One side self-adhesives tapes based on silicone pressure-sensitive adhesives – selections of the best compositions

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1. Introduction

Pressure-sensitive adhesive (PSA) is a class of adhesive material that adheres to a substrate under light pressure and can be removed cleanly, on demand, 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. 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 – 2].

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. Since the year 2000, there has been much interest in new uses for silicone PSAs, especially in applications such as medical and industrial tapes. The foregoing examples describe the growing range of potential commercial uses where silicone PSAs are being used and exploited [1, 3 – 6].

Silicone pressure-sensitive adhesives are usually comprised of high-molecular-weight silanol-functional silicone polymers and silanol-functional MQ siloxane resins, they may also contain a vinyl-functional polymer (although vinyl-functional polymers are used in addition-curable PSAs). The dimethyl groups around the Si–O–Si polysiloxane backbone are responsible for low surface tension properties and the ability of silicone PSAs to wet out and bond to substrates with low-energy surfaces, such as Teflon® and Kapton® films. The MQ siloxane resin provides adhesion performance and superior high-temperature stability [1, 6].

Silicone PSAs are widely used in pressure-sensitive tapes and labels when application conditions or the nature of substrate surfaces surpass the performance boundaries of organic-based PSAs. 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, excellent electrical properties, it makes they are superior compared to organic PSAs. They are inert and very hydrophobic but still have reasonable moisture permeability [1, 3 – 5, 7].

In this paper commercial silicones adhesives will be used as a composition to obtained one side self-adhesives tape based on silicone adhesives. Silicone pressure-sensitive adhesives are a self-adhesives materials used to special applications. They can find application in heavy industry, e.g. connect elements working in high temperature.

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2. Materials and Methods

2.1. Materials

In presented work commercial silicone adhesives was used (acronyms: PSA 529, PSA 590, PSA 6475, PSA 6573A, PSA 915). All silicone adhesives was product of Momentive (USA). Benzoyl peroxide (BPO) and dichlorobenzoyl peroxide (DClBPO) was used as a crosslinking agent. Both peroxides were product of Peroxid-Chemie (Germany).

2.2. Preparation of one 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 (0.5 to 3 wt. % on a base of polymer content). Subsequently, PSA was coated (5 cm/s, ca. 45 g/m^2) on polyester film (50 μm), dried for 10 min at 110°C in drying canal. Thus obtained adhesive film secured with a polyester film (36 μm).

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 15 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 [8].

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).

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 shear strength was tested at 20 and 70°C.

3. Results and Discussion

The highest adhesion demonstrated adhesives crosslinked by dichloronaftalenu chloride in an amount of 0.5 wt%. In most cases, at higher contents crosslinking compound decreased the value of adhesion of the adhesive (Fig. 1). For some adhesives: PSA PSA6537A, and 590 has improved adhesion with increasing share of benzoyl peroxide to a maximum of 2% by weight. and 1.5% by weight DClBPO. This could be due to the fact that adhesives may be allocated to crosslinking using a special compound based on platinum [9], which thermal crosslinkers did not cause cohesion significant improvement compared with the cohesion of other adhesives but led to increased adhesion of adhesive for steel plate. The adhesive PSA 6537 with both crosslinkers showed the lowest adhesion to the steel substrate (Fig. 1–2).

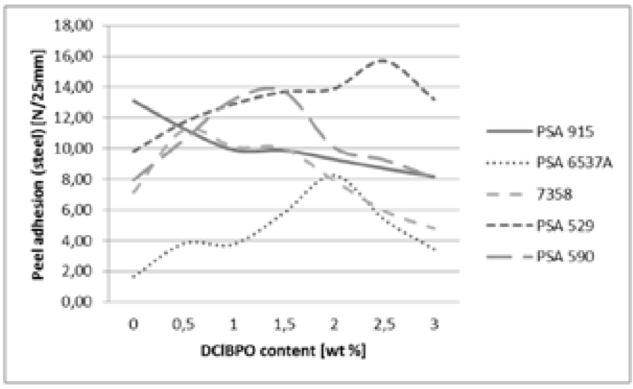

Fig. 1. Peel adhesion of silicone PSA crosslinked using variuous concentrations of DClBPO

