Strength of Peeling Adhesion of Tape: Influence of Temperature, Time, Thickness and Ultraviolet Light

B Y Li[1,*] and Y Y Huang[2]

[1]Institμte of Applied Chemistry, 106 Zhineng Road, International Education Park, Suzhou Vocational University, Suzhou, China 215104
[2] Research institute of silk applied technology, Suzhou Vocational University, Suzhou, China 215104

Corresponding author and e-mail: B Y Li, lby@jssvc.edu.cn

Abstract. In this paper,,peel force tests of Pressure sensitive adhesive (PSA) were carried out for selected PSA at different times, temperature, thickness, etc.. We use the method provided by ASTM D3330 to test its peel strength. The effects of temperature, time, substrate and UV irradiation on the peeling force tapes were observed. With the increase of time the peel strength of the tapes increase range of different substrates is Al(31%)~SUS(31%)>ABS(20%)>Glass(12%)>PC(11%)>PMMA(5%). In the range of 0-100°C he peeling force shows a significant upward trend for 24 hours. Prolonged time or UV curing increases the peel strength of the tape, and the thicker tape strengthens more.

1. Introduction

Pressure sensitive adhesive (PSA) is a pressure-sensitive adhesive in the bonding process. It can be adhered to the surface of the adherend by using pressure means such as finger abdomen pressure in the process of use [1]. We understand under “adhesion” the relatively weak,so-called van der Waals interaction. Adhesive forces can be easily seen in a contact of between two smoothsolid bodys which are widely used in omestic,industrial and medical applications [2-4]. In general, pressure sensitive adhesive tapes for certain purposes must provide 180° peel strength data. Standard test methods for 180° peel strength are included in each standard system.

In this paper, we use the method provided by ASTM D3330 [5] to test them. The effects of temperature, time, substrate and UV irradiation on the peeling force tapes were observed.

2. Experimental materials and equipments

2.1. Experimental materials

Double-sided tapes (PSA) (provided by Dow Corning, USA), substrates: ASTM SUS, Al, Polycarbonate (PC), Acrylonitrile Butadiene Styrene plastic (ABS), Polymethylmethacrylate (PMMA), Glass(Jinan languan,CHN).

Li, B. and Huang, Y.
Strength of Peeling Adhesion of Tape: Influence of Temperature, Time, Thickness and Ultraviolet Light.
In *Proceedings of the International Workshop on Materials, Chemistry and Engineering (IWMCE 2018)*, pages 670-673
ISBN: 978-989-758-346-9

2.2. Experimental equipments

Zwick Universal testing machine (BT1-FR2.5TH.140 Fnom 2.5kN), Weiss simulationsanlagen messtechnik Oven (WK-340/40 22604900), Roller press (HOWE Elektrotechnik RDD20050), UVACUBE2000 (Hoenle, Germany).

2.3. Experimental methods

The peel adhesion of pressure-sensitive adhesives was tested using a Zwick-Roell machine according to the international standard ASTM D3330 procedures. A sample of PSA-coated material (20mm wide and about 150mm long) was bonded to a horizontal target substrate surface consisting of a clean steel test plate providing at least 15 cm^2 firm contact. A 4 kg hard rubber roller was used to apply the strip. The free end of the coated strip was doubled back nearly touching itself, so that the angle of removal would be 180°. 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 30mm/min. The scale reading in Newton [N] was recorded as the tape was peeled from the steel surface. The data were reported as the average of the range of numbers observed during the test. The given result was an arithmetic average of three specimens [6].

The influence of temperature on PSA measurements was carried out after 24 hours at 0, 20,40,70,100 °C, respectively . The influence of time on PSA measurements was carried out after 15 seconds and 14 days. The influence of UV irradiation on PSA measurements was carried out after UV irradiation for 30 minutes in UV irradiator.

3. Results and discussion

3.1. Peel Adhesion of PSA on substrates after bonding for different time

From the test data (Table 1 and Table 2), it can be seen that the peel strength of the tape on different sheets is different. The initial viscous strength order obtained by the 15 seconds test method is PMMA>PC>Glass>SUS>ABS>Al. And after 14 days, the order of sticky strength obtained is PC> SUS > PMMA > Glass > Al> ABS. The inconsistency between them may be due to the different mechanism of initial stickiness and stickiness. The initial viscosity is affected by the activity of the molecular segment, while the stickiness is determined by the cohesion [1].The peel strength of the tape increases with the increase of time. The order of increase is Al (31%)~SUS(31%) >ABS (20%)>Glass (12%)>PC (11%)>PMMA (5%).This may be because the wetting effect between the substrates and the tape becomes better over time.The surface energy of the substrate has a positive relationship with the peel strength of the tape, the greater the surface energy, the better the surface wetting and the greater the peel strength [7].

Table 1. Peel force of PSA on substrates after bonding for different times.

Substrates	SUS				Al				PC			
Surface Energy(J)	64				40				48			
Time	15s		14d		15s		14d		15s		14d	
Surface	os	cs	os	cs	os	cs	os	cs	os	cs	os	cs
Average value (N/cm)	9.58	9.93	12.70	12.90	8.16	9.41	11.50	11.50	11.15	12.10	13.10	12.70
Failure mode	A F	A F	A F	A F	A F	A F	A F	A F	A F	A F	A F	A F

Table 2. Peel force of PSA on substrates after bonding for different times.

