Tack as an undefined very important property of pressure-sensitive adhesives

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ABSTRACT

The term pressure-sensitive adhesive (PSA) has a very precise technical definition and was dealt with extensively in the chemical literature. The function of PSAs is to ensure instantaneous adhesion upon application of a light pressure. Fundamentally, characteristics of PSA are categorized by tack, peel adhesion and cohesive strength. Tack is the dominant property of PSA, and is defined as the ability of an adhesive to form a bond of measurable strength to another surface under conditions of low contact pressure and short contact time. Most applications further require that they can be easily removed from the surface to which they were applied, through a light pulling force. The bonding and the debonding of PSA are energy driven phenomena. Pressure-sensitive adhesives must possess viscous properties in order to flow and to be able to dissipate energy during the adhesive bonding process. To determine the tack property, various testing methods are suggested, for example, rolling ball tack test, probe tack test, quick stick, and loop tack method.

Tack jako niezdefiniowana bardzo istotna właściwość klejów samoprzylepnych

Słowa kluczowe: tack, metody pomiaru, kleje samoprzylepne

STRESZCZENIE

Pojęcie tack (lepność) klejów samoprzylepnych jest wprawdzie precyzyjnie określone w literaturze, ale jest nie do końca jednoznacznie zdefiniowaną właściwością. Zasadniczo, kleje samoprzylepne są scharakteryzowane poprzez tack, adhezję przy odrywaniu oraz kohezję pod ściśle określonym obciążeniem. Tack jest dominującą właściwością klejów samoprzylepnych i jest określany jako zdolność warstwy samoprzylepnej kleju do utworzenia wiązania adhezyjnego w bardzo krótkim czasie kontaktu powierzchni kleju z substratem, bez nacisku zewnętrznego na sklejaną powierzchnię. W czasie pomiaru tacku dochodzi de facto do bardzo niewielkiego nacisku na substrat, wywołanego naciskiem, naniesionej z reguły na nośnik, warstwy samoprzylepnej kleju. Kleje samoprzylepne charakteryzują się doskonałymi właściwościami lepkosprężystymi, umożliwiającymi doskonałą zwilżalność sklejanych powierzchni. Pomiaru tacku dokonuje się za pomocą czterech metod: metodą toczącej się kuli, metodą próbnika, metodą odrywania (quick stick) oraz metodą pętli (loop tack).

1. PRESSURE-SENSITIVE ADHESIVES

Pressure sensitive adhesives (PSA) are materials that develop measurable adhesion upon contact with a substrate by the application of a light pressure without requiring a chemical reaction, with no curing of the adhesive, and with no loss of solvent during the adhesion process. Such properties imply that intimate contact between the substrate and the adhesive must be established rapidly and under slight pressure, but also that the energy necessary to separate the adhesive from the substrate must be suffcient for the spe - cific application [1]. PSA are widely used materials in our modern life, such as in one-sided, double-sided or transfer mounting tapes, sign and marking films, diverse kinds of labels, protective films, splicing and masking tapes, plasters, OP-tapes, biomedical electrodes and self-adhesive hydrogels [2]. Polymers employed as PSA have to fulfill partially contradictory requirements; they need to adhere to substrates, to display high shear strength and peel adhesion, and not leave any residue on the substrate upon debonding. In order to meet all these requirements, a compromise is needed. When using PSA there appears another difference with wet adhesives, namely the adhesive does not change its physical state because film forming is inherent to PSA [3].

According to suitable polymers for manufacturing of PSA, the commercially available PSA groups on the market are acrylics, synthetic and natural rubbers, silicones, polyurethanes, polyesters, polyether and ethylene-vinyl acetate copolymers (EVA). Pressure-sensitive adhesive acrylics can be synthesized and applied in forms as a solvent-borne, as a water-borne (dispersions) and as a solvent-free system. In the giant field of adhesives the pressure-sensitive adhesives make up but a low percentage and the solvent-borne pressure-sensitive acrylic adhesives with about 210.000 tons per annum in Europe in 2009 are almost a quantity negligible within this group [4]. The fundamentally properties, which are essential in characterizing the nature of PSAs comprise: tack, peel adhesion, and shear strength. The first (tack) measures the adhesive's ability to adhere quickly, the second (adhesion) its ability to resist removal through peeling, and the third (cohesion) its ability to hold in position when shear forces are applied [5]. Tack is an indication of how quickly an adhesive can wet out and so come into intimate contact with a particular surface and eventually reach its optimum adhesion and is not a well-defined property such as viscosity or elasticity, but depends upon the mode of the test procedure. A rigorous definition requires standardization of contact pressure, dwell time, rate of separation, and surface of the adherend. Many empirical tests have been devised, some intended to measure tack under light pressure, others at very short contact times. Some tests attempt to combine both features. The tack property is the main topic of the present study, so that

a more detailed description is given in the following section. To determine the tack property, various testing methods are suggested, for example, rolling ball tack test, quick stick tack test, probe tack test, and loop tack test [6].

