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Journal of Analytical & Pharmaceutical Research

Research Article

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Double-side tepes based on silicone PSA containing nanokaolin

Abstract

It is well known that silicone adhesives are products of special use. Combination of the unique properties of silicones, such as high Si–O–Si backbone flexibility, 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, chemical resistance and outstanding weathering resistance it makes they are superior compared to organic PSAs. The best mechanical properties showed compositions adhesive Q2-7566 with nanokoaolin (5% wt. based on the dry weight basis adhesive). Tape based on silicone PSA with nanokaolin could be used in heavy industry to combine elements operating at elevated temperature or aerospace bonding solar cells on board satellites and space station. The goals of this work were obtained double-side self-adhesive tapes based on Si-PSA with nanokaolin and investigate useful properties.

Keywords: nanokaolin, silicone pressure-sensitive adhesives, double-side tapes, processing technologies

Volume 8 Issue 1 - 2019

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Received: January 24, 2019 | **Published:** February 25, 2019

Introduction

Pressure-sensitive adhesives (PSAs) are a class of adhesive materials that adhere 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.[3–5] Silicone pressure-sensitive adhesives are usually comprised of high-molecular-weight silanol-functional silicone polymers and siloxane resins (MQ). It is well known that silicone adhesives are products of special use. Combination of the unique properties of silicones, such as high Si–O–Si backbone flexibility, 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, chemical resistance and outstanding weathering resistance it makes they are superior compared to organic PSAs.[7,8]

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). Modern double-sided adhesive tape can be an alternative to traditionally used in the assembly of parts requiring high strength and durability of welding connections and riveted. In recent years, engineers from all industries are discovering the possibilities of modern adhesive tape and are increasingly turning to a simple and reliable solution to provide strength and durability of the connection and fast and economical installation.[9–11]

The goal of this work was obtained double-side self-adhesive tapes from silicone pressure-sensitive composition with nanokaolin. For research were selected best compositions among surveyed by Antosik and team. The best mechanical properties showed compositions adhesive Q2-7566 with nanokoaolin (5 % wt. based on the dry weight basis adhesive). Tape based on silicone PSA with nanokaolin could be used in heavy industry to combine elements operating at elevated temperature or aerospace bonding solar cells on board satellites and space stations.[12,13] Mechanical properties and thermally resistance of obtained double-side self-adhesives tapes were improved. In the available literature there are no reports about double-side tapes based on silicone PSAs containing nanokaolin.

Materials and methods

In work commercial silicone adhesive was used (acronym: Q2-7566), which was product of Dow Corning (USA). Dichlorobenzoyl peroxide (DClBPO) was used as a crosslinking agent. Peroxide was product of Peroxid-Chemie (Germany). Nanokaolin was used as a nanofiller, which was a product of BASF (Germany).

Silicone pressure-sensitive adhesive was mixed with crossilinking agent to obtain homogeneous composition containing 50wt. % polymer (1,5wt. % on a base of polymer content 2,4-dichlorobenzoyl peroxide (DClBPO)). Composition was mixed with 5 wt. % on a base of polymer content filler (nanokaolin) to obtained homogeneous consistence. Subsequently for every basic weight (30, 60, 90 and 120g/m^2), composition was coated with coat speed of 5cm/s on polyester film (36µm), and dried for 10 min at 110°C in drying canal. Thus obtained adhesive film was protected with a both sides siliconized film. The other side of the carrie (polyester film–PET) was coated with an adhesive composition, crosslinked in the drying canal (10min, 110°C) to get the adhesive film and protected by both sides siliconized film. Double-side tapes were used for further tests, i.e. adhesion, tack and cohesion measured as (shear strength).