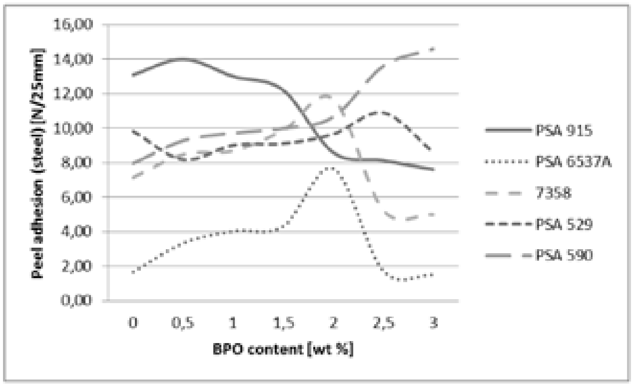

Fig. 2. Peel adhesion of silicone PSA crosslinked using variuous concentrations of BPO

In most instances with increased concentration of crosslinking agents we observed a significant decrease stickiness. For adhesive composition PSA590 and PSA529 crosslinking BPO and DClBPO reported an initial increase tackiness and then its decline. The best adhesive properties of silicone PSA compositions exhibit 915 and to a higher concentration DClBPO (from 1 wt%) PSA 529 and PSA 590.

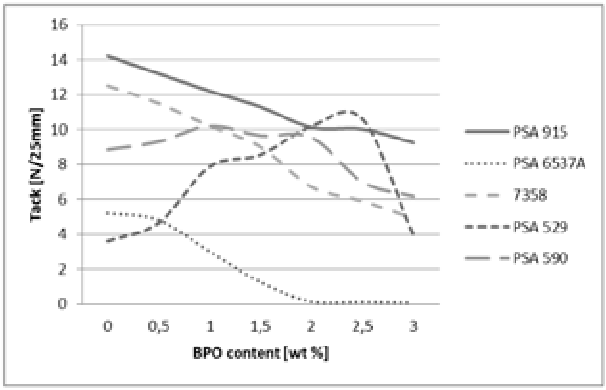

Fig. 3. Tack of silicone PSA crosslinked using variuous concentrations of BPO

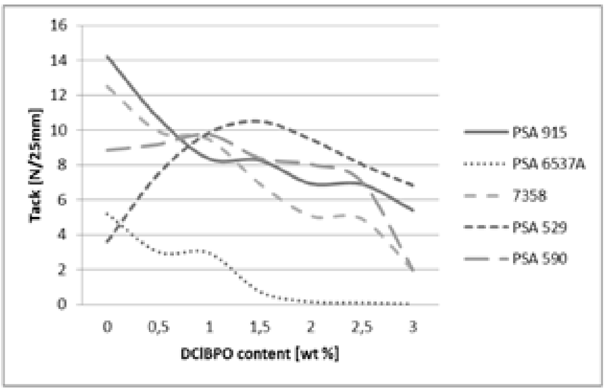

Fig. 4. Tack of silicone PSA crosslinked using variuous concentrations of DClBPO

The cohesion of the silicone pressure-sensitive adhesives, defined as the time at which the breakage occurred cohesive/adhesive are shown in tables (Tab. 1 – 4). The cohesion was measured at 20 and 70°C. In general, the increase in the concentration of peroxide in the composition influence the elongation of the time. The best cohesion of adhesives received symbol PSA 529 and PSA 590 has reached the maximum respectively 2.5 and 1.5 wt%. content DClBPO at 70°C. After exceeding this value, followed by crosslinking adhesive and due to a reduction in adhesion of the adhesive layer the detachment tested samples from steel plate.

