Double-side tape based on silicone pressure-sensitive adhesive

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1. Introduction

Pressure-sensitive adhesive (PSA) is materials that develop significant adhesive forces upon contact with a substrate without requiring a chemical reaction without leaving residues on the substrate. They can be defined as a viscoelastic material, which in a solvent free state remains permanently tacky at room temperature. To exhibit this property, a PSA should have cohesive strength that is much higher than its adhesion strength to the substrate. These adhesives play an important role in everyday life and are expanding their use in many sectors of the economy. Mechanically, a PSA is a soft, sticky substance; consequently, a supporting backing is often required to convert it into commercially useful forms, such as tapes and labels [1–3].

Silicone pressure-sensitive adhesives are high-performance adhesives. Since their commercial introduction in the 1960s, silicones PSAs have found uses in a variety of applications. Some of the long-established applications for silicone PSAs are found in industrial operations (masking, splicing, roller wrapping) as well as in electrical and electronics, medical care and healthcare, and automotive sectors. They are widely used in pressure-sensitive tapes and labels to connect and labeling low-energy surface. High Si–O–Si backbone flexibility of silicones, chemical resistance and outstanding weathering resistance low intermolecular interactions, low surface tension, excellent thermal stability and high UV transparency, often explains why silicone PSAs have superior performance at high- and low-temperature extremes (can be utilized over a wide range of temperatures, from –40 to 300°C), excellent electrical properties, it makes they are superior compared to organic PSAs. SiPSA with methyl groups and phenyl groups are crosslinking between 120 and 150°C by using organic peroxides. They are inert and very hydrophobic but still have reasonable moisture permeability. Since 2000, was observed increase in interest of new silicone pressure-sensitive adhesives and the possibility of their application. Particular emphasis is placed on solutions such as medical and industrial tape [3–8].

Double-sided tapes are used to bond many types of materials differing in surface energy. To receive them are used for different kinds of carrier and pressure-sensitive adhesives, the choice of which determine the properties of the materials to be joined. To obtain them are use carrier such as fabrics, woven fabrics, films or foams. To obtain a double-sided adhesive strip of adhesive are used applicators (manual application), semi-automatic coater (in laboratory) or fully mechanized coater (in industry) [9–10].

In this paper commercial silicones adhesives will be used as a composition to obtained double side self-adhesives tape based on silicone adhesives. In the available literature there are no reports about double-side tape based on silicone PSA. Tapes were obtained by double-side coating of the carrier. Silicone pressure-sensitive adhesives are a self-adhesives materials used to special applications. Double side self-adhesives tape based on silicone adhesives can find application in heavy industry or aerospace, e.g. connect elements working in high temperature or mounting solar panels on space stations and satellites.

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2. Materials and Methods

2.1. Materials

In presented work commercial silicone adhesive was used, which was product of Momentive (USA) and 2,4-dichlorobenzoyl peroxide (DClBPO) used as a crosslinking agent; product of Peroxid-Chemie (Germany).

2.2. Preparation of double side self-adhesive tape based on silicone adhesives

Silicone pressure-sensitive adhesive was mixed with crossilinking agent to obtain homorganic composition containing 50 wt. % polymer (2,5 wt. % on a base of polymer content peroxide 2,4-dichlorobenzoyl (DClBPO)). Subsequently, PSA was coated (5 cm/s) on polyester film (36 μm), dried for 10 min at 110°C in drying canal. Thus obtained adhesive film secured with a both sides siliconized film. The other side of the carrie (polyester film – PET) was coated (5 cm/s) with an adhesive composition, crosslinking in the drying canal (10 min, 110°C). to get the adhesive film and protected by both sides siliconized film. Double side tapes was used for futher tests, i.e. adhesion, cohesion and tack.

2.3. Methods

Peel adhesion of silicone pressure-sensitive adhesives was tested using Zwick-Roell Z1 machine according to international standard Association des Fabricants Europeens de Rubans Auto-Adhesifs (AFERA) 4001 procedures. A sample of PSA-coated material 1 inch (ca. 2.5 cm) wide and about 5 inch (ca. 12.7 cm) long was bonded to a horizontal target substrate surface of a clean steel test plate at least 32 cm^2 in firm contact. A 2 kg hard rubber roller was used to apply the strip. The free end of the coated strip was doubled back nearly touching itself so the angle of removal would be 180°. The free end was attached to the adhesion tester scale. The steel test plate was clamped in the jaws of a tensile testing machine, which was capable of moving the plate away from the scale at a constant rate of 300 mm/min. The scale reading in Newton [N] was recorded as the tape was peeled from the steel surface. The data was reported as the average of the range of numbers observed during the test. The given result was an arithmetic average of three specimens [3, 11–12].