2. EVALUATION OF THE TACK

2.1 Rolling Ball Tack Test

The rolling ball tack test has been the oldest and most widely used for at least 50 years. In the common form of the rolling ball tack test, a stainless steel ball with 1.1 cm diameter is released at an elevation on an inclined tack so as to roll down and at the bottom come into contact with the horizontal, upward-facing adhesive. The distance the ball travels out along the tape is measured as tack. It is primarily intended for quality control of adhesive tapes, but may also be used to investigate adhesive coatings. The experimental value of tack is the distance the ball rolls on the tape before stopping. Since the motion of the ball is closely related to bonding and debonding processes which occur simultaneously at the surface of contact, it is believed that the rolling motion of the ball on a pressure sensitive adhesive reflects tackiness of the adhesive. However, this test does not provide the level of control needed to understand tack, since the rate of application of the force varies somewhat as the ball travels the length of the tape [7]. The rolling ball tack test consist of a ball or cylinder rolling down an inclined plane or grooved ramp and contacting a firmly held horizontal tape stripe butted against the end of ramp (Fig. 1).

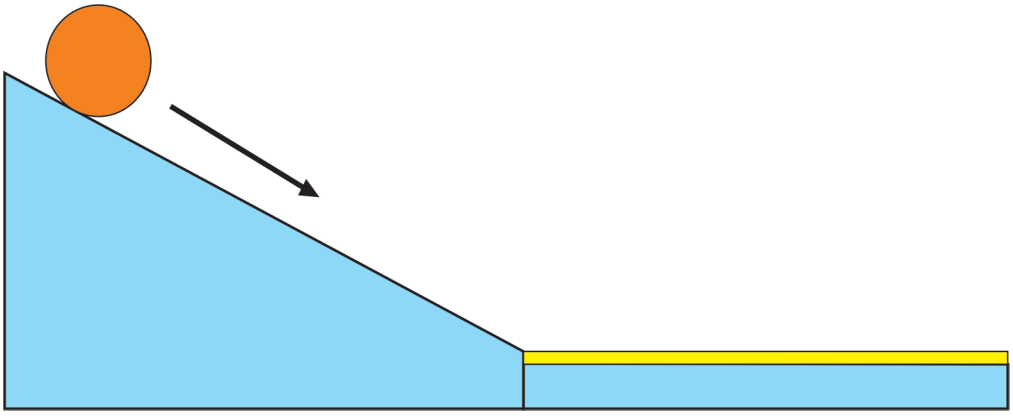

Figure 1 Rolling ball tack test
Rysunek 1 Pomiar tacku za pomocą toczącej się kuli

2.2 Quick stick tack test

Tack is often equated with quick stick, which is defined by PSTC as “ability of tape to adhere to a surface instantly, using no pressure other only weight of tape itself. It is measured as the force resisting peeling of tape at 90° from a standard surface upon which it has been applied under no other pressure than the weight itself”. “Quick stick” test resembles typical peel test. These methods involve the application of the adhesive, usually in the form of a tape on a flexible carrier substrate, to a defined surface under known conditions of time and light pressure (often just the weight of the tape alone). The peeling force required for debonding is measured under defined geometry, rate of separation and temperature conditions. This test, although functionally measuring the level of tack, does not provide the information necessary to understand tack, since the pressure and the rate of application of the tape are not controlled. The backing stiffness also has a marked effect, since stiffer backings do not allow easy intimate contact of the adhesive to a surface.

