

Determination of pressure sensitive tack and adhesion using axial measurements on a rotational rheometer



RHEOLOGY AND VISCOSITY

Introduction

Tack or tackiness in the context of material behaviour is associated with stickiness and may result from adhesive forces between two materials in contact or cohesive forces in a material bridging two substrates.

For pressure sensitive adhesives including tapes and labels, tack is defined as the ability to form an adhesive bond to a substrate under slight pressure and brief contact and is an essential requirement for such products. For other materials and applications tack may be an unwanted property, an example being bone cements, which according to ISO5833 must be tack-free, to allow the user to shape and apply the cement without adhering to gloves or application aids.

Tack may also influence the behavior and perception of consumer products, examples being the extrusion of thick viscoelastic products such as toothpaste from tubes or chewing or handling of sticky foods. It may also be used to assess the properties of a surface and judge whether it is clean or not. Therefore, a qualitative assessment of tack can be made simply through touch or feel, however, such assessments are subjective, difficult to quantify and may be influenced by other additional factors.

For many research and development activities it can be useful to screen, compare and quantify 'tack' or 'stickiness' using a simple objective test. For the adhesives industry there are many such standard tests available depending on the product type, including tests such as loop tack, quick stick and rolling ball tests.

This application note relates to another test which is commonly used in the adhesives industry, known as the inverted probe test. In this test an inverted probe is brought in to contact with the adhesive at a fixed speed, contact pressure and contact time. The tack is then recorded as the maximum force required to break the resultant bond.

Here the peak in negative normal force (tension) can be attributed to 'tack', the area under the force-time curve to adhesive or cohesive strength and the time taken for the peak force to decay by 90% a comparative measure of failure rate or time as illustrated in Figure 1.

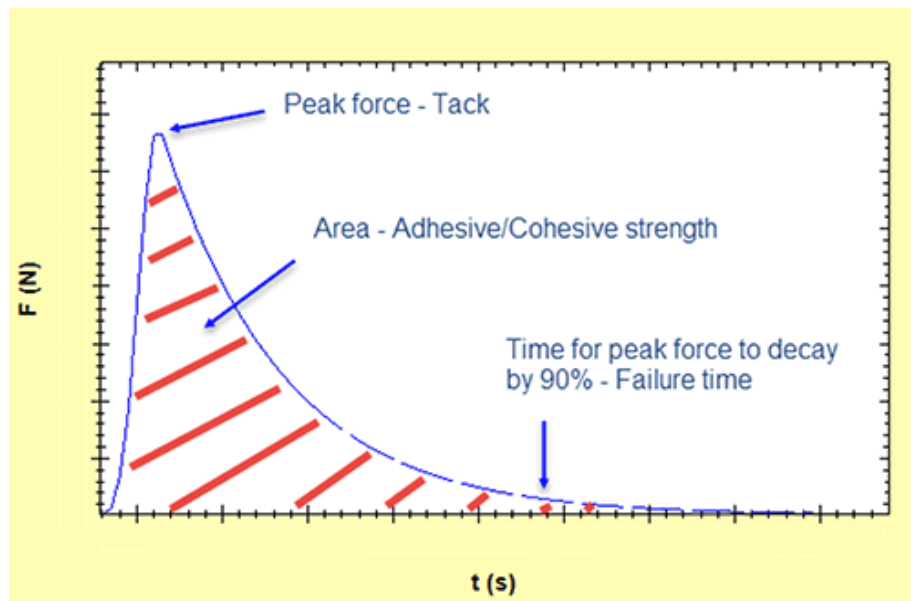


Figure 1: Annotated normal force-time profile showing key features for assessing adhesive/cohesive properties under tension

Experimental

- Tack properties of Blu-Tack ® were measured using a range of contact forces (5N, 10N, 15N and 20N)
- Measurements were made using a Kinexus rotational rheometer with a Peltier plate cartridge using a 20mm upper plate and 65mm lower plate (stainless steel) and standard pre-configured sequence in the rSpace software.
- A 1.3g ball of sample was placed in the center of the lower plate with no pressure applied and the upper plate brought in to contact with the sample at an approach speed of 10mm/s until required contact force was attained.
- Following a contact period of 2 seconds the gap was increased linearly at 10mm/s and the normal force recorded as a function of time.
- All measurements were performed at 25°C.

Results and Discussion

A gap and normal force profile for the Blu-Tack[®] with 10N normal force applied is shown in Figure 2. This shows the approach of the upper plate to the sample at 10mm/s and the rise in normal force as contact is made. Following a contact period of 2 seconds the gap is increased linearly at 10mm/s, corresponding with a reduction in compressive force but a residual tensile force corresponding with tack and adhesion.

