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Investigation of the wettability of PVC and PET films used for finishing furniture fronts

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Abstract: *Investigation of the wettability of PVC and PET films used for finishing furniture fronts.* In this study, the wettability of PVC and PET films by measuring the contact angle of water on the basis of embedded drop method was examined. The values of contact angles of the film were measured at 5 s intervals over the period of one minute from the application of the drop of liquid on the film surface. The PVC and PET films were applied onto MDF. The PVC films were characterized by a greater contact angle than the PET films. It should be assumed that PVC coatings will provide better hydrophobic protection for surfaces of wood-based panels, which can result in improved durability of products made from them.

Keywords: wettability, PVC film, PET film, MDF, furniture

INTRODUCTION

The wettability of materials used for finishing the surface of wood-based panels is one of the important factors which determine their properties and application possibilities. Many processes occur on the surface of materials. Analysis of surface properties of materials is therefore particularly important in the research on finishing or modification of their surface. Such analysis often allows to predict the behavior of materials under specific conditions. Physicochemical parameters directly affect the way in which the surface interacts with factors such as water and organic solvents, which is consequently reflected in resistance, or lack of resistance, to the factors degrading the material. One of the basic tools for describing the physicochemical properties of the solid surface is the contact angle.

The lower value of the contact angle shows better surface wettability. It is assumed that the liquid does not wet the solid if the contact angle is greater than 90°. The surface is wetted when the angle is lower than 90°. The material whose surface wettability is examined ought to be homogeneous. On the basis of the contact angle value (depending on the type of the reference liquid) such parameters are determined as surface free energy, wettability, spreading coefficient, and work of adhesion. These parameters directly determine the interaction of the substrate with agents such as e.g. lacquer or glue. Establishing the functional characteristics of a given material requires appropriate characterization of the physicochemical properties of their surface.

Adhesion energy is defined as the work necessary to separate two layers of joined materials. The balance of surface free energy and interphase energy in the solid - liquid structure is described by the Young equation.

$$\gamma_S = \gamma_L \cos\theta + \gamma_{SL}$$

where:

γ_S – surface free energy of the solid,

γ_L – surface tension of the liquid,
γ_{SL} – free interphase energy in the solid - liquid structure,
θ – contact angle.

Laboratory tests determining the surface free energy of solids cause many problems. The most common method is to measure the angle of the embedded liquid drop on the test surface (Chibowski 2007). Fowkes (1964) assumed that for the solid - liquid structure, in which dispersion interactions have crucial role, the value of the surface free energy of the solid γ_{SL} (presented in the Young equation) can be expressed by the geometric mean of the dispersive components of the surface free energy of the liquid and the solid. Extending Fowkes theory, Owens and Wendt (1969) established that if polar (non-dispersive) interactions occur additionally on phase boundary, the dispersive γ^D and polar γ^P components of surface free energy of the solid can also be determined on the basis of Young equation and γ_{SL} as a function of the geometric mean of these two components. Owens Wendt method is the most popular method for determining the surface free energy of polymeric materials (Żenkiewicz 2007).

In analyzing the contact angles it is also important to observe the changes in their values in time. Worse wettability of materials may result in greater problems with their impregnation or finishing, especially when using water-based agents. The material whose surface wettability is being determined ought to have isotropic structure. For example, clear glass (monolith) is hydrophilic; in relation to water it shows so-called perfect wettability - the contact angle $\theta \rightarrow 0°$ (as a result the drops spread).

With regard to the coatings, surface wettability may indirectly determine its resistance to moisture. The analysis of the contact angle in time on coatings generated on a given material allows to determine their resistance to moisture penetration into the material. It is known that aging of the coatings may bring about defects (local damage in coating such as cracks), which may consequently increase water permeability of the coating. The direct indicator of this is the change in contact angle of the sample surface in time, resulting from the penetration of moisture into the material.

The aim of the study was to determine the wettability of PVC and PET films used in finishing the surface of furniture fronts made of medium density fibreboards (MDF).

MATERIALS

Test specimens were prepared from furniture fronts produced in industrial conditions. The PVC and PET films were applied onto 16 mm thick MDF of 650 kg/m^3 density. 3 PVC and 3 PET films were used in the tests (Table 1).

