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SUBSTRATES & ADHESIVES: MEANT FOR PRINTING & PACKAGING INDUSTRIES

Amaranand
M. Tech. (Print & Graphics Communication), GJUS&T, Hisar (Haryana)

ABSTRACT

Adhesives play a fundamental role in many modern technologies, and adhesive failure can have catastrophic consequences. In packing industry, adhesive is used as an ancillary material. Different types of adhesives are designed for a large variety of applications. Some have very weak strength for holding papers in place, others are so strong that they can used for bonding cars and airplanes. There is no one adhesive that is suitable to all applications. It is, therefore, valuable to understand the factors important for the production of a good durable adhesive bond.

I. INTRODUCTION

Adhesives are used in a wide variety of paper bonding applications ranging from corrugated box construction and the lamination of printed sheets to packaging material used for all types of consumers products to the production of large industrial tubes and cores used by manufacturers of role goods and other materials. They can also be found in the products used by consumers everyday such as bathroom tissue, paper towels, and books. The use of adhesives offers many advantages over other binding techniques such as sewing, welding, bolting, screwing, etc. These advantages include the ability to bind different materials together, the ability to distribute stress more efficiently across the joint, the cost effectiveness of an easily mechanized process, an improvement in aesthetic design, and increased design flexibility.

II. RESEARCH OBJECTIVE

- To examine the various types of adhesives used in packaging and their adhesive strength with the packaging substrates.
- To find out job suitability of adhesives for different packaging applications.

Common classes of packaging adhesives

Starch and starch based adhesives

Starch is used as an adhesive in its unmodified as well as in modified forms. It is a naturally occurring vegetable polymer usually extracted from corn, grains or potatoes. Corrugated board manufacturer is the largest single starch based adhesive application. Starch has limited solubility because of its higher molecular weight. Starch molecular weight can be reduced and solubility increased by roasting in the presence of acids. Glucose is totally depolymerised starch. Dextrin is a partly depolymerised starch with intermediate molecular weight. Dextrin dissolves more readily in water than starch and provides solid contents of 40 or 50%. Dextrins are economical and set faster than starches but are still relatively slow setting compared to synthetic systems. Starch based adhesives have good adhesion to glass and metal but not to plastics. Mixing dextrins with borax improves tack and provides stable viscosities at moderate concentrations. Starch and dextris adhesives are thermoset polymers and have more heat resistance than most synthetic thermoplastic polymer based adhesives.

Casein adhesive

Casein is the protein component of milk which is solubilized by treating with aqueous alkali. Starch may be added to increase its viscosity and tack. Properly formulated caseins have the unique property of having good cold water resistance but of being rapidly hydrolyzed in aqueous solutions. Refillable beverage bottles use casein-based adhesives so that the bottle will retain its label when immersed in ice water. Some casein is used for foil laminating.

Animal glue

These consist of mixtures of gelatins extracted from animal hides and bones. Animal glue can be supplied as solid cakes which are run at about 60°C. Their use in packing is now restricted to applications that require high tack such as cardboard box making, file making and abrasive paper manufacture. Their ready repulpability in warm water may make them an attractive choice for environmental reasons.

Synthetic emulsions

Large molecules give very strong bonds, but their solubility goes down as molecular weight goes up. The problem of having strong adhesive material and high solids content is resolved by making an emulsion. Synthetic emulsion adhesives are based on polymers such as polyvinyl acetates, acrylates and maleates, which in themselves are not water soluble. However , when fine particles of the polymer are surrounded by a protective colloid such as polyvinyl alcohol, the resulting product can be suspended in water. The polymers used in emulsion adhesives can be of relatively high molecular weight, providing for bonds having good performance under high stress and good heat resistance. Water based adhesives are easy to use and clean up. They are economical and are used extensively in all forms of paper packaging application, from cartoning to label gluing .

