Journal of the University of Chemical Technology and Metallurgy, 45, 2, 2010, 213-214

Short Communication

WATER-VAPOUR PERMEABILITY OF POLYMER FILMS

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Received 05 December 2009
Accepted 12 April 2010

ABSTRACT

The water-vapour permeability (P_{wv}) of polymer films, made from polyvinyl chloride (PVC), blends of PVC and perchlorovynil (PCV), copolymers vinyl chloride-vinyl acetate (Vc-VAc) and vinyl chloride-ethylene (VC-E) was investigated. The time for the obtaining of maximal rate of water-vapour permeability was determined for every sample and the values of P_{wv} were calculated from these data. The dependence of P_{wv} from the thickness of the films is no linear. A relationship between P_{wv}, the values of permahor (π_p) and oxygen permeability of all investigated polymer films was made.

Keywords: water-vapor permeability, polymer films, permahor.

INTRODUCTION

The influence of the compositions of the polymer films on their water-vapour permeability was described in many works [1-3]. In [4] were compared several standard methods for determination of water-vapour permeability and the differences of the obtained values were between -0.91 and + 0.97. In several of these works the values of P_{wv} were compared with the values of oxygen permeability P_{O2} [3]. In [5] calculation of P_{O2} with the values of the permahor (π_p) of the polymer films was made by equation 1:

$$P_{O2} = 6.1x10^{-9}.\exp(-0.115\ \pi_p) \quad (1)$$

In our previous work [6] was made the bond between the thermostability of polymers and permahor.

According to ASTM 0960 the value of P_{wv} was calculated from the linear part of the dependence ΔG/time. From all points it is possible to calculate the values of the maximal rate of the process of water-vapour permeability by the slope of the line, passing through the linear part.

The aim of these investigations is to increase the accuracy of this calculation by determination of the value of the maximal rate of the water-vapor permeability from the slope of the tangent line, passing through the inflex points of the dependences ΔG/time of the different films and to connect these values with permahor.

EXPERIMENTAL

Films with thickness from 0.09 to 0.4 mm were obtained from the 10 % solutions of suspension PVC, technical grade, produced in Bulgaria, blends of this PVC and 5, 10 and 20 % PCV, technical grade, produced in Russia, copolymers vinyl chloride -vinyl acetate (87:13 mol/mol) and vinyl chloride - ethylene (1:1 mol/mol), technical grade, produced in Germany. After 15 days drying at 25°C, 75 % humidity and 6 days at 25°C, 5 % humidity, the thickness of the films was measured with uncertainty of 0.001 mm. With these films were sealed the aluminum containers with 10 g P_2O_5 p.a., product of Merck, from each kind of films were sealed 2 containers. The masses of all containers with P_2O_5 before and after sealing with polymer films were measured with uncertainty of 0.0001 g. All containers were placed in a camera at 25°C and 100 % humidity. The masses G, g of the containers were measured every hour. From these values ΔG, g, for every kind of films was determined. From

Table 1. Influence of the thickness of the films on the values of P_{wv}.

Thickness, mm	0.09	0.13	0.16	0.18	0.22	0.24	0.27
P_{wv}, g/m^2 24h	103	74	65	53	50	49	48

Table 2. Characteristics of the polymer films.

N	Polymer films	T, h	π_p	P_{wv}, g/m^2 24h	P_{O2}, cm^3/cm^2.s.cm Hg bar
1	copolymer VcVAc	39.5	44	49.7	2.91
2	copolymer VCE	48	59.1	24.5	0.52
3	PVC	54	62	10.82	0.37
4	PVC+ 5% PCV	60	63.2	8,62	0.32
5	PVC+ 10% PCV	72	64.3	13.05	0.283
6	PVC+ 20% PCV	74	66.2	19.35	0.23

the dependences ΔG/time, g h^{-1}, the values of the rate of water-vapour permeability were calculated as the slope of the tangent lines, passing through the inflexed points and the time for obtaining of this rate. The value of π_p were taken from [5].

RESULTS AND DISCUSSION

With films of 7 different thicknesses, made from copolymer Vc-VAc, were sealed 14 containers. From the obtained results for the dependences ΔG/time, g h^{-1}, the values of P_{wv}, g/m^2 24 h were calculated. The results for the influence of the thickness of the polymer films, made from copolymer Vc-VAc to their P_{wv} are given in Table 1.

It is evident, that the dependence of the values of P_{wv} from the thickness of the films is not linear. This is the reason to calculate P_{wv} for a definite thickness of the film. The results for another investigated polymer films are the same. In the literature there is the same and opposite dependences thickness / P_{wv} as well. The explanation of the first dependence is: with increasing the thickness of the films the possibility of water vapours transport decreased. The explanation of the second dependence is: with increasing of the thickness of the films increased and the possibility for obtaining of defects in the films, if the solvents are not suitable and this is the reason for increasing of water vapour transport. The time in hours, T, for obtaining of the values of maximal rate W of the water-vapour permeability was determined from the abscissa values of the inflex points of the dependences ΔG/time, g h^{-1}, for all polymer films. The results obtained for all of investigated films are presented in Table 2. In the same table are given also the values for P_{wv} and for P_{O2}, calculated with eq. 1.

It is evident, that the values of T and π_p increase in the same way when decreasing P_{O2}. It is well known, that PCV crystallizes and may be this is the reason for the increasing of the values of P_{wv} with the increasing of the amount of this polymer in the mixtures with PVC. Analogical results were described in [7]. From the obtained results it is evident, that application of permahor is available for prediction of water-vapour permeability.

CONCLUSIONS

Increasing of the accuracy of the calculation of water-vapour permeability was made by determination of the values of the maximal rate of the process drom the slope of the tangent line, passing through the inflex points of the dependences ΔG/time, g h^{-1}, of polymer films from polyvinyl chloride, blends of PVC and perchlorovynil, copolymers vinyl chloride-vinyl acetate and vinyl chloride-ethylene with different thicknesses. The values of water-vapour permeability were connected with the values of the permahor of these polymers.

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