Table 1. The PVC and PET films tested

Type of film	**Colour**	**Symbol**
PVC	white	PVC_1
PVC	red	PVC_2
PVC	wenge	PVC_3
PET	black	PET_1
PET	red	PET_2
PET	white	PET_3

The film thickness was determined according to the requirements of EN ISO 2808:2007. The thickness was determined at six points of measurement for each of the film specimens. Statistical analysis of the research results was performed at a significance level of 0.05. The water contact angles of PVC and PET were tested on the basis of the embedded drop method in a Phoenix 300 goniometer manufactured by Surface Electro Optics. The volume of drops applied to the surface of the wood was 1 ml. The contact angles were determined at 5 to 60 s, every 5 s, from the application of a drop of liquid on the film surface. Percentage changes in the contact angle after 55 s were determined.

RESULTS

The average thicknesses of the PVC and PET films are shown in Figure 1. The average thicknesses of the PVC and PET films were 388.9 µm (standard deviation 21.3 µm) and 379.4 µm (standard deviation 20.9 µm), respectively. There were no significant differences in thickness between the PVC and PET films.

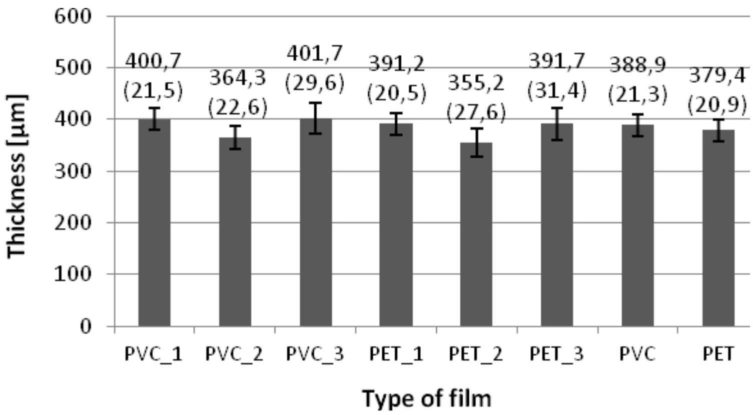

Figure 1. Thickness of PVC and PET films

The contact angle for each film is shown in Figure 2. The study results show 61 - 72^{o} range of contact angle for PVC films, and 47 - 59^{o} range of contact angle for PET films (at 5 to 60 s, every 5 s, from the application of a drop of liquid on the film surface). These results are significantly lower than those obtained by Wulf et al. (1997) for MDF. The authors stated that the contact angle of MDF (depending on the wood species, binder content, water repellent finish, wood humidity and roughness) was in the range of 68 - 139^{o}. The highest angle (72^{o}) was obtained for PVC_2 film, and the lowest (47^{o}) for PET_6 film. It follows that PVC films were characterized by lower wettability than the PET films.