Hot melts

A hot melts by convention describes a lower molecular weight material than “thermoplastic.” Hot-melt adhesives are 100% solids and are applied in hot, molten from. Ethylene-vinyl acetate is the most common base resin used formulating hot melt adhesives. The main polymer is usually diluted, or “let down,” with a material such as wax to improve melt flow properties and reduce cost. Tackifiers improve hot tack and viscosity. Other materials influence melt temperature. Added colorants make the application more visible. Like many organic materials, hot-melt adhesives can degrade with extended heating. Antioxidants and heat stabilizers are important hot melt components. Most general purpose hot melts are applied at about 177°C(350°F). The defined melting point of hot melts can limit their application. Few packaging hot melts are reliable above 70°C (158°F), although formulations based on polyamides and polyurethanes have fairly good performance at elevated temperatures, but at a higher cost. The substrate must be able to tolerate the application temperature without warping or shrinking. Hot melts may not be suitable for items coming out of or going into thermal processing. Conversely, an economical hot melt may have a significant amount of wax diluent, Such an adhesive could become quite brittle at freezer conditions. Conventional hot melts are by nature, water resistant and can be formulated for many specialty applications, including thermosetting and pressure sensitive formulas. Hot melts come in a variety of solid shapes. Slats, pillows, wafers and chips are the most common forms. Hot melt adhesives are a paper recycling concern. At the paper mill, current hot-melt formulations cannot be readily removed or dispersed and can cause major problems when bits of hot melt run through the paper drying rolls.

Lacquer Adhesives

The term “lacquer adhesives” generally applies to any solvent based adhesive. These adhesives are used most often by converters in coating and laminating operations, particularly with plastic substrates. They dry much faster than waterborne systems. In addition, there is considerable formulation latitude. Environmental, health and safety concerns are slowly eliminating the use of solvent based adhesive systems.

Pressure-Sensitive Adhesives

Pressure sensitive adhesives (PSA) are mostly based on one of two elastomeric polymer classes: acrylics and rubber/resin blends. The surface of a PSA is classed as a very high viscosity liquid, and it is this feature that provides the instant bonding characteristic. Extremely soft PSAs will bond to virtually any surface; however, their cohesive strength will likely be too low for most practical uses. Acrylic formulations are typically based on acrylic acid ester monomers with appropriate comonomers. The more highly polymerized grades have higher cohesion but lower adhesion. Acrylic based systems usually perform better at low temperatures than rubber/resin blends do. Rubber/resin blends balance adhesion and cohesion properties by the choice of base rubber/resin combinations, their molecular weights and the type and amount of added tackifiers. Low cohesive strength formulations are sometimes used in peelable and resealable packages. PSAs are frequently used in conjunction with a release paper to manufacture pressure-sensitive label stock. The base is a heavily calendared paper that has been coated with a silicone or fluoropolymer release (antiadhesive) coating.

Cold-Seal Adhesives

Co-adhesives or cold seal adhesives are similar to pressure-sensitive adhesives. "Co-adhesive" simply means that the adhesive has a greater tendency to stick to itself rather than other surfaces. Cold seal adhesives, a type of co-adhesive, are usually based on natural rubber latex. Cold seals were originally developed for bounding plastic based chocolate bar wraps, where chocolate's low melting point precludes heat sealing. The applications for cold seal adhesives have expanded to other flexible packaging applications where the instant bond on contact feature allows for faster machine speeds.

III. ADHESIVE SELECTION AND CONSIDERATIONS

Chemistry of Materials to Be Bonded :-The Chemical nature of the two materials to be joined is the single most important factor when selecting an adhesive. Special treatments or primers may be needed to achieve good adhesion.

Physical Nature of the Surfaces to Be Bonded:-The Physical nature of the surfaces to be bonded may dictate certain adhesive choices. For example, recycled paper will have short, closely matted fibers and a surface that is not very porous. The low-solids, low-viscosity adhesive could be used, since it will not readily be "lost" in the board. A Kraft stock, on the other hand, will have a long fiber, open structure with a porous but nonabsorbent surface. A high-solids, high-viscosity adhesive might be a better choice.

Application Method, Machine Speed, Pot life:-Application method, machine speed and pot life are interrelated and basically describe the manufacturing method. The adhesive's viscosity characteristics must suit the application method and the substrate. "Pot life" refers to the stability of the adhesive in the machine. Reactive thermosets in particular must have a pot life that will preclude them setting up in the machine during normal operations. Drying time, as opposed to setting speed, may be important in applications where there are frequent machine stoppages. Slower-drying adhesives will not be as likely to foul the machine.

