



FUNCTIONAL PRODUCTS INC.

ILMA 2014

QUANTITATIVE EVALUATION OF TACKINESS IN
POLYMER-OIL SOLUTIONS USING MODIFIED PROBE
TACK METHOD

Outline

- Introduction
- Current Test Methods
- Adhesion and Cohesion
- Contact Angle
- Capillary Action and Surface Tension
- Experimental Methods
 - Modified Probe Tack Test
- Conclusions

Lubricant Tackifier

- Imparts tack or stringiness to a lubricant
- Used to provide adherence of oil to metal surfaces in way oils and chain lubricants
- Adds tackiness to greases, and anti-mist properties to metalworking fluids
- Composed of polymers dissolved in oil.
 - Traditionally high MW PIB in paraffinic oil

Lubricant Tackifiers Are Not Adhesive Tackifiers

Adhesive Tackifiers:

- Used to increase the stickiness of a material
- Lower MW compounds
- Typically have high T_g
- Usually resins (e.g. rosins and their derivatives), terpenes, aliphatic, cycloaliphatic and aromatic resins, hydrogenated hydrocarbon resins, and terpene-phenol resins
- Used in hot melt and pressure sensitive adhesives

Current Test Methods For Adhesives

- Organizations:
 - American Society of Testing and Materials (ASTM)
 - Pressure Sensitive Tape Council (PSTC)
 - European Association of the Self-Adhesive Labelling Industry (FINAT)
 - British Standards Institution (BSI)
 - Tag and Label Manufacturers Institute (TLMI)

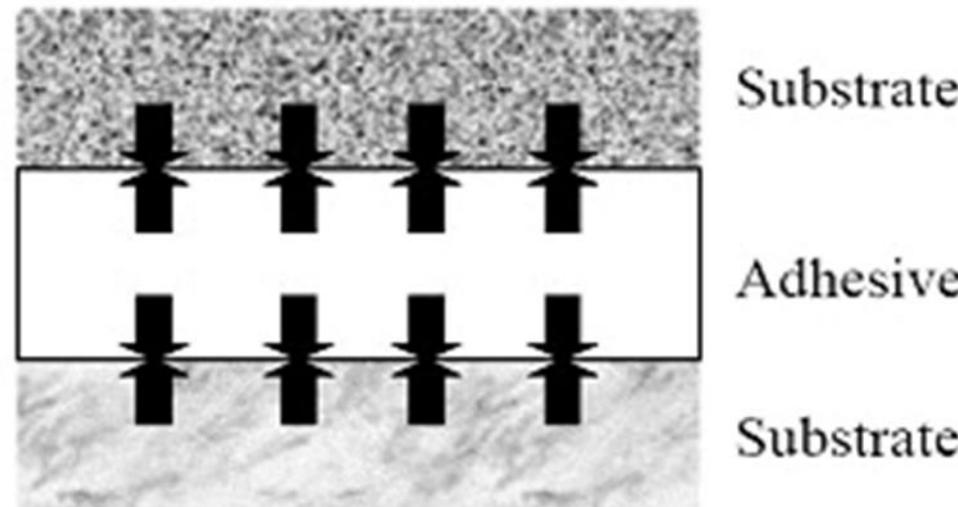
Current Test Methods For Lubricant Tackifiers

- No standardized test methods currently exist
 - Ductless siphon
 - Brookfield spindle
 - BASF in-house method