2.3 Probe Tack Test

The probe tack tests are mechanical simulations of thumb or finger tack tests. In them, the tip of a probe is brought into contact with a supported adhesive under low contact pressures for a short time and then pulled away at a fixed rate, during which the peak force of separation is measured. In this test method, the effect of the tape backing is eliminated because the tape is either rigidly affixed to a steel plate or mounted on an annular ring of known weight. The test can be used for quality control or research purposes. Probe tack conditions are set forth by ASTM [8] and the Polyken Probe Tack Testers. Shown schematically in Figure 2 is the most commonly used instrument. In this device a 5 mm diameter flattened rod, connected

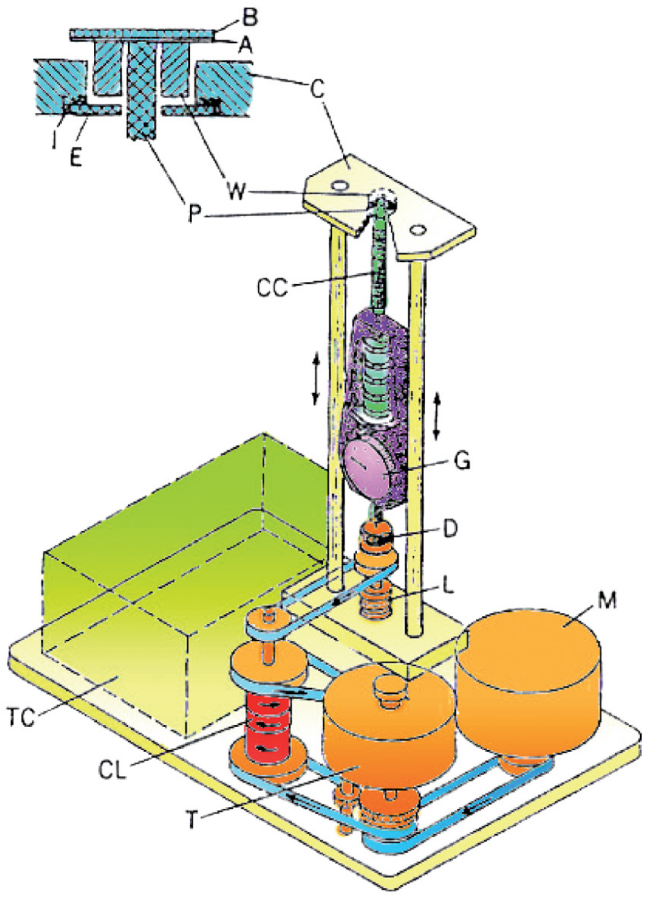

Figure 2 Polyken probe tester: B-backing, A-adhesive, W-weight, P-probe, C-carrier, I-insulation, E-electrical contacts, CC-collet chuck (probe holder), G-force gauge, D-dashpot, L-lead screw, CL-clutches, T-transmission (multispeed), M-motor, TC-timer and controls
Rysunek 2 Pomiar tacku za pomocą próbnika

to a load cell, constitutes the probe. The instrument mechanically lifts the probe to make contact with the pressure-sensitive adhesive, holds it there for a preset time of contact, variable in 10 steps from 0.1 to 100 sec. The adhesive, on some backing, is attached to the flat bottom of an inverted metal cup with a hole in the bottom through which the probe enters. The probe material can be varied, but a stainless steel probe is almost always used. Probe tack value is the force required to remove the probe, as measured by a mechanical-force gauge, under the specified conditions. The ability of the Polyken Probe Tack Tester to vary test conditions permits it to be used for research purposes as well as comparative testing.

2.4 Loop Tack Test

The loop tack test is widely used in the adhesive tape and PSA industries, primarily as a quality control tool. The test methods can be divided into two different types depending on which substrate the adhesive coats. In one, the adhesive is on the forming loop. This test is used to test adhesive tapes. In the other, the adhesive is on the rigid base plate. This test method tends to be used for double-sided tapes, pressure sensitive adhesives, and coatings. The most popular method is the FINAT Test Method No. 9 or AFERA 4015. The loop in the loop tack test is formed by using a stripe coated by PSA. The stripe clamps the test machine with the load cell, which has to be sensitive over the suffcient range. A loop contacts the substrate by PSA stripe weight. The loop tack value is acquired from the pulling force during the detachment of the PSA coated stripe. The maximum force required to debond the loop is recorded as the tack value [9]. This test is presented in Figure 3.