Rate of Assembly:-"Open time" describe the time between application and the time at which the adhesive has set or dried. For wet adhesives, the development of tack and the period over which a successfully bond can be made is sometimes referred to as the "tack and range." In Fig. (1),neither the PVA emulsion nor the dextrin has much tack at the beginning. The PVA emulsion rapidly develops tack when the emulsion breaks. The dextrin takes longer to develop tack, and has a longer tack period in which assembly can be done. It is also slower drying. Open time for each adhesive would be the time to peak tack level.

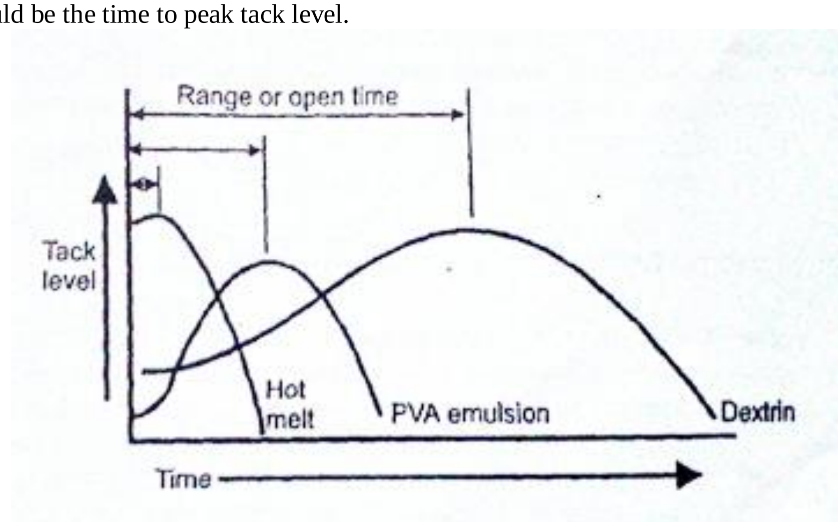

Fig.1. "Open time" or "tack & range" for three adhesive types.

Application and End-use Temperatures:-Both application and end-use temperature requirements must be taken into account. Some products may still contain process heat, while others may be subjected to thermal processing or freezing. End-use temperatures may be environmental, or they may involve use conditions such as boil-in-bag or microwavable applications.

Humidity and Water Resistance:-Water resistance is described in terms like good, poor, fair, waterproof and iceproof. There are varying degrees of water resistance, ranging from merely resisting high humidities to being totally waterproof when immersed. Poor water resistance generally means easier clean-up. Good water resistance is necessary when the item being packed is wet or the package will be exposed to weather of freezer conditions. Iceproof adhesives (adhesives that remain adhered when immersed in cold water) are needed for brewery and soft drink labeling.

Chemical Resistance:-Adhesives can be softened or plasticized by oils or plasticizer compounds that migrate from other materials. Products may also contain volatile ingredients that will deteriorate bond strength. Some flavoring ingredients, such as oil of wintergreen, are particularly aggressive. An adhesive's chemical resistance should be verified in applications involving solvents or other aggressive chemicals.

Food Applications:-All food applications must use adhesives approved for that use. The food use status is provided in the U.S. by the Food and Drug Administration or in Canada by the Canadian Health Protection Branch. Some adhesives are capable of imparting off flavors or odors to some foodstuffs.

Color:-Dark-colored adhesives may show through substrates with poor opacity. In other applications, color may be added to provide visual evidence of spray or wheel patterns on white board. Hot melts that have been degraded are darker than the color stated on data sheets, indicating aging or degradation.

