agency, Slovakia.
This paper was processed in the frame of the Project No. 26220220091 "Re-engineering" of the Agency of Slovakian Ministry of Education ITMS.

REFERENCES

1. NOVÁK, S. FLORIÁN, J., 2003: Mater. Sci. Lett. 22, 1237.
2. FOULGER,S. H., 1999: J. Appl. Polym. Sci.72, 1573.
3. NOVÁK, I. KRUPA, I. CHODÁK, I., 2002: Synth. Met. 131, 93.
4. NOVÁK, I. KRUPA, I. CHODÁK, I., 2004: Synth. Met. 144, 13.
5. FIGOVSKY,O. L., SKLYARSKY,L. S., SKLYARSKY, O. N., 2000: J. Adhes. Sci. Technol. 14, 915.
6. SAVOLAINEN,P., KIVILAHTI,J., 1995: J. Adhesion 49, 187.
7. SANCAKTAR,E., DILSIZ,N., 1999: J. Adhesion Sci. 13, 679.
8. NOVÁK, I. KRUPA, I. CHODÁK, I., 2003: Eur. Polym. J. 39, 585.
9. KIM,H. K., SHI,F. G., 2001: Microelectr. J. 32, 315.
10. LU,D., TONG,Q. K., WONG,C. P., 1999: IEEE Transactions on Electronics Packaging and Manufacturing 22, 223.
11. CHODÁK, I. KRUPA, J., 1999: Mat. Sci. Lett., 18, 1457.

Streszczenie: *Własności klejów przylepcowych ze specjalnym wypełniaczem.* Praca dotyczy własności klejów przylepcowych i ich własności elektrycznych. Głównym celem było określenie własności adhezyjnych i elektrycznych izotropowego elektroprzewodzącego kompozytu PSA na bazie poliakrylanów z wypełniaczem z elektroprzewodzących cząstek nieorganicznych, takich jak srebrzony bazalt i włókna wollastonitu. Powlekane włókna wollastonitu są lepsze przy otrzymywaniu mocnych połączeń, zapewniając lepsze parametry niż PSA z wypełniaczem ze srebrzonego bazaltu.

Corresponding authors:

Ing. Igor Novák, PhD.
Doc. Ing. Štěpán Florián, CSc.
Ústav polymérov SAV
Dúbravská cesta 9
845 41 Bratislava
Slovakia
upolnovi@savba.sk

Doc. Ing. Ján Sedliačik, PhD.
Technical University
T.G. Masaryka, 24
960 53 Zvolen
Slovakia
janos@vsld.tuzvo.sk

Ing. Ján Matyašovský, PhD.
VIPO, a.s. Partizánske
ul. gen. Svobodu 1069/4
958 01 Partizánske
Slovakia
jmatyasovsky@vipo.sk

Ing. Danica Červinková
VÚSAPL, a.s. Nitra
Novozámocká 179
949 05 Nitra
Slovakia
cervinkova@vusapl.sk