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ANALYSIS SPREADABILITY POLYMER MATERIALS

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ABSTRACT
This study presents the results of investigation of influence wettability, viscosity and dry substance content of polymer materials on basis of polyurethan (PU) on the spreadability of wood surface. The investigations were carried out with the three lacquers on basis PU intended for finishing technology of wood. The beech wood (Fagus sylvatica), prepared with sanding with the average arithmetic deviation of R_a =2,75 μm profile was used as the basis for investigation. The wettability wos determined by measuring of the contact angle on projected droplet profile, but the spreading wos determined of the spread factor. At the viscosity of 327 - 95 mPa.s the investigated lacquers have the limited wettability (cos θ =0,559 - 0,786). The influence of dry substance content and viscosity of polymer materials on basis of polyurethan to the spread factor is linear. The influence of wettabiliti to the spread factor is a linear function, as well.

Key words: polymer materials, polyurethan, wettability, spreadability, dry substance content, viscosity.

1. INTRODUCTION
During the formation of the liquid material film on a solid surface, significant physical and chemical processes take place, the most important of which are: wetting, spreading, penetration and adhesion. In order to provide a maximum contact possible of the liquid material and surface, base spreading is necessary. Many factors related to the liquid polymer material affect the spreadability, such as: wettability, surface tension, type, viscosity, concentration, solvents and thinners applied, surface active substances etc. The paper analyses the influence of the wettability, viscosity and dry substance content of the (PU) polyurethan-based polymer materials on the spreadability on a wooden base (Fagus sylvatica).

2. THEORETICAL BACKGROUND
Spreading of liquid on a solid depends on the relative magnitudes of free energy (surface tension) of interface surface of the three phase system (solid, liquid, gas). Young has showed that these three tensions are in balance as followes [1]:

$$\cos\theta = \frac{\gamma_{sg} - \gamma_{sl}}{\gamma_{\lg}}, \qquad (1)$$

where γ_{sg} is the surface tension of solid-gaseous, $\gamma_{\lg}$ the surface tension of liquid-gaseous, γ_{sl} the surface tension of solid-liquid interface, and θ is the contact angle or the angle of wetting.
The spreadability of the liquid on the solid phase surface is assessed based on the energy freed per surface unit where the liquid spreads. That energy consists of the consumed cohesion energy (W_c)

required to separate a coating of liquid from another same such coating of liquid and the adhesion energy yielded (W_a) when the separated liquid coating spreads on the surface of the solid phase.
The cohesion energy consumed is:

$$W_c = 2\gamma_{\lg} . \tag{2}$$

And the yielded adhesion energy:

$$W_a = \gamma_{sg} + \gamma_{\lg} - \gamma_{sl} . \tag{3}$$

If Young's equation (1) is introduced in expression (3), one gets:

$$W_a = \gamma_{\lg}(1 + \cos\theta) \tag{4}$$

The difference between the adhesion energy yielded and the cohesion energy consumed represents the energy yielded, i.e. freed during the spreading of liquid on the surface of the solid phase (Figure 1), i.e. the energy of spreading (W_s) is determined by the expression:

$$W_s = W_a - W_c = \gamma_{sg} - \gamma_{\lg} - \gamma_{sl} \tag{5}$$

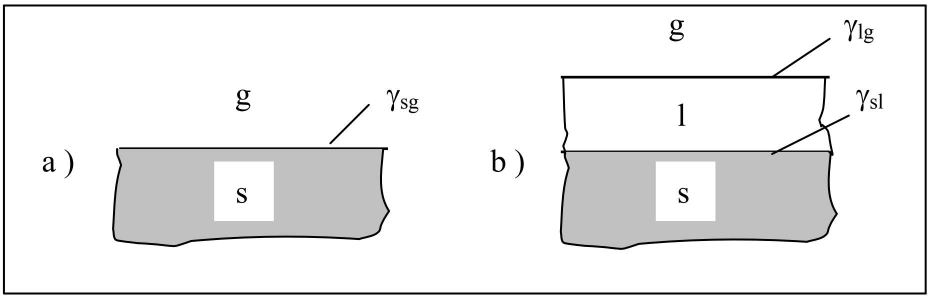

Figure 1. The spreading of liquid on the solid phase surface
a = The energy before spreading
b = The energy after spreading

Introducing expression (4), relationship (5) can be expressed in the form:

$$W_s = \gamma_{\lg}(\cos\theta - 1) \tag{6}$$

3. MATERIALS AND METHOD

The investigations were conducted with three transparent (PU) polyurethan-based lacquers intended for surface wood processing. The lacquers applied are two-component systems with the basic properties, after the mixing of components, presented in Table 1 with the initial letters.