Specific Density (Weight/Gal. or Kg/Litre) :-Specific density is the ratio of product density to that of water at the same temperature. Most adhesives are sold by weight. If they were always used by weight, usage calculations would be simple, but most adhesives and coatings are used by volume; therefore the lower density product will provide better yield if all other characteristics are equal. Some adhesives are extended with fillers and appear less costly when comparing per kilogram price, but when density is taken into account, they are in fact more expensive.

pH (Water-based Adhesives Only) :-Adhesives at pH extremes, either acid or base, should be run with stainless steel equipment. Acidic and alkaline pH systems are not generally compatible and will coagulate when mixed. Resin emulsions are generally acidic. Most latexes and borated dextrins are alkaline. Some substrates can be affected by extreme pH values. Aluminum foil, for example, corrodes quickly in the presence of alkali.

IV. FACTORS AFFECTING ADHESION

Surface Energy and Substrate Polarity:-The type of coating chosen will depend greatly on the surface energy of the substrate (and ultimately, whether the surface is polar or non-polar). Polar substrates carry a positive or negative charge and adhere best to other polar coatings. Non-polar substrates are charge-neutral and have to rely on other adhesion mechanisms, such as diffusive or mechanical bonds, for bonding. For example, thermoplastic olefin (TPO) single-ply roofs are non-polar because they are made of polyethylene and polypropylene. TPOs are very hard to coat, especially with polar coatings like polyurethanes or acrylic, because these coatings have no charged surface with which to interact. As a result, the cured film can be removed easily from the surface. In order to coat a TPO, a diffusive bond must be formed with a solvent-based primer. The suitable primer then becomes a more compatible substrate onto which a topcoat is applied. In contrast, polar substrates, such as polyurethane foams, can be coated easily with acrylic or polyurethane coatings, which are also polar. In such cases, the polar coating interacts with the polar surface to create a dispersive force which, when taken over the whole area, is very strong. In addition, other factors such as surface contamination and surface texture further strengthen the surface Area Covered and Contact Points Achieved The polarity of the substrate also affects its surface energy. Surface energy is what enables a coating to wet out or bead on a substrate. "Wet out," as the phrase implies, is the ability of the coating or adhesive to

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spread onto the surface to which it is applied. In contrast, beading is what occurs when the adhesive or coating is not wetting out well. Simply put, the more the coating is able to wet out, the more surface area is covered. The more surface area covered, the more contact points achieved. The more contact points achieved, the better the adhesion to the substrate.

Surface Contamination:-When a substrate is contaminated with dust, oil, or debris, coating adhesion is impaired. Areas with high concentrations of contaminates provide an alternate substrate over the intended substrate. Because the coating adheres so well to these polar contaminate particles, it has only partial or no contact with the intended substrate. An inadequate coating bond to the substrate can lead to blistering, peeling, or film delamination. This is why coating manufacturers and distributors stress a clean surface prior to coating application. The surface also must be dry, because water can act as a contaminate. For example, a roof coating that covers a water droplet is a prime candidate for cracking and blistering. When the water droplet dries and diffuses through the coating, the void left underneath the coating will expand and contract with changing atmosphere and, depending on the strength of the coating, will crack. If this occurs on a roof, it will lead to water absorption and eventual leakage. In addition, if the water droplet is trapped between two non-porous substrates, the droplet itself could expand within its confines during a hot day and actually cause localized delamination or blistering.

Surface Texture:-The texture of a substrate also can impact the adhesive bond. You will recall that the greater the surface area covered by a coating or adhesive, the better the adhesion. A substrate has more surface area when its surface is rough than when it is smooth. The simple act of etching or abrading a surface even a few microns deep, prior to coating, will increase the surface area the coating will “see.” The greater the area covered, the greater the contact points that improve adhesion. There is a catch, however. If the substrate has a low surface energy, the coating will not wet out and will not cover as much area. This reduced surface coverage means fewer contact points, especially if the surface is etched. A non-polar, low-energy substrate will not allow a coating to fill all of the voids. An etched, polar high-energy surface will wet out a polar coating and adhere at an infinite number of contact points along its bond line, resulting in very strong adhesion.

V. CONCLUSION

Different adhesives have different adhesion properties. But their end use depends upon the type of packaging surfaces it is going to adhere. So printers and packaging persons need to take utmost care while selecting suitable type of adhesive for their end user applications. It will certainly help in gaining optimum adhesion results for packaging requirements.

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