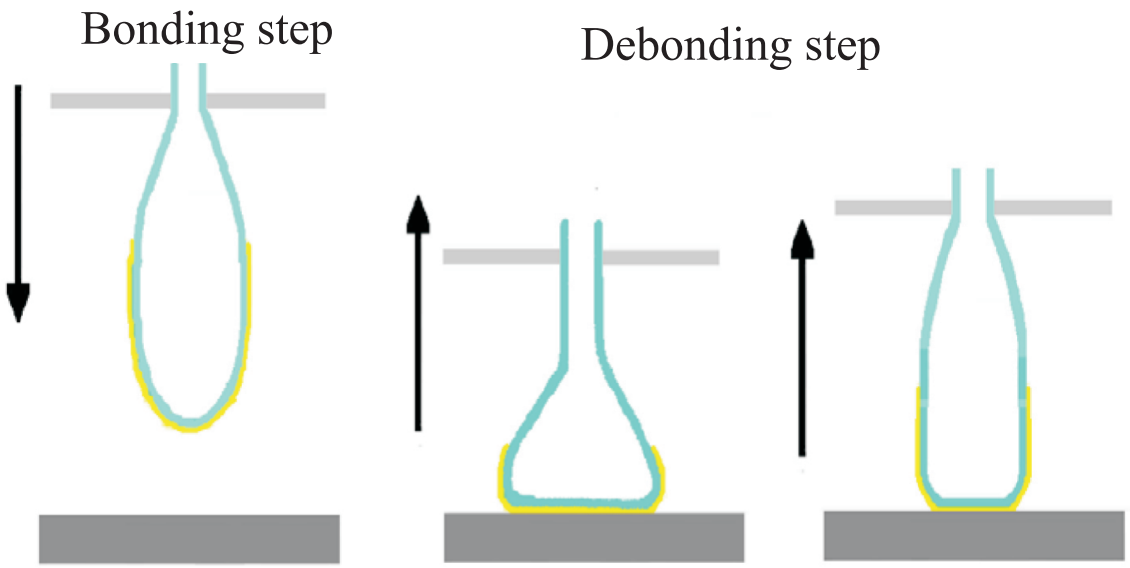

Figure 3 Loop tack method
Rysunek 3 Pomiar tacku za pomocą paska taśmy samoprzylepnej

Pressure sensitive tack is the adhesive property related to bond formation. Generally, the test procedure to measure tack consists of two steps: bond formation and bond separation and to be measured at low contact pressures and short contact times. The normalized test methods are used to compare different pressure-sensitive adhesives. The data are not absolute values, but may be used to compare the various products. A sample of PSA-coated material 1-inch (about 2.5 cm) wide and about 7-inch (about 17.5 cm) long is bonded to a vertical of a clean steel test plate at least 10 lineal cm in firm contact. The vertical steel test plate is clamped in the jaws of a Zwick tensile testing machine. The scale reading in Newtons is recorded as the tape is peeled from the steel surface with a constant rate of 100 mm per minute. Quick stick has the advantage of allowing tack to be measured on a wide range of substrates, such as stainless steel, glass, polyethylene and paper (Fig. 4).

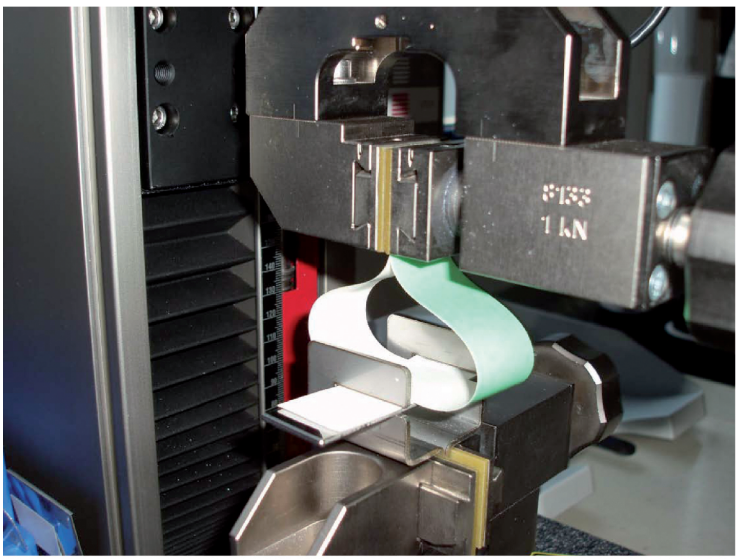

Figure 4 Loop tack on paper according to AFERA 4015
Rysunek 4 Pomiar tacku wg metody AFERA 4015

3. CONCLUSIONS

Tack is a very important and significant main parameter of pressure-sensitive adhesives. Tack, other known as initial adhesion by the very short contact time, theoretically zero, between PSA layer and surface of bonded substrates plays fundamental role by special applications in the wide of industry areas. Tack is responsible for applications in the label industry characterized by very short and pressureless contact with labeled surfaces and in the splicing of dehesive materials, such as EPDM, PP, OE and Teflon. The tack values of PSA and self-adhesive materials are a function of adequate tack methods. Loop tack is the most popular tack measurement in the industry and technology of PSA and PSA products.

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