Tack of PSA was measured using Zwick-Roell Z1 machine according to international standard Association des Fabricants Europeens de Rubans Auto-Adhesifs (AFERA) 4015 procedures. Joint is composed of a rigid layer (steel plate) and flexible layer (PSA tape), which was peeled off the plate at an angle of 90° at 300 mm/min. The contact surface of the adhesive layer to the substrate was 5 cm^2 (2.5 cm x 2 cm) [3].

The shear strength test of PSA was performed according to the method of Fédération Internationale des Fabricants et Transformateurs d'adhesifs et thermocollants sur papiers et autres support (FINAT) FTM 8. PSA tape was adhered to steel plates and loaded with 1 kg weight. The contact surface of the adhesive layer to the substrate was 6.25 cm^2 (2.5 cm x 2.5 cm). Samples of adhesive tape were mounted in a machine designed at the Laboratory for Adhesives and Self-adhesive Materials of the West Pomeranian University of Technology in Szczecin,

which enabled automatic time reading of shear strength crack (the time at which an adhesive tape adhesive film falls away from the steel plate). The shear strength was tested at 20°C [3, 12–13].

3. Results and Discussion

Among the tested pressure-sensitive adhesives based on silicone, as described by the authors in the articles [3, 12–13], the selected adhesive crosslinked Si-PSA 2,4-dichlorobenzoyl peroxide, the effect of concentration on investigated properties is quoted in Table 1. The preparation of double-sided adhesive tape based adhesive silicones used composition exhibiting the best useful properties [3].

Table 1

Basic properties of Si-PSA containing various concentrations of DClBPO

Properties	Content of DClBPO [wt. %]						
	0	0.5	1	1.5	2	2.5	3
Cohesion [h]	18.0	>72	>72	>72	>72	>72	>72
Adhesion [N/25mm]	9.8	11.7	12.9	13.7	13.9	15.7	13.2
Tack [N/25mm]	3.6	7.5	9.9	10.5	9.5	8.0	6.8

The highest adhesion demonstrated tape on layer "B" witch adhesives films has basic weight 90 and 120 g/m^2. On both side tapes increasing basic weight of adhesive film resulted adhesion increase. In highest type of basic weight layer "B" show highest adhesion in compared to layer "A", it could be result of the long residence time of the layer "A" in the drying canal. Probably this difference can be eliminated by appropriate reducing crosslinking time of the first layer (Fig. 1–2).

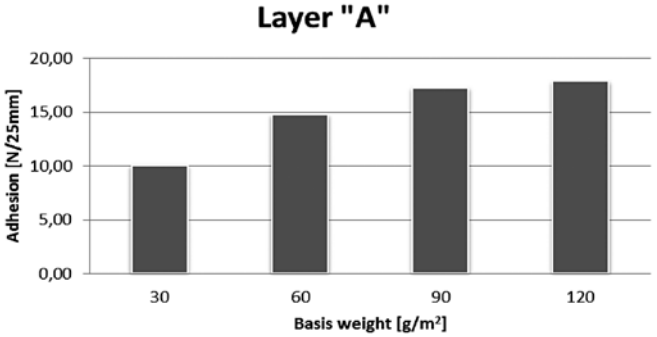

Fig. 1. Peel adhesion of layer "A" double side SiPSA with variuous basic weight

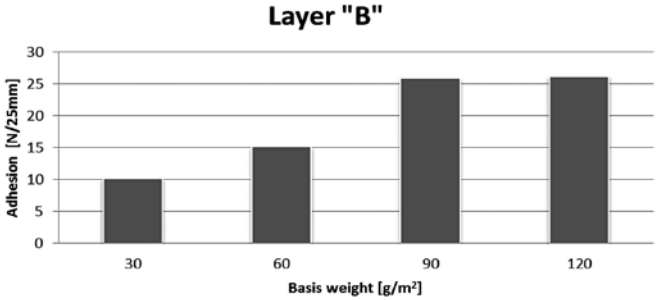

Fig. 2. Peel adhesion of layer "B" double side SiPSA with variuous basic weight

A similar situation was observed in the case of tack for double side adhesive tapes based on silicones, for both layers tape. The highest tack demonstrated tape on layer "B" witch adhesives films has basic weight 90 and 120 g/m^2. On both side tapes increasing basic weight of adhesive film resulted tack increase. In all type of basic weight layer "B" show highest tack in compared to layer "A", it could be result of the long residence time of the layer "A" in the drying canal. Probably this difference can be eliminated by appropriate reducing crosslinking time of the first layer (Fig. 3–4).