Table 1. Data about the lacquers used in the investigation

Property	PU1	PU2	PU3
Dry substance content (%)	30,95	28,32	25,58
Viscosity (mPa.s.)	327	310	295

Beech tree (Fagus sylvatica) of unvaried structure, with radial texture on the investigated surface, with average humidity of 8.65 % was used as the basis for the investigation. The surface was prepared by sanding, so that a surface with the mean profile deviation of $R_a = 2.75$ µm was yielded. Roughness

was measured perpendicularly to the fibres along the length of 1.2 mm and the contact needle radius of 12.5 μm. The wettability was determined by measuring the contact angle on the projected droplet profile [2], with liquid lacquers of different viscosity.
In parallel with the examination of wettability, the determination of spreadability was also conducted. The criterion for the intensity of spreading was the ratio of the spreading diameter (d) to the liquid droplet diameter (D) that is spreading (Figure 4), i.e. the spreading factor d/D [4].

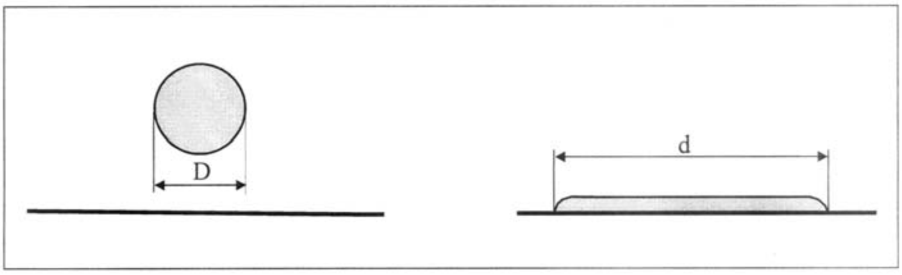

Figure 2. The parameters of spread factor, D=droplet diameter, d=spreading diameter

4. RESULTS AND DISCUSSION

The results of the investigation into the influence of dry substance content and viscosity on spreadability are presented in Figures 3 and 4.