Peel adhesion of silicone pressure-sensitive adhesives was tested using Zwick-Roell Z1 machine (Germany) according to international standard Association des Fabricants Europeens de Rubans Auto-Adhesifs (AFERA) 4001 procedures. A sample of PSA-coated material 2.5cm wide and about ca. 12.7cm long was bonded to horizontal target substrate surface of a clean steel test plate at least 32cm² in firm contact. A 2kg 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 300mm/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.[2,7,14]

Tack of PSA was measured using Zwick-Roell Z1 machine (Germany) 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 300mm/min. The contact surface of the adhesive layer to the substrate was 5cm² (2.5cm x 2cm).[7,15]

Cohesion 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 1kg weight. The contact surface of the adhesive layer to the substrate was 6.25cm² (2.5cm x 2.5cm). 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 Szczecin, which enabled automatic time reading of shear strength crack. The shear strength was tested at 20°C and 70°C[2,7,16] and as expressed temperature (ºC) elapsing between the moment burden on the sample until to cohesion/adhesion crack.

Cohesion (shear strength) of PSA was measured using Zwick-Roell Z1 machine (Germany) according to international standard Association des Fabricants Europeens de Rubans Auto-Adhesifs (AFERA) 4012 procedures. Joint is composed of a rigid layer (material plate e.ie steel), flexible layer (material plate e.ie steel) and layer (steel plate). The contact surface of the adhesive layer to the substrate was 6.25cm² (2.5cm x 2.5cm).

Results and discussion

To create new double-side tape based on silicone pressure-sensitive adhesives with nanokaolin were used selected compositions with the best physical properties such as adhesion (for different substrates), tack, cohesion and adhesion-cohesive balance.[7] Increasing content of nanokaolin in composition was affected on decreasing adhesive properties such as tack and adhesion, by increasing share strength and temperature resistance of tested tapes. These results were presented in the Table 1. To better characterized Si-PSA with nanokaolin, tested viscosity was presented in Table 2.[13]

Table 1 Influence of nanokaolin content on useful properties of silicone pressure-sensitive adhesives[13]

Adhesive composition	Nanokalolin content [wt.%]	Adhesion [N/25mm]	Cohesion [h]		Temp. resistance [°C]	Tack [N]
			20°C	70°C		
Q2-7566 + 1,5wt.% DCIBPO	5	10.1	>72	>72	226	8.6

Table 2 Influence of nanokaolin content on viscosity of silicone pressure-sensitive adhesives

Adhesive composition	Viscosity [Pas]						
	1	2	3	5	7	36	90
Q2-7566 + 1,5wt.% DCIBPO + 5wt.% nanokaolin	6650	6550	6750	7050	8125	17450	N/A

Composition with 5wt.%. filler exhibits best useful properties and it was use to manufacturing of double-side tape based on silicone pressure-sensitive adhesives containing nanocaolin.[13] Adhesion properties of double-side adhesive tapes based on silicones pressure-sensitive adhesives with nanokaolin increasing with increasing basic weight of PSA. The highest results were observed for the tape which films have basic weights of 90 and 120g/m². Presented on Figure 1 results were average of measurements both sides. In all types of basic weight layer "B" show little highest adhesion in compared to layer "A" comprised within the limits of measurement error, 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 coated layer, which should compensate for the double time residence of layer A drying channel (this is due to the specifics of the dSi-PSA techology).

A similar situation was observed for tack properties of double-side adhesive tapes based on silicones pressure-sensitive adhesives with nanokaolin (Figure 2). The highest tack have tapes with film basic weights 90 and 120g/m².

The cohesion of the adhesive film double-side silicone pressure-sensitive adhesives with nanokaolin tape on diffrent basic weight, defined as the time at which the breakage occurred cohesive/adhesive and were presented in Table 3. Increasing basic weight and time in drying canal it showed for almost no effect on cohesion in 20ºC except composition coated basic weight 120g/m², which adhesion peeling off after about 55h from the testing surface, what can be caused by non-crosslinked composition.[2] Cohesion in 70ºC for composition with 90g/m² and 120g/m² showed similar efect (adhesion peeling off). Cohesion defined as the temperature at which the breakage occurred cohesive/adhesive and were illustrated in Table 3. The samples with lowest basic weight adhesives film showeth higest temperature resistance (eaven 225ºC). This allows the state that the tapes are resistant to elevated temperatures. There were no significant differences between the two layers of double adhesive tape.

