FUNCTIONAL PRODUCTS INC.
Innovative Chemistry for Lubricants

Quantitative evaluation of tackiness in polymer-oil solutions using modified probe tack method

Functional Products Inc.
www.functionalproducts.com

Outline

- Introduction
- Current Test Methods
- Adhesion and Cohesion
- Contact Angle
- Capillary Action and Surface Tension
- Experimental Methods
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- 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

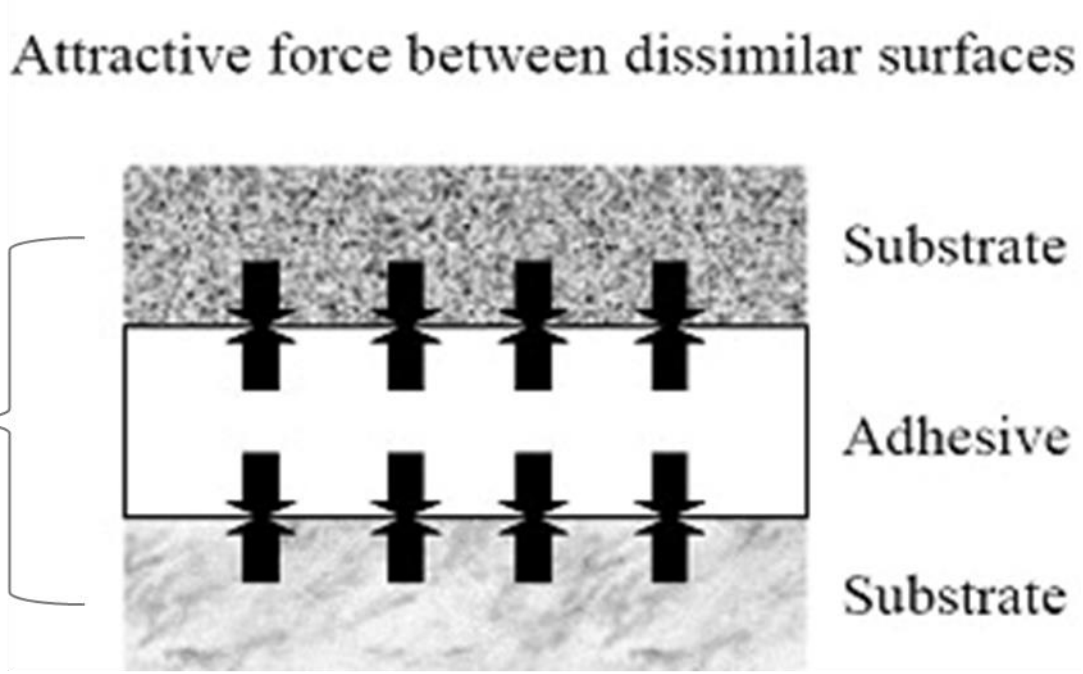
Current Test Methods For Adhesives

- 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 Manufactures Institute (TLMI)