Adhesion

Attractive force between dissimilar surfaces

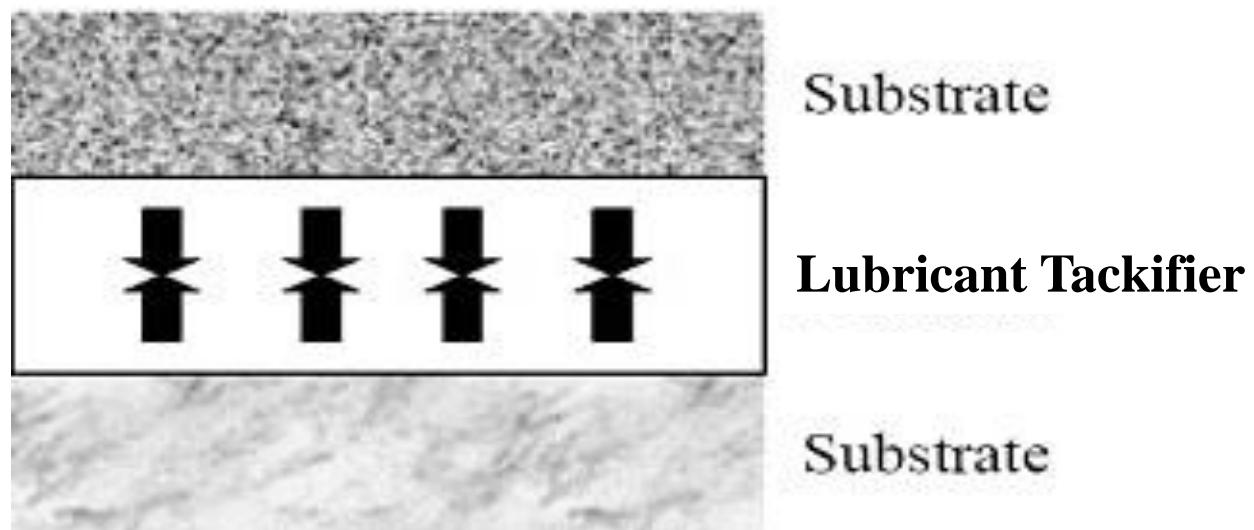
The substrates are held or glued together



(Courtesy 3M)

Cohesion

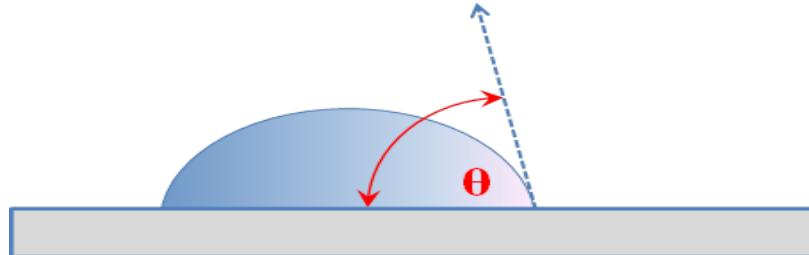
Internal strength of material



(Courtesy 3M)

Can also be
the oil phase
in the lubricant
tackifier

Contact Angle



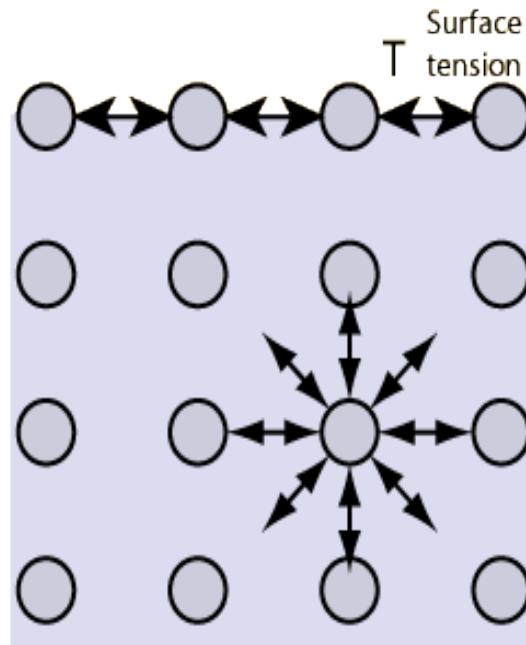
Contact angle of a liquid droplet on a solid surface.

$\Theta < 90^\circ$ increased wettability of surface; better adhesion

$\Theta > 90^\circ$ decreased wettability of surface; better cohesion

Surface Tension

The molecules at the surface of a liquid do not have other like molecules on all sides of them and consequently their cohesive forces are higher