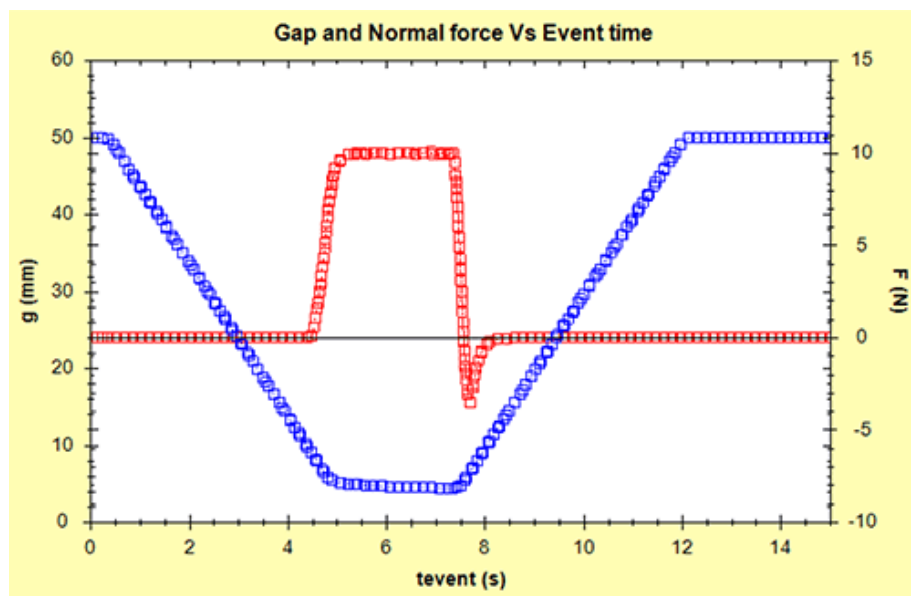


Figure 2: Normal force-time profiles for Blu-Tack[®] with 10N pressure applied

Comparative results for the different contact pressures are shown in Figure 3 and Table 1. These results relate only to the tensile (negative) force, which corresponds with tack and adhesion.

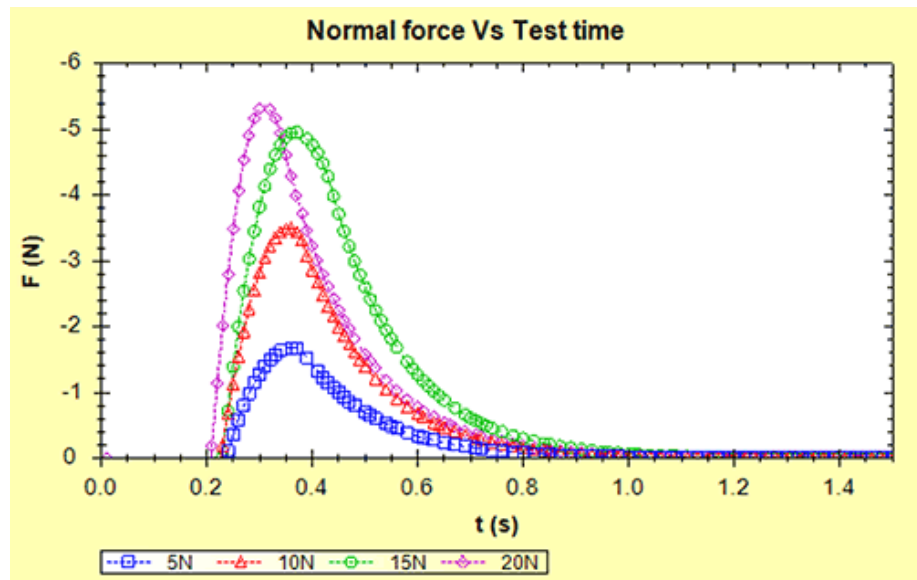


Figure 3: Tensile force-time profiles for Blu-Tack ® with different contact pressures

The results show that residual tension or tack increases with applied force, particularly up to 15N, with only a slight incremental increase observed with 20N applied force. In terms of the area under the curves, which relates to the adhesive/cohesive strength of the material, this appears to increase with contact force up to 15N and then a decrease at 20N is observed, indicating that there is an optimum contact force between 10N and 20N that gives maximum adhesion under these conditions.

The times for the force to decay by 90% of their peak values are similar for contact forces of 5N, 10N and 15N but slightly lower for 20N suggesting a slightly quicker failure rate after 20N of pressure.

Table 1: Analysis results based on Figure 3 for different contact pressures

Sample Description	Action Name	Time (action)(s)	Normal force(N)	Gap(mm)	Area result
5N	Peak normal force	0.3573	-1.677	7.8614	
5N	Time for Force to reduce by 90% of peak	0.7006	-0.1677	11.2888	
5N	Area under force time curve (N/s)				0.4799
Sample Description	Action Name	Time (action)(s)	Normal force(N)	Gap(mm)	Area result
10N	Peak normal force	0.3525	-3.492	6.6156	
10N	Time for Force to reduce by 90% of peak	0.6906	-0.3492	9.9909	
10N	Area under force time curve (N/s)				0.8353
Sample Description	Action Name	Time (action)(s)	Normal force(N)	Gap(mm)	Area result
15N	Peak normal force	0.3690	-4.220	6.0800	
15N	Time for Force to reduce by 90% of peak	0.7127	-0.4220	9.5118	
15N	Area under force time curve (N/s)				1.977
Sample Description	Action Name	Time (action)(s)	Normal force(N)	Gap(mm)	Area result
20N	Peak normal force	0.3105	-5.363	5.2124	
20N	Time for Force to reduce by 90% of peak	0.6522	-0.5363	8.6237	
20N	Area under force time curve (N/s)				1.280

Conclusion

A Kinexus rotational rheometer with advanced axial test capabilities can be used to assess the tackiness or cohesive/adhesive properties of pressure sensitive adhesives. In this study such properties were assessed and compared for a sample of Blu-Tack ® with different contact forces. This suggests there is an optimum pressure between 10N and 20N which gives maximum adhesion under the conditions of the test.

References

- Roberts R.A., Review of Methods for the Measurement of Tack, PAJ1 Report No 5, September 1997.
- ASTM D2979-95, Pressure sensitive tack of adhesives using an inverted probe machine.
- ISO 5833:2002 Implants for surgery - Acrylic resin cement.



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