

Auto Gas Permeability Testing of Complex Film

Abstract: this article presents a detailed introduction about the common methods of improving material permeability. Based on the testing characteristics of auto gas permeability testing, it relates on the precautions and corresponding improving measures.

Key words: high permeability, complex, complex film, blending, edge leaking.

For many high permeability materials, there will be some disadvantages when being used separately, such as high in price, permeability being sensitive to water, lower transparency, low film mechanical intensity. Although high permeability material is the main factor for film application development, to replace traditional high permeability material such as metal and glass, its manufacturing cost must be controlled and the mechanical roughness should be increased. When permeability is used as one layer of multi-layer complex film, the protection of other materials can effectively improve its applicability and therefore reduce its manufacturing cost.

1. Complex Film

Complex film is a kind of multi-layer film, which is made from various kinds of plastics and paper, metal or other materials through technologies such as coextrusion and moulding. The property of complex film (such as damp proof, oxygen resistance, fragrant protection, photophobic, mechanical performance, easiness of shaping, seal and print) can be adjusted by changing the type of base material and number of compounded layers. Moreover, choosing rational material structure can save material and reduce package cost.

2. Permeability of Complex Film

Two ways are usually used to improve the gas permeability of plastic package material.

One is by coextrusion of various materials (materials used as inner layer or outer layer, such as material of layer 1 and 3 in fig.1. these material have excellent function in improving mechanical strength, heat sealing and friction) with high permeability material or by coating high permeability material on the base film to form complex film of multi-layer structure. Complex technologies include dry method complex, extrusion complex, coextrusion complex, solvent-free complex, coating and vacuum evaporating methods. Generally, Complex film made through these methods can improve material permeability effectively.

When using this kind of complex film, the orientation of gas transmission is usually made vertical to the complex structure of material (see Fig. 1), which can make the material demonstrate more excellent permeability. Different solubility coefficient S and diffusion coefficient D as well as the complex technology of each layer can exert a certain influence on complex film permeability, but the overall permeability is mainly influenced and restricted by the permeability and thickness of the layer (permeable layer with high permeability material) that has the best permeability. Some documents provide formulas for

permeability calculating of complex film. However, since condition of the material for each layer and overall complex condition is not as ideal as that of the theoretical model, actual parameters of gas permeability of complex film should be tested with auto gas permeability tester. Commonly, permeability coefficient of complex film, which is mainly determined by the actual thickness of permeable layer and the thickness percentage of this layer, is bigger than that of permeable layer material.

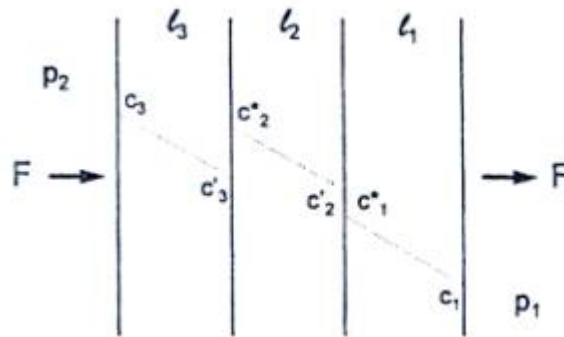


Fig.1 transmission through plane multi-layer structure

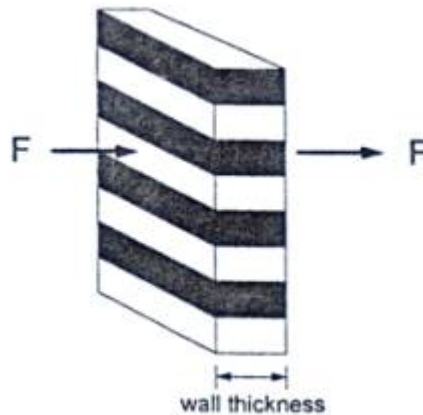


Fig.2 transmission through parallel multi-layer structure

If the orientation of gas transmission is parallel to the complex structure (see fig.2), permeability obtained in this case is the worst among various complex methods. The formula is:

$$P_{\text{total}} = \phi_1 P_1 + \phi_2 P_2$$

Φ is the volume percentage of each polymer/ however, in the using of complex film, this case is rather rare.