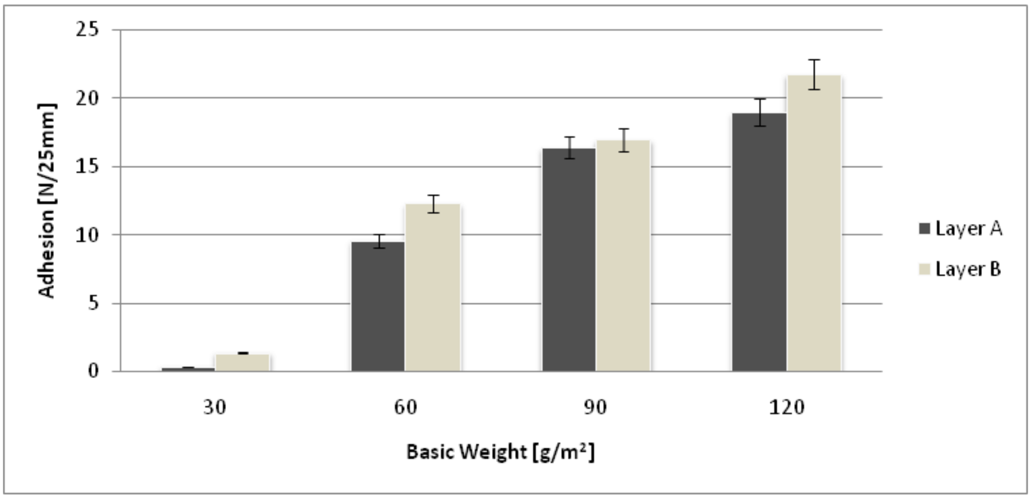

Figure 1 Peel adhesion of double-side SiPSA with variuous basic weight with modified nanokaolin.

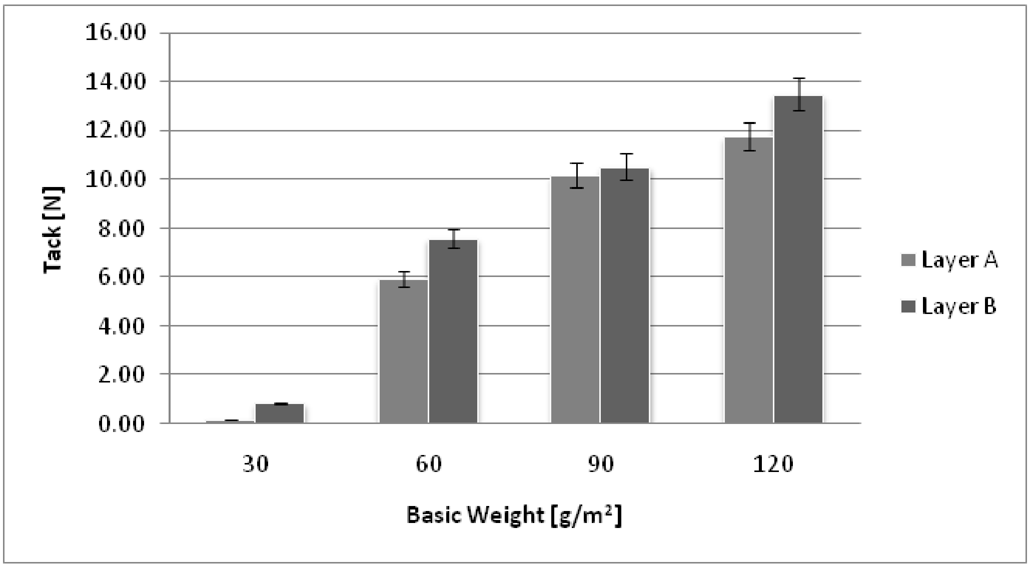

Figure 2 Tack of double-side SiPSA with variuous basic weight modified with nanokaolin.