Current Test Methods For Lubricant Tackifiers

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

Adhesion

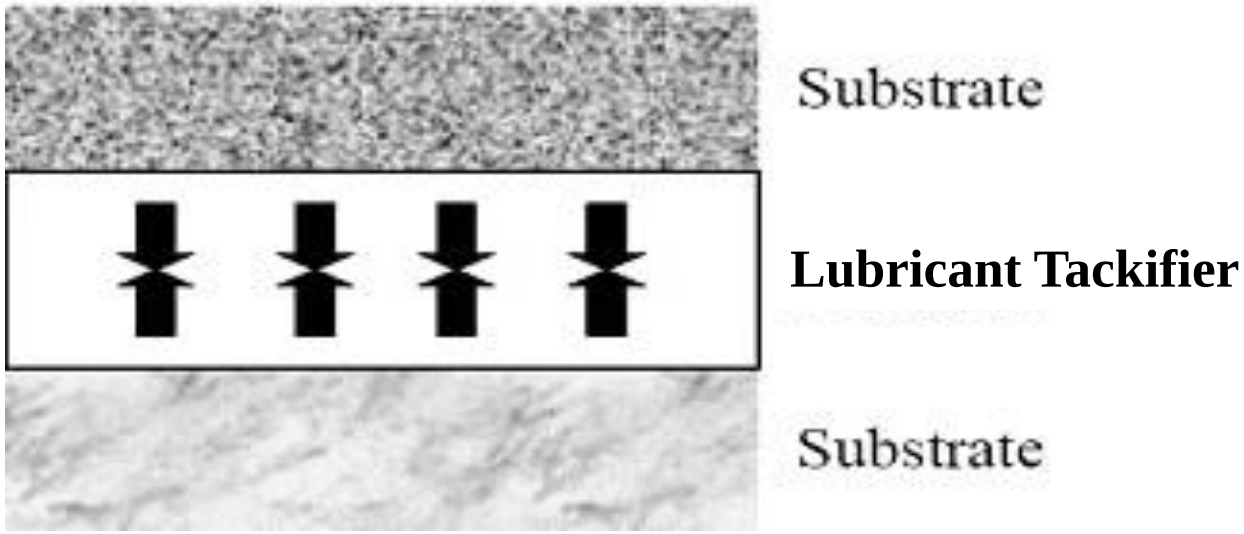


(Courtesy 3M)

Cohesion

Internal strength of material

Can also be the oil phase in the lubricant tackifier



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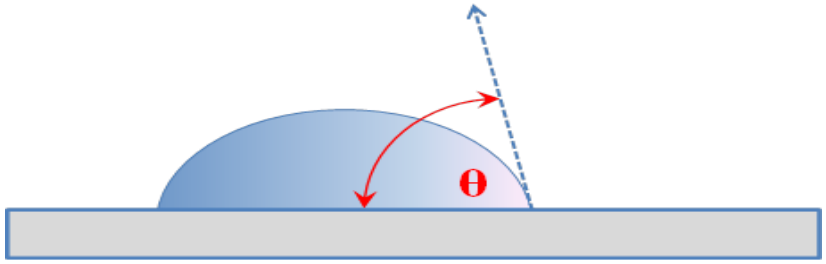
Contact Angle



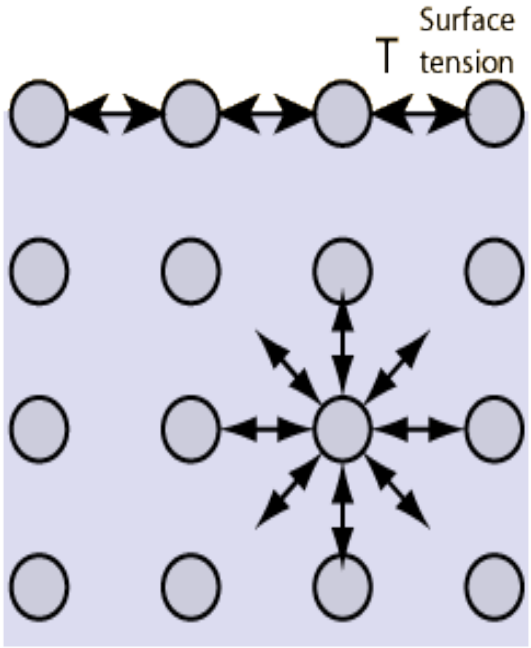
Contact angle of a liquid droplet on a solid surface.