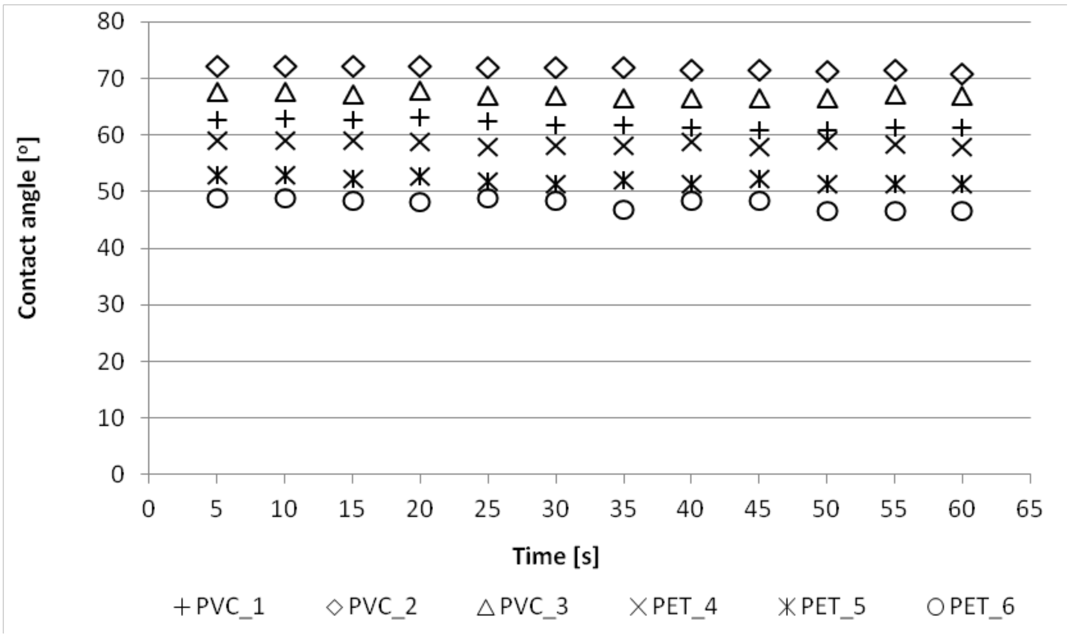

Figure 2. Contact angle of particular PVC and PET films

Figure 3 shows the mean values of contact angles for different groups of test materials (PVC and PET films). The average contact angle of PVC, 5 seconds after a drop of water was embedded on its surface, was 68° and that of the PET - 54°. The average change in the angle over a period of 55 seconds proved to be greater for PET films, i.e. 2°, than for PVC films - 1°. The lower value of the contact angle indicates better wettability of the material. The surface wettability may determine the resistance of the tested films to moisture and detergents based on water.

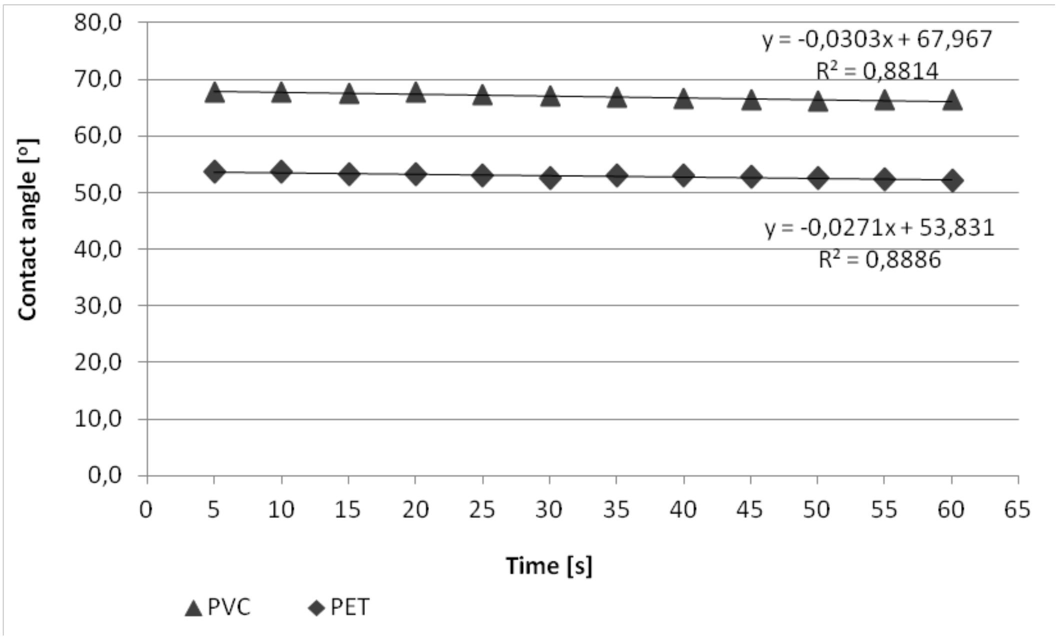

Figure 3. Average contact angle of PVC and PET films

Changes in the contact angle in time for PVC films can be expressed by a linear equation y = -0.0303x+67.967, and for PET films by a linear equation y = -0.0271x+53.831. High values of the coefficients of determination (R^2 at 0.88) indicate high linear fitting in describing the changes in contact angle in time.

CONCLUSIONS

On the basis of the above study it has been established that PVC films used in surface finishing of wood materials have higher water contact angle than PET films. It may be assumed that PVC coatings will provide a higher degree of hydrophobic surface protection for wood-based panels, which may help to increase the durability of products made from them. Reducing the hygroscopic properties of products based on lignocellulosic materials by coating them with PVC may improve their resistance to biotic factors.

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Streszczenie: *Badanie zwilżalności folii PVC i PET wykorzystywanych do wykańczania powierzchni frontów meblowych.* W pracy określono zwilżalność folii PVC i PET poprzez pomiar kąta zwilżania wodą na podstawie metody "osadzonej" kropli. Wartości kątów zwilżania folii wodą określano co 5 sekund przez minutę licząc od naniesienia kropli cieczy na powierzchnię folii. Folie PVC i PET naniesione były na płytę MDF. Powłoki wykończone foliami PVC charakteryzowały się większym kątem zwilżania niż folie PET. Należy przypuszczać, że powłoki PVC będą w większym stopniu uodparniać hydrofobowo powierzchnię płyt drewnopochodnych, co może wpłynąć na zwiększenie trwałości wytworzonych z nich wyrobów.

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