Table 3 Cohesion at 20°C and 70°C, expressed as a time (h) and temperature (°C) elapsing between the moment burden on the sample until to cohesion/adhesion crack of double-side tape based on Si-PSA comprising nanokaolin

Basic weight [g/m²]	Cohesion [h]		Temperature resistance [°C]
	20°C	70°C	
30	>72	>72	225
60	>72	>72	212
90	>72	6 h	178
120	55 h	3 h	156

Conclusion

Double-side self-adhesive tapes based on silicone pressure-sensitive adhesives modified with nanokaolin were obtained. The properties of double-side tape, thermally crosslinked using 2,4-dichlorobenzoyl peroxide (according to a radical mechanism) with 5% wt. nanokaolin, used as a filler, depend on the basic weight and time in drying canal (crosslinking time) were show in this work. Increasing the basic weight affected a significant increasing adhesion and tack too. Increasing basic weight and time in drying canal it showed almost no effect on cohesion in 20ºC and at 70ºC for samples with low basiv weight. The termaly resistance for samples with low bastic weight (30g/m^2 and 60g/m^2) was improved (respectly 225 and 212ºC). It is well known 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.[7] Among those obtained double-side self-adhesives tape based on silicone pressure-sensitive adhesives with nanokaolin composition could be used in heavy industry to combine elements operating at elevated temperature or aerospace bonding solar cells on board satellites and space stations. This modern double-sided adhesive tape can be as an alternative to traditionally used in the assembly of parts requiring high strength and durability of welding connections and riveted.

Acknowledgments

None.

Conflicts of interest

The author declares that there is no conflicts of interest.

References

1. Khan I, Poh BT. Natural rubber–based pressure–sensitive adhesives: a review. *Journal of Polymers and the Environmental*. 2011;19:793–811.
2. Antosik AK, Ragańska P, Czech Z. Termiczne sieciowanie samoprzylepnych klejów silikonowych nadtelenkami organicznymi. *Polimery*. 2014;59:792–797.
3. Mecham S, Sentman A, Sambasivam M. Amphiphilic silicone copolymers for pressure siensitive adhesive applications. *Journal of Applied Polymer Science*. 2010;116:3265–3270.
4. Sun F, Hu Y, Du HG. Synthesis and characterization of MQ silicone resins. *Journal of Applied Polymer Science*. 2012;125(5):3532–3536.
5. Tolia G, Li SK. Study of drug releas and tablet characteristics of silicone adhesive matrix tablets. *European Journal of Pharmaceutics and Biopharmaceutics*. 2012;82:518–525.
6. Anderson GL, Stanley SD, Young GL, et al. The effects of silicone contamination on bond performance of various bond systems. *The Journal of Adhesion*. 2010;86:1159–1177.
7. Antosik AK, Bednarczyk P, Czech Z. Jednostronnie klejące taśmy na bazie samoprzylepnych klejów silikonowych – dobór najlepszej kompozycji. *Chemik*. 2015;69:95–97.
8. Lin SB, Durfee LD, Ekeland RA, et al. Recent advances in silicone pressure–sensitive adhesives. *Journal of Adhesion Science and Technology*. 2007;21:605–623.
9. Gawryś M. Nowoczesne taśmy klejące alternatywą dla połączeń mechanicznych. *Spajanie Metali i Tworzyw w Praktyce* 2004;3:29.
10. Liu Z, Cheng L, Zhang L, et al. 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.
11. Zeichner A, Levin N. Collection efficiency of gunshot residue (GSR) particles fromhair and hands using double–side adhesive tape. *Journal of Forensic Science*. 1993;38:571–584.
12. Adrian AK. Silicone pressure–sensitive adhesives with improved thermally resistance. *Journal of Nanomedicine and Nanotechnology*. 2015;6:100.
13. Antosik AK, Bednarczyk P, Czech Z. Wpływ nanocząstek kaolinu na fizyczne właściwości silikonowych klejów samoprzylepnych. *Przemysł Chemiczny*. 2016;95:1000–1003.
14. Wilpiszewska K, Czech Z. Citric acid modified potato starch films containing microcrystalline cellulose reinforcement – properties and application. *Starch*. 2014;66:660–667.
15. Antosik AK, Czech Z. New Si–PSA tape with cellulose fibers–obtaining and usefully properties. *J Anal Pharm Res*. 2018;7(3):357–358.
16. Antosik AK, Czech Z. Wpływ ilości barwnika na fizyczne właściwości silikonowych klejów samoprzylepnych. *Przemysł Chemiczny*. 2015;94:41–42.