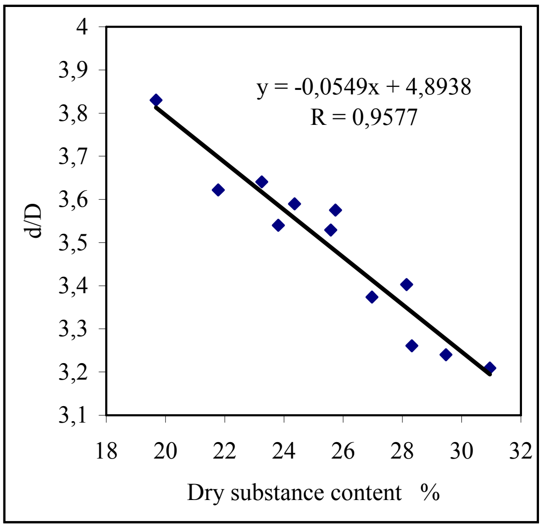

Figure 3. The influence of PU dry substance content on the spreading factor

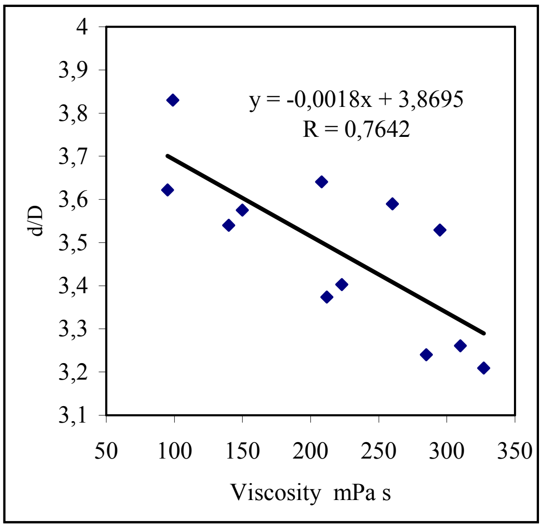

Figure 4. The influence of PU viscosity on the spreading factor

As can be seen from the results (Figures 3 and 4), the linear function is a good correlation for the influence of dry substance content (δ) and viscosity (μ) on spreading (d/D) within the limits of the experiment, therefore the following can be adopted:

$$\frac{d}{D} = f(\delta) = a_1\delta + b_1 . \tag{7}$$

$$\frac{d}{D} = f(\mu) = a_2\mu + b_2 . \tag{8}$$

The influence of viscosity on contact angle cosine of the polymer materials is a linear [3], as can be seen from the PU polymer materials investigation results (Figure 5), i.e.:

$$\cos\theta = f(\mu) = a_3\mu + b_3 . \tag{9}$$

From expression (8) and (9) is yielded the influence of contact angle cosine on spreading factor:

$$\frac{d}{D} = f(\cos\theta) = a_4\cos\theta + b_4 , \qquad a_4 = \frac{a_2}{a_3}, \quad b_4 = b_2 - \frac{a_2 b_3}{a_3} . \tag{10}$$

Expression (10) demonstrates that the influence of contact angle cosine on the spreading factor is linear, to which the investigation results point (Figure 6).

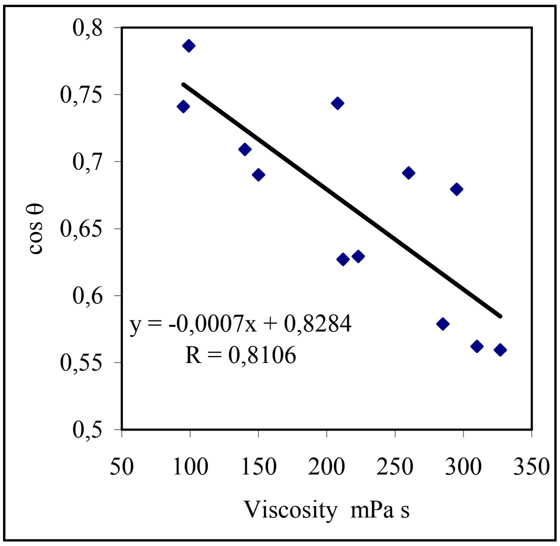

Figure 5. The influence of PU viscosity on contact angle cosine

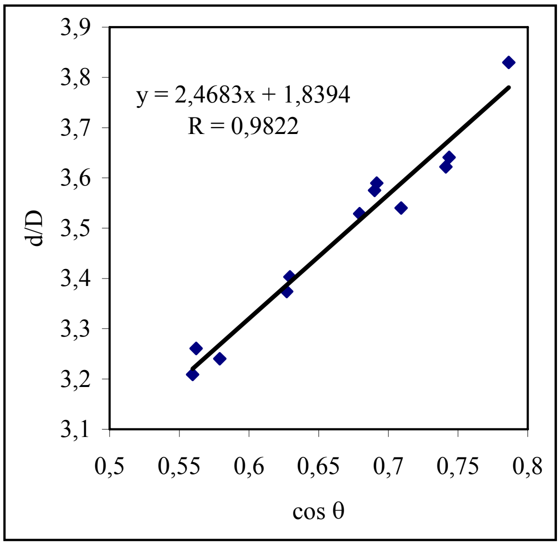

Figure 6. The influence of PU contact angle cosine on spreading faktor

5. CONCLUSION

The investigated polymer materials on the basis of polyurethan have limited wettability $(\cos\theta = 0{,}559 - 0{,}786)$ at the viscosity of 327–95 mPa.s. Linear function is a good correlation for the influence of the dry substance content and viscosity of the investigated PU materials on the spreading factor within the limits of the experiment. The influence of contact angle cosine on the spreading factor is also a linear function.

6. REFERENCES

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