Another way to improve gas permeability is to mix high permeability material into the film material. That is, mix two kinds of polymer or add additive into it. Mixing particles of high permeability material with film material can increase the route of gas transmission, which in turn can increase material permeability. Shape of filling material, aspect ratio as well as the conglutination between filling material and polymer can all influence gas permeability. When the conglutination condition is not good, material permeability will decrease because there is diffusion through micropores of the conglutinating interface.

The influences of complex and blending on permeability improving are different to some extent. In fig.3, A is the complex method; B and C are blending method. From fig.3 we can see that through complex method, overall permeability can be obviously improved using less high permeability material. However, to achieve similar effect, a large amount of high permeability material is needed in blending method.

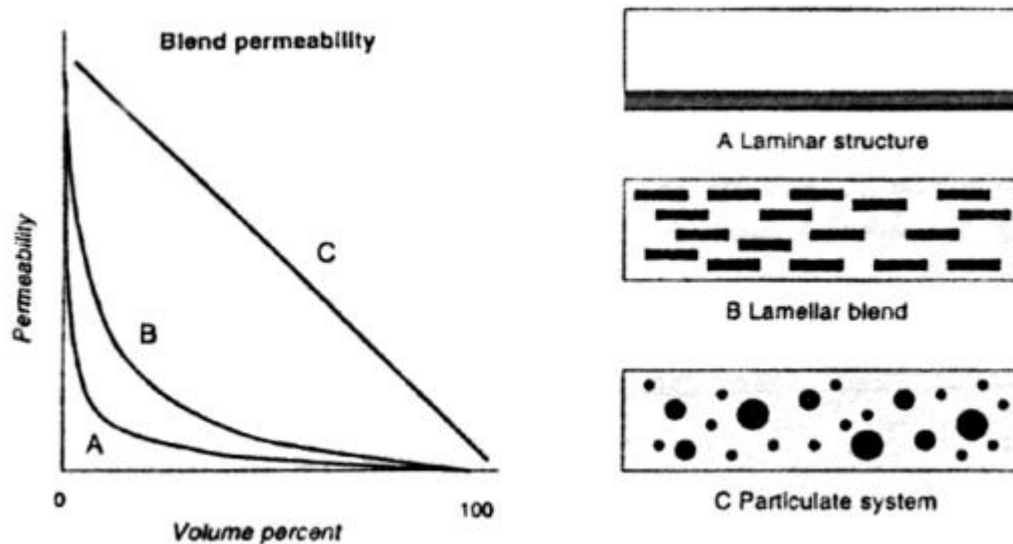


Fig.3 the influences of complex and blending on permeability improving are different to some extent

3. Permeability Testing of Complex Film

Permeability testing of complex film is one of the important testing items. Being the main basis in judging whether the structure of complex film is rational and whether there is wasting of material, it is an important step of package design and material choosing.

Different from the testing of single layer film (including blending material), testing results can be inferred because multi-layer structure of complex film makes its layers discharge or inhale gas. Since content of gas composition of ambient atmosphere is almost the same with that of general atmosphere, specimen edge without seal treatment will become a leaking place of the whole system, which will not only influent data accuracy but also increase the influence of surrounding environment fluctuation on testing. Permeability testing is a rather sensitive micro testing. This is more obvious in the testing of multi-layer complex film. Please refer to table 1.

Table 1. Testing Fata Comparison

Specimen	A		B	
Specimen description	PE milk film, 105 μ m		Coextrusion film, 70 μ m	
Testing condition	Edge sealing	Without edge sealing	Edge sealing	Without edge sealing
O ₂ GTR	977.786	1268.84	1.04	1.676
	986.045	1208.35	1.04	1.694
	999.079	1165.64		1.743
O ₂ GTR (mean)	987.637	1214.28	1.04	1.704
S	10.735	51.85	0	0.035
CV%	1.087	4.270	0	2.035
Testing temperature °C	23 °C	24 °C	24 °C	24 °C

From table 1 we can see that for multi-layer complex film A and B, whether specimen edge is sealed during testing has a great influence on testing result and data stability. Testing data of Specimen A without sealing treatment increased 23% and the data fluctuation has expanded 3%. For specimen B, the influence is more obvious.

To eliminate the influence of edge leaking on testing result, material edge should be sealed strictly during film permeability testing. Edge leaking can be reduced to a minimum extent by applying vacuum grease on non-transmission area of lower testing chamber and by adding seal ring on specimen periphery during specimen placing.