Substrates	ABS				PMMA				Glass			
Surface Energy(J)	38				40				48			
Time	15s		14d		15s		14d		15s		14d	
Surface	os	cs	os	cs	os	cs	os	cs	os	cs	os	cs
Average value (N/cm)	8.83	8.62	10.70	10.20	11.48	12.11	12.80	12.10	11.01	11.68	12.50	12.70
Failure mode	A F	A F	A F	A F	A F	A F	A F	A F	A F	A F	A F	A F

Note: Adhension Failµre(A F)

3.2. Peel Adhesion of PSA on substrates after bonding for different temperatures

Table 3. Peel force of PSA on substrates after bonding for different temperatures.

Time	Initial	24 hours							
Temperatµre(℃)	RT	0	RT	40	60	70	85	100	T/S(-40-85℃)
Average (N/cm)	7.50	7.80	8.40	9.40	9.80	9.80	10.30	10.40	9.70
Increase (%)	0	4	12	25	31	31	37	38	29
Failµre mode	A F	A F	A F	A F	A F	A F	A F	A F	A F

The experimental results (Table 3) show that compared with the initial peel force at room temperature, the peeling force after one day of soaking at all test temperatures shows a significant upward trend, which can be concluded that long soaking time helps to improve the adhesive performance. The peel strength peaked around 85 °C, and the cross-linking reaction was almost complete. When the temperature continues to rise, the bond strength does not increase much.

Under the thermal shock temperature test, the samples were tested at a low temperature of -40 °C and a high temperature cycle of 85 °C. The peel force of the sample was still very good, achieving an average peel force of 9.68 N/cm. The tape has good adhesive properties and still shows good performance under severe temperature conditions.

3.3. Peel Adhesion of PSA on substrates after bonding for different tape thickness

The data (Table 4) show that as the thickness of the tape increases, the peel strength also increases. The increase within 15 seconds is relatively small, with an average increase from 10-12.30 N/cm(23%) , which after 14 days, the increase rate increased from 12.7-17.1 N/cm (35%) on average.. From 15 seconds to 14 days, the tape thickness increased from 23 µm to 34 µm, and the increase in strength increased from 26% to 41%. When the thickness increases again, the strength does not continue to increase. In general, the film can be plastically deformed. The thicker film, the greater the energy consumed for plastic deformation, the greater the peel strength.

Table 4. Peel force of PSA on substrates after bonding for different thickness.

Substrates	Glass											
Thickness(µm)	23				34				48			
Time	15s		14d		15s		14d		15s		14d	
Surface	os	cs	os	cs	os	cs	os	cs	os	cs	os	cs
Average value (N/cm)	9.80	10.30	12.50	12.90	11.00	12.00	16.50	16.00	11.90	12.70	17.60	16.50
Increase (%)	0		26		0		41		0		39	
Failµre mode	A F	A F	A F	A F	A F	A F	A F	A F	A F	A F	A F	A F

3.4. Peel Adhesion of PSA on substrates after bonding for UV irradiation

Table 5. Peel force of PSA on PET after bonding for UV irradiation(1000 mJ).

Substrates	PET					
Thickness(μm)	50		100		200	
Status	Uncured	Cured	Uncured	Cured	Uncured	Cured
Average (N/cm)	7.90	9.40	8.50	9.90	10.20	10.90
Increase(%)	19		16		7	

Utraviolet (UV) curing is the process of polymerization of unsaturated organic compounds initiated by UV light of appropriate wavelengths and light intensity, resulting in the formation of crosslinked structural macromolecules[8]. The data (Table 5) showed that the adhesive tapes of different thicknesses increased after irradiation with ultraviolet light, and as the thickness decreased, the peeling strength increased from 7% to 19%. The thinner the thickness, the greater the increase in viscosity after UV light irradiation.

4. Conclusions

In this work, peel force tests were carried out for selected PSA at different times, temperature, thickness, etc.With the increase of time the peel strength of the tapes increase, which the increase range of different substrates is
Al(31%)~SUS(31%)>ABS(20%)> Glass(12%)>PC(11%)>PMMA(5%). The peeling force after one day of soaking at 0-100 ℃ shows a significant upward trend. As the thickness of the tape increases, the peel strength also increases.The thinner the thickness, the greater the increase in viscosity after UV light irradiation.

Acknowledgements

The financial support from the Technology Plan Project Foundation of Suzhou Science and Technology Bureau (Grants SS201742).

References

[1] Xu S and Luo Y W 2015 Progress in Pressure Sensitive Adhesives *J. Chemical Reaction Engineering and Technology* **31(6)**:556-565
[2] Yang S, Qi S H, Cheng B and Ma L N 2014 Research Progress of Pressure-sensitive Adhesives *J. Adhesion* **3**:83-86
[3] Zhang P, Li Y, Li J B, Yao X L and Chen Z S 2017 Discussion on influence Factors of Aging-Resistance of Protective Film for Aluminum oxide Profile *J. Adhesio*n **1**:52-54
[4] Afferrante L and Carbone G 2016 The ultratough peeling of elastic tapes from viscoelastic substrates *J. Journal of the Mechanics and Physics of Solids* **96**:223–234
[5] Astm D 3330:96 *Standard test methods for peel adhesion of pressure sensitive tape at 180° angle[S]*
[6] Wilpiszewska K and Czech Z 2014 Citric acid modified potato starch films containing microcrystalline cellulose reinforcement—properties and application *J. Starch.* **66(7-8)**:660-667
[7] Yang H W H 1995 Water-based polymers as pressure-sensitive adhesives: viscoelastic guidelines *J. Journal of Applied Polymer Science* **55(4)**:645-652
[8] Yang H D, Qu C Y and Wang D Z 2012 UV light (UV) curing adhesive research progress *J. Heilongjiang Science* **3(6)**:38-40