Θ < 90° increased wettability of surface; better adhesion

Θ > 90° 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

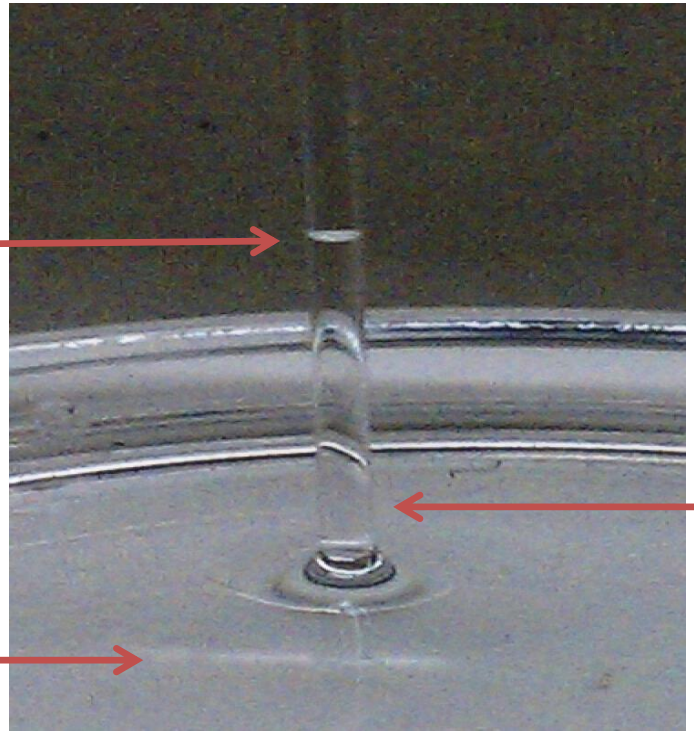


Surface Tension

- 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



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

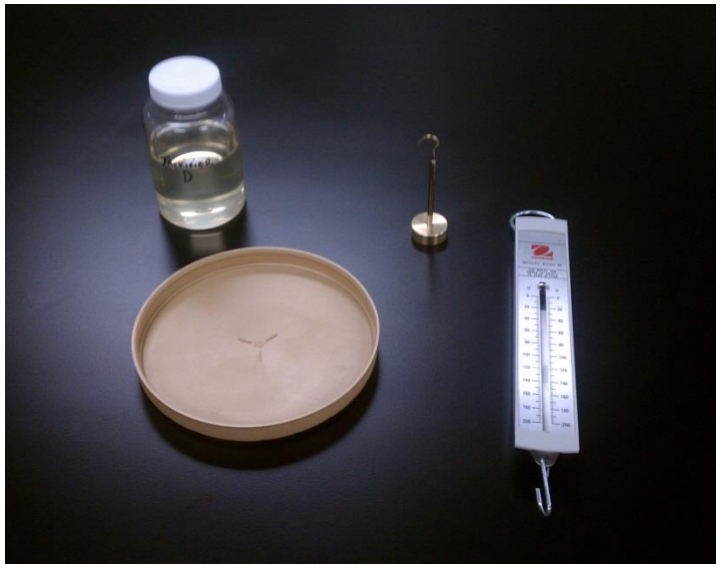
Modified Probe Tack Test for Tackifier Solutions:

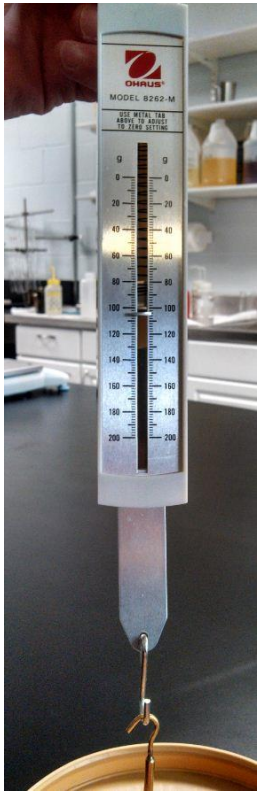
Equipment –

- Round flat dish with three centrically 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 –