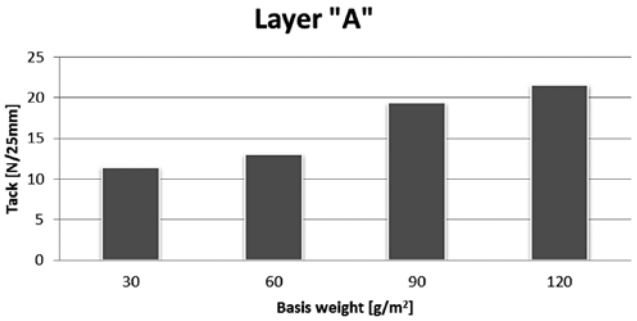

Fig. 3. Tack of layer "A" double side SiPSA with variuous basic weight

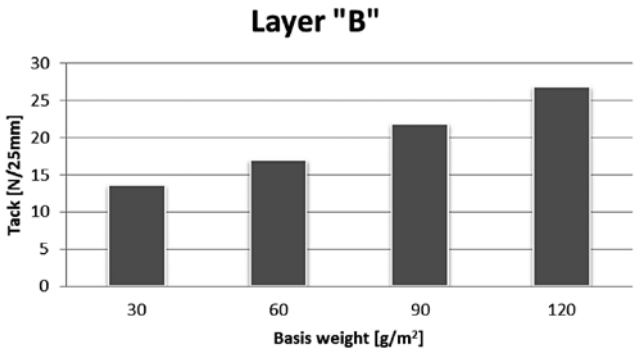

Fig. 4. Tack of layer "B" double side SiPSA with variuous basic weight

The cohesion of the adhesive film silicone pressure-sensitive adhesives on diffrent basic weight, defined as the time at which the breakage occurred cohesive/adhesive are shown in table (Tab. 2). The cohesion was measured at 20°C. The increase in basic weight and drying time had no effect on cohesion. All tapes showed high cohesion for both the "A" and "B".

Table 2

Cohesion in 20°C, expressed as a time (h) elapsing between the moment burden on the sample until to cohesion/adhesion crack of double side tape based on Si-PSA containing various basic weight

Adhesive basic weight [g/m^2]	Tape side	Cohesion [h]
30	A	> 72
	B	> 72
60	A	> 72
	B	> 72
90	A	> 72
	B	> 72
120	A	> 72
	B	> 72

4. Conclusion

The properties of double side silicone pressure sensitive adhesives tape (dSiPSA), thermally crosslinked 2,4-dichlorobenzoyl peroxides (according to a radical mechanism) depend on the basic weight and time in drying canal (crosslinking time). Increasing the basic weight affected a significant increasing adhesion and tack. Increasing basic weight and time in drying canal it showed no effect on cohesion in 20°C.

It is well known that silicone adhesives are products of special use. It is generally accepted that one-sided adhesive tape must meet the basic properties (adhesion > 10N/25mm; tack > 8 N/25mm; cohesion > 72 hours) so they can be dealt with in terms of specific applications, eg. heavy industry [3]. Among those adhesives they have proved to all double side SiPSA based on silicon adhesive. They meet the demands placed on self-adhesive tapes for special applications and could be used in heavy industry to combine elements operating at elevated temperature or aerospace bonding solar cells on board satellites and space stations.

Literature

1. Khan I., Poh B. T.: Natural rubber-based pressure-sensitive adhesives: a review. Journal of Polymers and the Environment 2011, 19, 793–811, DOI: 10.1007/s10924–011–0299-z
2. Lin S. B., Durfee L. D., Ekeland R. A., McVie J., Schalau G. K.: Recent advances in silicone pressure-sensitive adhesives. Journal of Adhesion Science and Technology 2007, 21, 605–623. DOI:10.1163/156856107781192274
3. Antosik A. K., Bednarczyk P., Czech Z.: Jednostronnie klejące taśmy na bazie samoprzylepnych klejów silikonowych – dobór najlepszej kompozycji. Chemik 2015, **69**, 12, 862–867.
4. Anderson G. L., Stanley S. D., Young G. L., Brown R. A., Evans K. B., Wurth L. A.: The effects of silicone contamination on bond performance of various bond systems. The Journal of Adhesion 2010, 86, 1159 – 1177. DOI: 10.1080/00218464.2010.529380
5. Czech Z., Kurzawa R.: Acrylic pressure-sensitive adhesive for transdermal drug delivery systems. Journal of Applied Polymer Science 2007, 106, 443–446. DOI: 10.1002/app.26751
6. Tolia G., Li S. K.: Study of drug releas and tablet characteristics of silicone adhesive matrix tablets. European Journal of Pharmaceutics and Biopharmaceutics 2012, 82, 518 – 525. DOI: 10.1016/j.ejpb.2012.07.006
7. Mecham S., Sentman A., Sambasivam M.: Amphiphilic silicone copolymers for pressure siensitive adhesive applications. Journal of Applied Polymer Science 2010, 116, 3265 – 3270, DOI: 10.1002/app.31752
8. Sun F., Hu Y., Du H. -G.: Synthesis and characterization of MQ silicone resins. Journal of Applied Polymer Science 2012, 125, 3532 – 3536. DOI: 10.1002/app.35194
9. Liu Z., Cheng L., Zhang L., Jing Ch., Shi X., Yang Z., Long Y., Fang J.: Large-area fabrication of highly reproducible surface enhanced Raman substrate via a facile double sided tape-assisted transfer approach using hollow Au–Ag alloy nanourchins. Nanoscale, 2014, 6, 2567–2572. DOI: 10.1039/C3NR05840A
10. Zeichner A., Levin N.: Collection efficiency of gunshot residue (GSR) particles from hair and hands using double-side adhesive tape. Journal of Forensic Science, 1993, 38, 571–584.
11. Wilpiszewska K., Czech Z.: Citric acid modified potato starch films containing microcrystalline cellulose reinforcement – properties and application. Starch 2014, 65, 1–8. DOI: 10.1002/star.201300093
12. Antosik A. K., Ragańska P. Czech Z.: Termiczne sieciowanie samoprzylepnych klejów silikonowych nadtelenkami organicznymi. Polimery 2014, 59, 792–797. DOI: 10.14314/polimery.2014.792
13. Antosik A. K., Czech Z.: Wpływ ilości barwnika na fizyczne właściwości silikonowych klejów samoprzylepnych. Przemysł Chemiczny 2015, 94, 41–42. DOI: 10.15199/62.2015.1.3