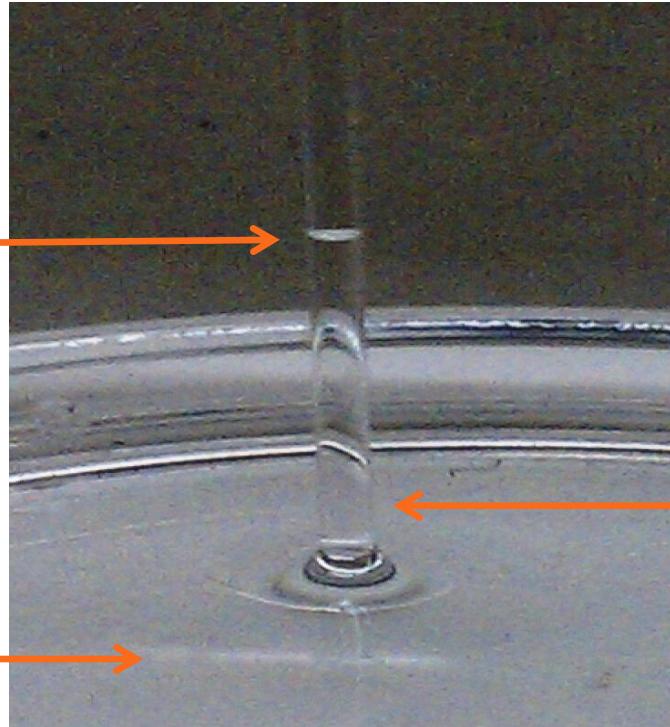


Surface Tension

- Especially strong cohesive forces at the surface constitute surface tension
- Adhesive forces stronger than the cohesive forces lead to an upward turning meniscus and contribute to capillary action

Capillary Action

Concave Meniscus



Capillary Tube

Tackifier Solution

Experimental Methods

Modified Probe Tack Test (ASTM D2979) – Discussed in next slides

Capillary Test – measured the number of millimeters that a tackifier solution was drawn into a 0.7mm diameter capillary tube

Contact Angle – several samples were sent out for measurements. A contact-angle goniometer with an optical subsystem was used to capture the profile of a drop of tackifier solution on a flat glass surface

Experimental Methods

Probe Tack Test (ASTM D2979) for Adhesives:

- This test method involves bringing the tip of a probe or rod into contact with the adhesive at a controlled rate, under a fixed pressure, for a short time, at a given temperature; and
- breaking the bond formed between the probe or rod and adhesive, also at a controlled rate
- Tack is measured as the maximum force required to break the adhesive bond



Experimental Methods

Modified Probe Tack Test for Tackifier Solutions:

Equipment –

- Round flat dish with three centrally located protruding ridges.
- Ohaus model 8262-M spring balance
- 50 gram weight with an attached hook
- Camera
- 3% wt tackifier in oil solutions

Experimental Methods

Modified Probe Tack Test Equipment



Experimental Methods

Modified Probe Tack Test for Tackifier Solutions:

Tackifier Solutions –

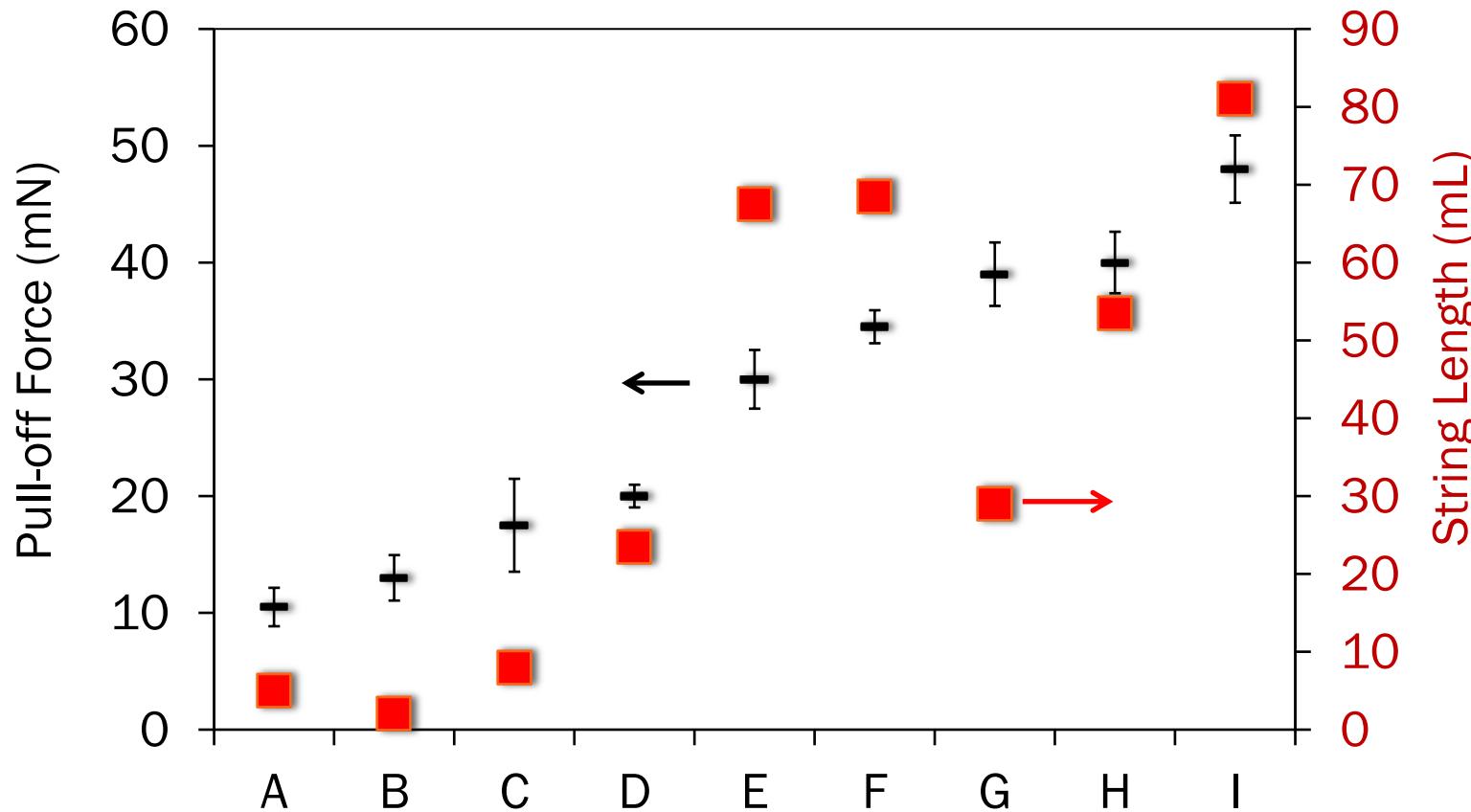
	Polymer	Molecular Weight	Diluent Oil
A	OCP	Low	Group I Paraffinic
B	PBR	Med	Vegetable
C	PBR/NR	Med/High	Vegetable
D	PIB	Low	Group I Paraffinic
E	PIB/PIB	Med/Low	Group I Paraffinic
F	PIB	Med	Group I Paraffinic
G	PIB	Med	Group III Paraffinic
H	PIB	Med	Group I Paraffinic
I	PIB	High	Group I Paraffinic