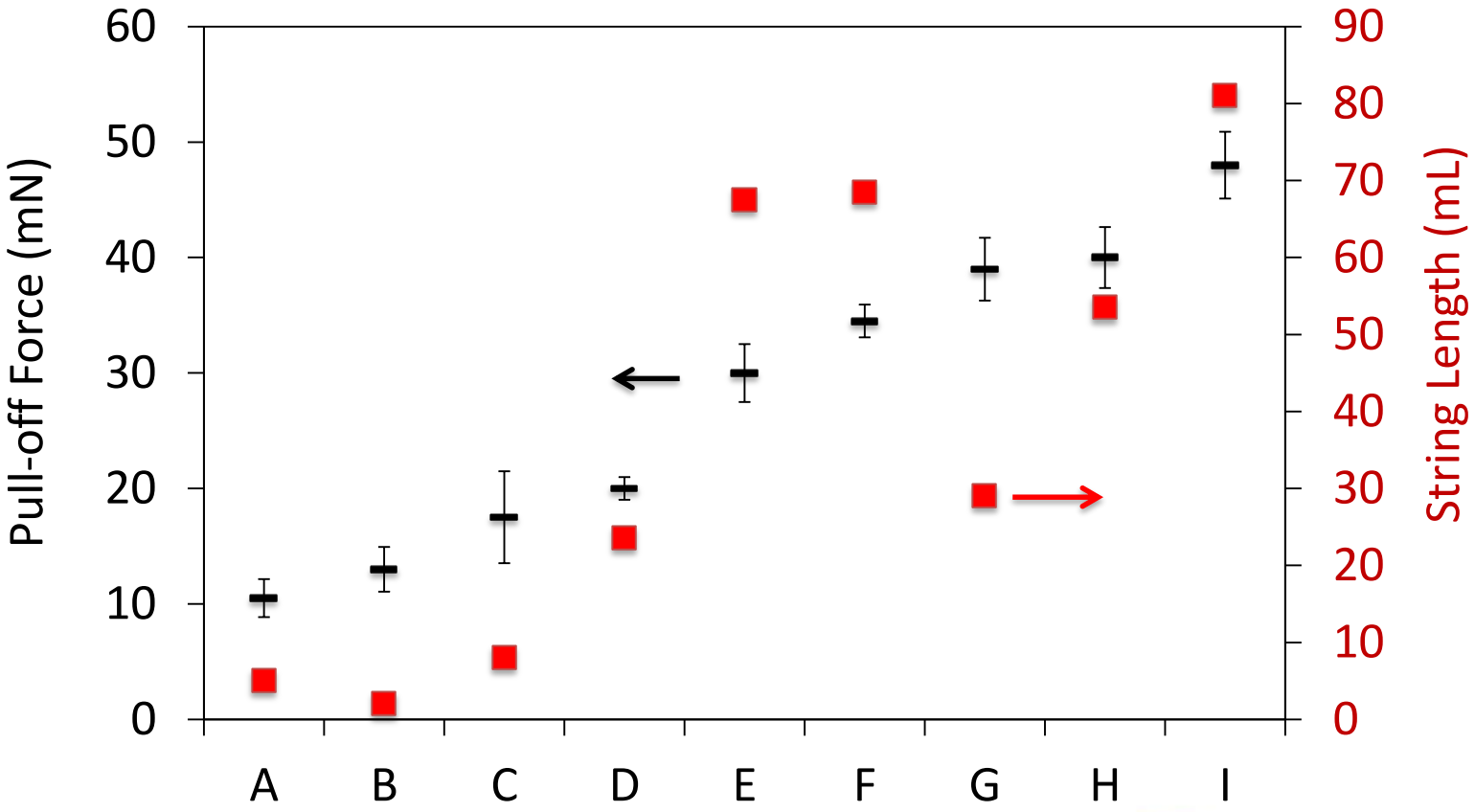
	Polymer	Molecular Weight	Diluent Oil
A	OCP	Low	Group I Paraffinic
B	PBR	Med	Vegetable
C	PBR/NR	Med/High	Vegetable
D	PIB	Low	Group I Paraffinic
E	PIB/PIB	Med/Low	Group I Paraffinic
F	PIB	Med	Group I Paraffinic
G	PIB	Med	Group III Paraffinic
H	PIB	Med	Group I Paraffinic
I	PIB	High	Group I Paraffinic