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PGE i PGZ podpisały list intencyjny w sprawie sprzedaży akcji spółki Exatel

PGE Polska Grupa Energetyczna i Polska Grupa Zbrojeniowa podpisały list intencyjny, w którym wyrażają wolę współpracy mającej na celu zbycie przez PGE na rzecz PGZ akcji spółki Exatel. List intencyjny zakładający współpracę przez najbliższe 6 miesięcy podpisano 31 maja br. Szczegóły potencjalnej transakcji, m.in. cena i termin, będą przedmiotem szczegółowych analiz i zostaną wypracowane w ramach rozpoczętej współpracy. *(kk)*

(http://www.gkpge.pl/, 31.05.2016)

Duży sukces emisji obligacji PCC EXOL

PCC EXOL, spółka chemiczna z Grupy PCC, notowana na Giełdzie Papierów Wartościowych, z dużym sukcesem zakończyła pierwszą w swojej historii ofertę obligacji korporacyjnych w ramach I Programu Emisji Obligacji. Zapisy złożyło 424 inwestorów na kwotę ponad 49 mln PLN, przy oferowanych przez Spółkę 20 mln PLN. Redukcja emisji wyniosła blisko 60%. *(kk)*

(http://www.pcc-exol.eu/, 24.06.2016)

KONKURSY, NAGRODY, WYRÓŻNIENIA

Rola bezpieczeństwa „Złota Setka" Kuriera

W czerwcu br. ukazała się „Złota Setka" Kuriera Lubelskiego – ranking największych i najbardziej znaczących firm naszego Województwa. W głównym zestawieniu ułożonym na podstawie wielkości przychodów za 2015 roku Grupa Azoty Puławy awansowała w stosunku do poprzedniego roku i zajęła drugie miejsce, za PGE Dystrybucja, a przed Grupą Kapitałową Emperia Holding, Lubelskim Węglem Bogdanka i Grupą Black Red White.

Zakłady Azotowe Puławy od lat są największym eksporterem Lubelszczyzny. Ubiegłoroczne zyski Spółki plasują ją na drugim miejscu w Województwie. W kategorii największych inwestorów Grupa Azoty Puławy także zajęła miejsce na podium – za PGE i Bogdanką. W gronie największych pracodawców Lubelszczyzny uplasowała się na 5 miejscu. Pośród 100 największych firm Lubelszczyzny znalazła się także należąca do Grupy Kapitałowej Puławy spółka Remzap (45 miejsce). *(abc)*

(http://www.pulawy.com, 10.06.2016)

PGE z „Orłem Wprost 2016"

PGE Polska Grupa Energetyczna otrzymała statuetkę „Orła Wprost 2016" w kategorii firm o największym średnim zysku netto w województwie mazowieckim. „Orły Wprost" to nagrody, które trafiają do firm w sposób szczególny zasłużonych dla swoich regionów. Przyznawane są w dwóch kategoriach – najwyższy średni wzrost oraz najwyższy zysk netto. Finał mazowieckiej edycji Orłów Wprost odbył się 8 maja br. Nagrodę w imieniu Grupy PGE odebrał wiceprezes ds. rozwoju Ryszard Wasiłek. *(kk)*

(http://www.gkpge.pl/, 10.06.2016)

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