

SURFACE TENSION

INTRODUCTION

Wetting is a phenomenon that we see every day. It may be a rain drop on a leaf or soup on a spoon. It is also seen in how an ink, adhesive or coating spreads on a film. Wetting, in simple terms, is the ability of a liquid to spread across the surface of a solid to produce a uniform, continuous surface. How a solid is wetted by a liquid is measured by the surface tension of the liquid relative to the surface tension of the solid. For a coating, adhesive or ink to be usable it must a) wet and adhere to the substrate, b) cure, and c) exhibit excellent enduse properties. The surface tension of a solid has important influence on these properties. A solid surface with intimate coverage of a liquid is necessary to produce a strong uniform adhesive, coating or ink bond.

THEORY

Surface Tension

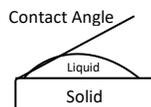
The interactions at the interface between a liquid and solid are complex but have practical importance. For a drop of liquid to spread across the surface of a solid (wet the surface) work occurs to change the shape of the liquid drop. Surface tension is the work per unit area to reshape the liquid. It is measured in dynes/cm.

For a liquid to wet the surface of a solid, the surface tension of the liquid must be lower than the solid surface tension.

Contact Angle

A useful measurement of the ability of a liquid to wet a surface is contact angle. Contact angle is the angle between the solid surface and the tangent to the liquid surface at the angle of contact.

(Fig. 1)



If the contact angle is greater than 90 degrees, the liquid tends to bead up. Liquids having contact angles

less than 90 degrees tend to wet surfaces. A contact angle of 0 degrees indicates a liquid will completely cover a surface, while a contact angle of 180 degrees indicates the liquid beads up on a surface.

MEASUREMENT

The surface tension of a solid film cannot be measured directly. Practical measurements of solid surface tensions utilize the interaction of solid surfaces with test liquids.

ASTM D724 describes one method to measure surface tension. Contact angle of a test liquid is measured on a specified surface. This procedure uses projection instruments and microscopes or a reflective Goniometer to measure the resultant contact angle. The procedure is more appropriate for laboratory measurements. Lower contact angles indicate better wetting.

Another commonly used method employs a series of liquids of varying surface tensions to measure critical surface tension based on the principles detailed in ASTM D2578. Critical surface tension of a solid is the highest surface tension liquid which just wets its surface. Test liquids and application kits are available from a number of sources. (See Appendix)

Application kits or “dyne pens” provide useful but not precise measurements of surface tension. A CFFA member study indicated that surface tension measurements for individual technicians are consistent, but modest differences exist between testing labs. In the study, dyne pens are shown to be directional indicators of significant differences in the surface tension, capable of identifying “good” and “bad” printing surfaces.

APPLICATION

Surface tension measurements are useful to predict surface wetting, however, they are not the only criteria for good print acceptance or adhesion. Each

printing, coating, or adhesive application is unique and is affected by many process and material variables. Several factors may affect any individual application.

Climatic Conditions

- Temperature and humidity affect how a solid and liquid interact. Surface wetting characteristics may be significantly different winter to summer or dependent on humidity.

Liquid Consideration

- High surface tension liquids have more difficulty wetting the surface of solids than low surface tension liquids. Waterborne inks and coatings have higher surface tensions than most solvent systems. Surfactants and cosolvents are useful in lowering surface tensions.
- The viscosity, drying time and solvency (“bite”) of the liquid will affect how an ink or coating wets a surface. Changing the solvent in the ink or coating can improve surface wetting.
- Heating the ink or coating can favorably affect application.
- It is important to remember that the surface tension of an ink, coating, or adhesive must be lower than the surface to which it is applied to achieve good wet out. Working with the ink or coating supplier, many additional suggestions may be obtained to improve surface wetting.

Solid Considerations

- Surface tension is affected by material composition. Selection of plasticizer, lubricants, stabilizer, and process aids contributes to surface tension. Material selection and application information should be reviewed with suppliers for each application.
- Surface roughness can affect ink and coating wetting. Rougher surfaces allow ink and coating “dive in” and promote mechanical bonding.
- Surface tension can decrease with material age. Wiping the surface with a solvent to freshen the surface or a light mechanical

roughening with an abrasive can improve surface receptivity.

- Surface treatments, chemical washes, corona treatment, sanding, or primer coats can increase surface tensions and improve ink or coating acceptance.
- Moderate heating of the film can increase surface tension and receptivity.
- Surface contamination or surface exudate will adversely affect ink and coating acceptance. Cleaning the surface with solvent or light mechanical roughing can improve receptivity to ink and coating. It is also important to consider sources of contamination which may affect surface tension during printing and coating operations.
- Exudation or surface bloom can indicate material problems. Ingredient quantity and selection in the material formula must be adjusted to the application. Plasticizer, lubricant or stabilizer can be optimized to the particular application with suppliers.
- Surface tension of a solid surface must be higher than the liquid applied to achieve acceptable wet out.

SUMMARY

Surface tension is a key measure of how a solid surface and liquid will interact. Intimate wetting promotes good print acceptance and adhesion.

Surface tension measurements are good indicators of wettability but do not produce precise numbers which guarantee good adhesion or print acceptance. Each application is unique. Surface tension testing which has been correlated to good product experience is useful benchmarking. Surface tension requirements will indicate significant changes from these baseline values. Good ink and coating acceptance and adhesion are results of many variables at play in each application; surface tension is one of many.

APPENDIX

Test liquids and application kits employing the principle detailed in ASTM D2578 are available from a number of sources, including but not limited to:

Sherman Treaters, Inc.
964 Westport Crescent
Mississauga, Ontario,
Canada L5T 1G1
905.670.9117

Diversified Enterprises
91 Main Street-Suite N
Claremont, NH 03743
800.833.4644

UV Process Supply, Inc.
1229 West Cortland Street
Chicago, IL 60614-4805
800.621.1296

Entercor Industries Corporation
P.O. Box 773
Menomonee Falls, WI 53052
414.255.6070

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> coated fabrics and film