Experimental Methods

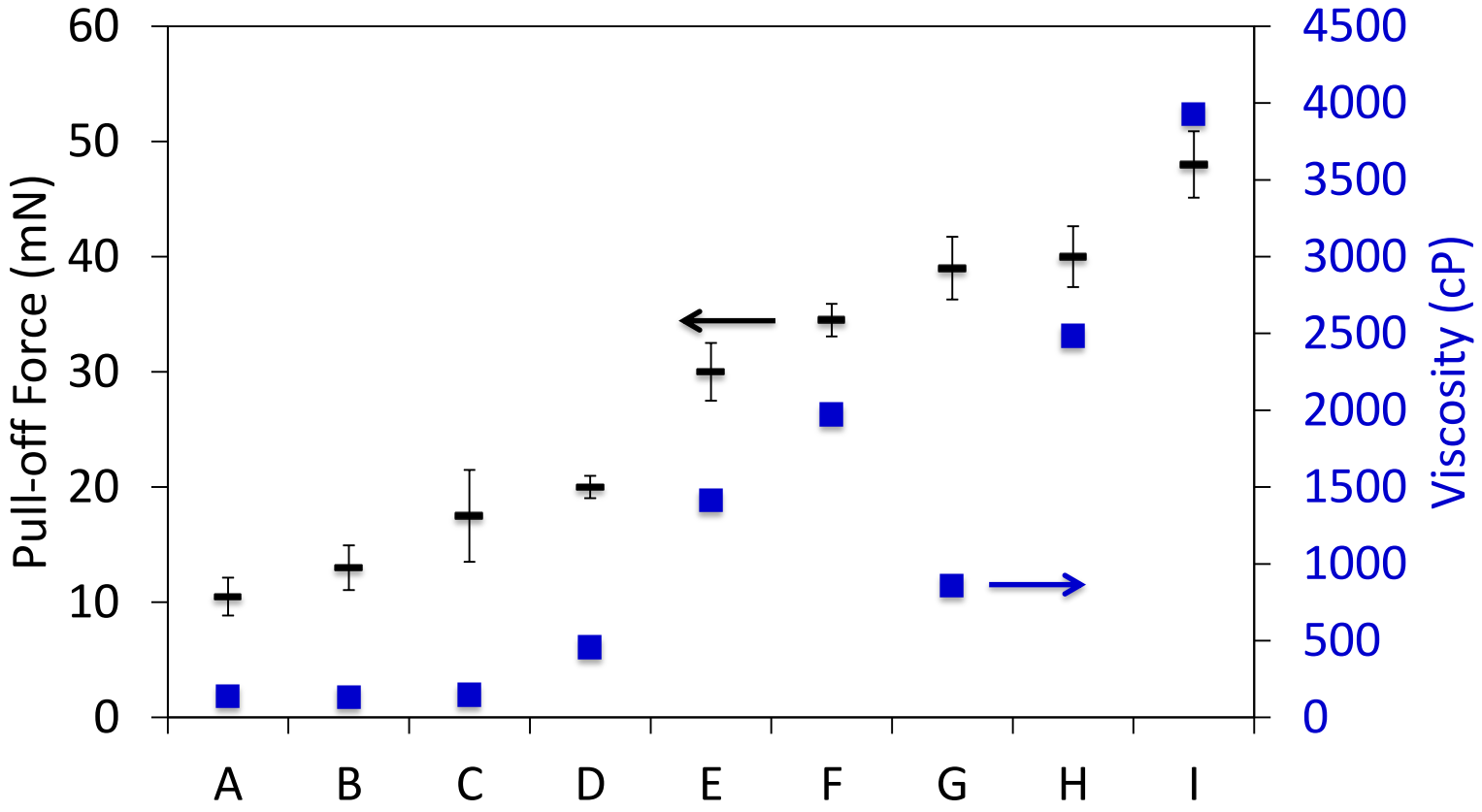
Modified Probe Tack Test for Tackifier Solutions:

- 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/m^3)	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