Table 1

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

Adhesive sample	Content of BPO [wt. %]						
	0	0.5	1	1.5	2	2.5	3
PSA 915	5.6	37.9	48.4	50.5	>72	29.2	11.1
PSA 6537A	>72	>72	>72	>72	>72	>72	>72
7358	60.3	>72	>72	>72	>72	>72	9.3
PSA 529	18.0	22.9	24.4	28.5	48.5	48.8	>72
PSA 590	10.1	>72	>72	>72	>72	>72	>72

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 Si-PSA containing various concentrations of DClBPO

Adhesive sample	Content of DClBPO [wt. %]						
	0	0.5	1	1.5	2	2.5	3
PSA 915	5.6	47.0	>72	>72	>72	35.2	17.0
PSA 6537A	>72	>72	>72	>72	>72	>72	>72
7358	60.3	16.1	>72	>72	>72	>72	>72
PSA 529	18.0	>72	>72	>72	>72	>72	>72
PSA 590	10.1	5.0	42.1	>72	>72	>72	>72

Table 3

Cohesion in 70°C, expressed as a time (h) elapsing between the moment burden on the sample until to cohesion/adhesion crack of Si-PSA containing various concentrations of BPO

Adhesive sample	Content of BPO [wt. %]						
	0	0.5	1	1.5	2	2.5	3
PSA 915	0.2	0.3	0.4	0.4	1.0	1.0	0.90
PSA 6537A	1.1	2.4	2.5	7.1	4.6	3.9	0.6
7358	0.2	0.1	0.3	0.4	1.3	3.3	0.2
PSA 529	0.2	0.3	0.3	0.3	0.4	0.4	0.6
PSA 590	0.1	0.2	6.9	7.8	33.9	>72	>72

Table 4

Cohesion in 70°C, expressed as a time (h) elapsing between the moment burden on the sample until to cohesion/adhesion crack of Si-PSA containing various concentrations of DClBPO

Adhesive sample	Content of DClBPO [wt. %]						
	0	0.5	1	1.5	2	2.5	3
PSA 915	0.2	0.5	0.8	1.3	0.5	0.5	0.5
PSA 6537A	1.1	3.2	4.2	5.2	7.1	7.0	0.6
7358	0.2	3.0	3.9	1.9	1.3	1.0	0.6
PSA 529	0.2	0.7	5.0	8.0	11.0	>72	7.1
PSA 590	0.1	3.1	7.1	>72	0.6	34.4	0.3

4. Conclusions

The properties of silicone pressure sensitive adhesives (Si-PSA), thermally crosslinked organic peroxides (according to a radical mechanism) depend on the type and concentration of crosslinker used. Increasing the content of benzoyl peroxide or dichlorobenzoyl peroxide in the system affected a significant (generally) increasing cohesion, while reducing the adhesion of the tested adhesive.

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. Among those adhesives they have proved to be the best PSA 529 and PSA 590 added respectively 2.5 and 1.5 wt. % dichlorobenzoyl peroxide. 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.

5. Literature

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335 mln zł dla polskich naukowców w konkursach NCN

Narodowe Centrum Nauki ogłosiło wyniki konkursów PRELUDIUM 9, SONATA 9, OPUS 9. Tegoroczna edycja konkursów to ponad 4200 nadesłanych wniosków i niemal 335 mln PLN na realizację najlepszych projektów. Osoby, które nie ukończyły jeszcze studiów doktoranckich, mogły ubiegać się o finansowanie w kolejnej edycji PRELUDIUM. W tym roku do konkursu zgłoszono 1427 wniosków. Środki na realizację swoich projektów naukowych otrzyma 336 młodych naukowców. Wartość dofinansowania dla wszystkich przyjętych wniosków to 36 mln PLN. SONATA jest konkursem dla osób rozpoczynających karierę naukową, które zdobyły stopień doktora maksymalnie 5 lat przed złożeniem wniosku. Łączne dofinansowanie w wysokości 54,5 mln PLN otrzyma w tym roku 142 naukowców z ponad 700, którzy złożyli wnioski. Autorzy wybranych projektów planują prowadzenie innowacyjnych badań podstawowych z wykorzystaniem nowoczesnej aparatury lub oryginalnych rozwiązań metodologicznych. W tegorocznej edycji OPUS – jednego z najpopularniejszych konkursów NCN – o finansowanie ubiegało się aż 2112 naukowców. Środki na zakup aparatury badawczej otrzyma 425 osób – łączna wartość przyznanych grantów to ponad 264 mln PLN. *(kk)*

(http://www.nauka.gov.pl/, 17.11.2015)

Dokończenie na stronie 871