Experimental Methods

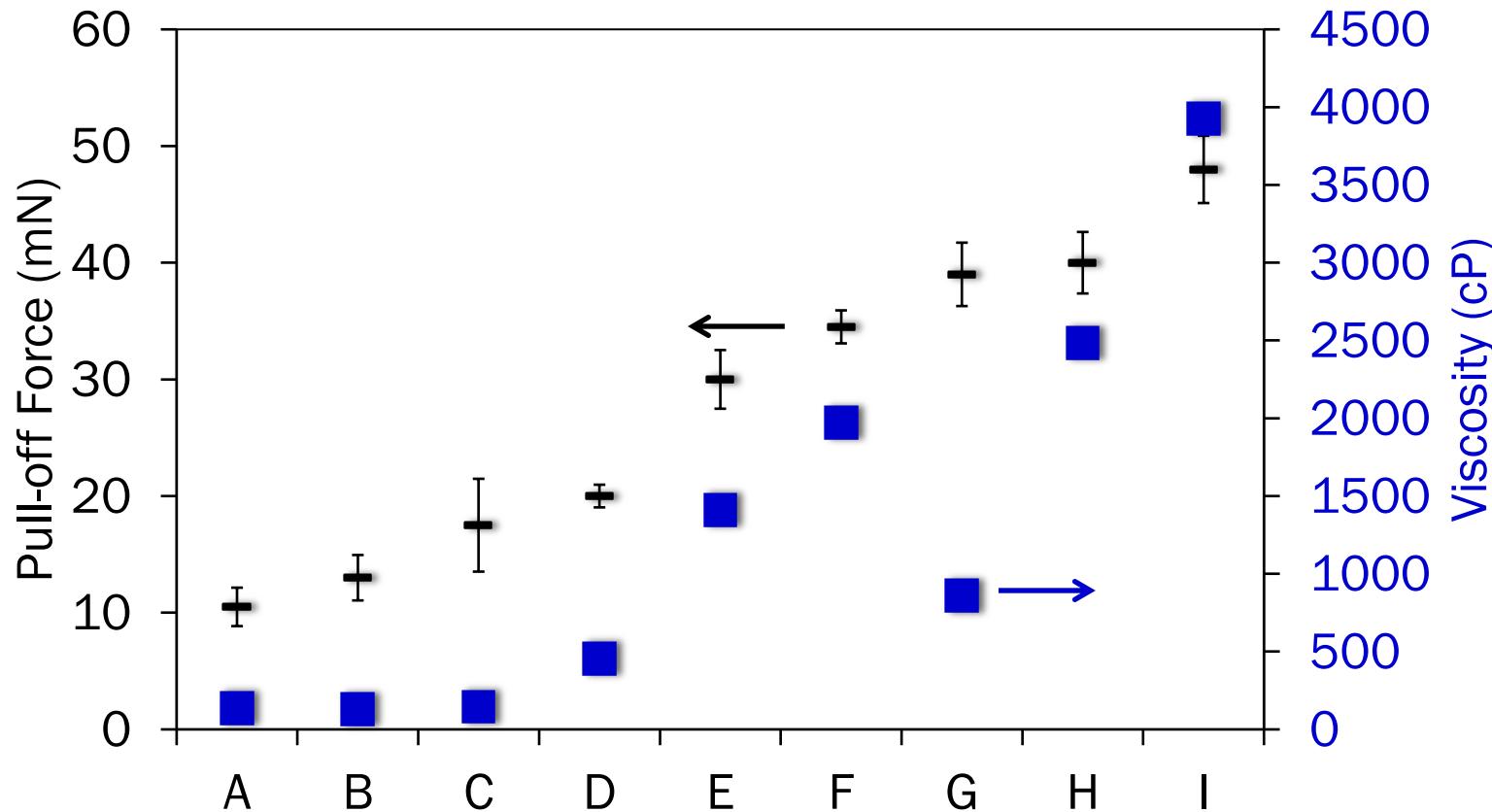
Modified Probe Tack Test for Tackifier Solutions:

- The hooked weight was placed in a tackifier solution
- Steady upward force was applied using a spring scale
- The maximum weight registering on the scale was recorded and the mass of the weight was subtracted
- Tack measured as the maximum force applied

Modified Probe Tack Test Results



Modified Probe Tack Test Results



Capillary Height and Surface Tension Results

	Height (mm)	Density (22°C, kg/m³)	Contact Angle (°)	Dynamic Viscosity (100°C, cP)	Surface Tension (N/m)
A	15	857	24.4	137.3	0.024
B	15	898		130.2	
C	16	922		145.4	
D	12	860		455.5	
E	10	846		1411	
F	8	857	33.7	1971	0.014
G	8	830		857.8	
H	7	864		2483	
I	6	845	41.0	3925	0.012

Adhesive Forces

Cohesive Forces

Capillary Height and Surface Tension Results

- **As surface tension increases the adhesive forces also increase, the solutions are becoming less effective tackifiers**
 - A, B, and C are less effective tackifiers
 - Better adhesion to surfaces (lower contact angle)
- **There is a trade-off between increasing cohesive forces and decreasing adhesive forces**
 - Shown by the inverse correlation between the pull-off force and surface tension

Conclusions

- A correlation exists between the pull-off force and string length
- There is a correlation between the pull-off force and viscosity
- Capillary height is related to adhesiveness
- An inverse relationship between adhesiveness and cohesiveness has been demonstrated.

Conclusions

- The pull-off and capillary test used in this study are relatively quick and simple to perform and require minimal equipment
- Potential tackifiers can be quantitatively evaluated and judgments can be made about their performance
 - A potential tackifier should have a high pull-off force and a low capillary height
 - Combined with previous tests and knowledge of the polymer molecular weight, a tackifier solution can be developed and evaluated more readily