Labthink Instruments CO.,LTD.
144 Wuyingshan Road, Jinan, China
Tel: +86-531-85811021 85864214
Fax: +86-531-85812140
E-mail: trade@labthink.cn

Pressure Difference Has no Effect on Barrier Property of Material

Abstract: empirical test data have proved that in differential-pressure method gas permeability testing, various pressure differences applied on two sides of specimen has no effect on test data of gas permeability testing.
Key Words: pressure difference, differential-pressure method, equal-pressure method, gas permeability

Some holds that the existing of pressure difference in differential-pressure method affects the structure of polymer materials, and in turn influences results of gas permeability testing. Labthink and Hunan Industrial University carried out a research project about the influence of pressure difference on barrier property of polymer materials. The analysis of empirical test data has proved that in gas permeability testing using differential-pressure method, the existing of pressure difference has no effect on barrier property of materials.

It is very difficult to monitor the structure of specimen during gas permeability testing. Therefore, to verify whether configuration state of materials changes when there is pressure difference and to analyze the relationship between pressure difference and test data of gas permeability, users should appeal to measurable indexes of specimen.

1. Data Repeatability of Continuously Testing and the Thickness Variation of Specimen

If the influence of pressure difference on microcosmic structure of specimen is to change it from loose to compact, that is, make the loose structure into more compact one so that it becomes more difficult for gases to transmit, specimen will become thinner under the function of long-term pressure. At the same time, permeability data presents a reducing tendency with the increasing of test times. Gas barrier properties of the three types of materials being selected, i.e., aluminum foil laminated film , PET film and PC film, belong to high, medium and low range respectively. One same specimen will be tested repeatedly and then the thickness variation is analyzed. Labthink VAC-V1 differential-pressure method gas permeability tester and CHY-C2 thickness tester are selected as testing instrument. Empirical test data are listed in table 1 below.

Table 1 Empirical Data of Oxygen Permeance and Specimen Thickness

specimen	Gas permeability testing			Thickness testing (μm)		
	Oxygen transmission rate[1]	Temperature	CV(%)	Before test	After test[2]	Δd
aluminum foil laminated film	0.150	27°C	14.72	97.9	97.9	0
	0.202	28.1°C				
	0.179	27.3°C				
PET film	58.467	30.2°C	1.65	25.6	25.7	0.1
	58.770	29.6°C				
	60.291	30.1°C				
PC film	521.122	30.3°C	1.43	128.3	128.3	0
	536.198	30.4°C				
	529.115	30.3°C				

Note：1. the unit of oxygen transmission rate is：ml/m^2·24h·0.1MPa。

Labthink Instruments CO.,LTD.
144 Wuyingshan Road, Jinan, China
Tel: +86-531-85811021 85864214
Fax: +86-531-85812140
E-mail: trade@labthink.cn

Specimen thickness should be measured within effective test area. Other area is contaminated by vacuum grease, thus having little significance of measurement.

Through the data analysis it can be seen that test data of gas permeability testing basically stable on the whole and present no reducing tendency with the increasing of test times. Moreover, thickness of specimen measured before and after testing presents no change. Therefore, it is not correct to say pressure difference compresses the loose structure of materials and in turn affects results of gas permeability testing.

2. The Relationship Between Pressure Differences and Gas Barrier of Materials

Theoretically, permeability coefficient and gas transmission rate have nothing to do with pressure difference, that is, when one same kind of material is tested under different pressure differences, gas permeability coefficient and gas transmission rated being tested under various pressure differences should be consistent. If the influence of pressure difference on microstructure of materials is to cause defects of small fissure, pinhole and etc, the measured gas transmission rate and permeability coefficient should become bigger with the increase of pressure difference. Conversely, if pressure difference on two sides of specimen increases while permeability coefficient and gas transmission rate remain unchanged, it can be proved that pressure difference does not destroy the structure of materials.

Since March 2007, Labthink carried out massive tests to tens of specimen belonging to 8 kinds under seven pressure differences :30kPa、50kPa、70kPa、90kPa、110kPa、130kPa、150kPa. At the temperature of40℃, at least three tests are repeated under each pressure difference. The materials of selected specimens are the most commonly used materials for flexible packaging such as PC（125μm）、PC（175μm）、PET（12μm）、PET（23μm）、PET（25μm）、PA（35μm）、PE（40μm）、CPP（40μm）、OPP（38μm）and laminated materials such as PE/EVOH/PE（55μm）and PA/PE（80μm）. These materials range from high barrier property materials to low barrier property materials and their gas barrier properties are from $1.5cm^3/m^2 \cdot 24h \cdot 0.1Mpa$ to $7000cm^3/m^2 \cdot 24h \cdot 0.1Mpa$. For lack of space, please visit Labthink website for field data. In figure 1 and figure 2, the relationship between gas transmission rate of PC（125μm）and PC（175μm）and corresponding pressure difference on two sides of specimens as well as the relationship between permeability coefficient of PET（12μm）、PET（23μm）、PET（25μm）and corresponding pressure differences on their two sides are compared respectively. From the two figures we can see that in differential-pressure method, pressure difference exerts no influence on gas transmission rate and permeability coefficient of specimen.

Labthink Instruments CO.,LTD.
144 Wuyingshan Road, Jinan, China
Tel: +86-531-85811021 85864214
Fax: +86-531-85812140
E-mail: trade@labthink.cn

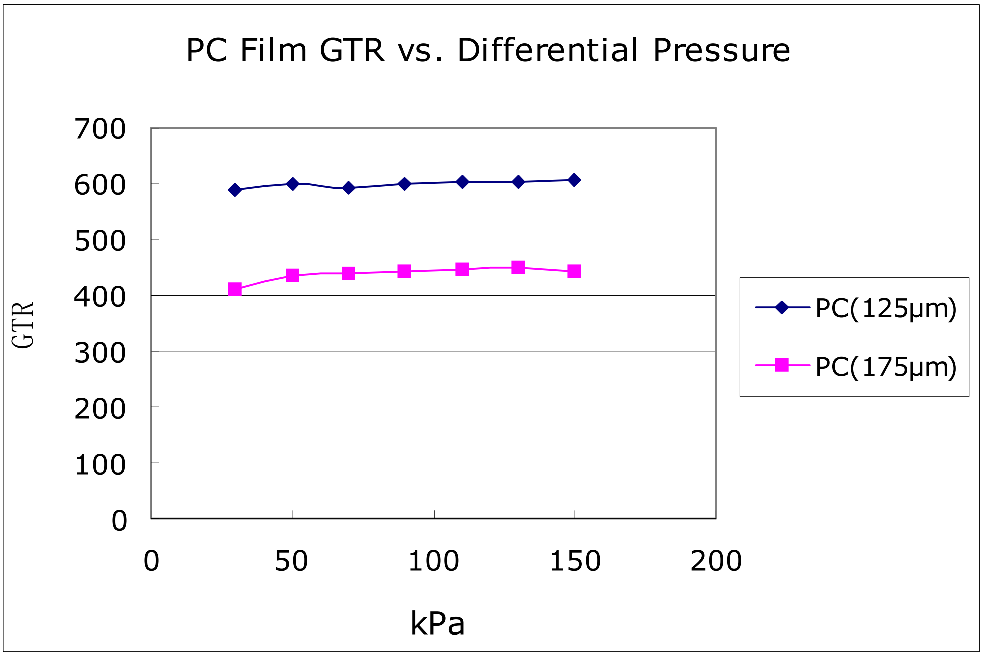

Figure 1

the unit of oxygen transmission rate is $cm^3/m^2 \cdot 24h \cdot 0.1MPa$

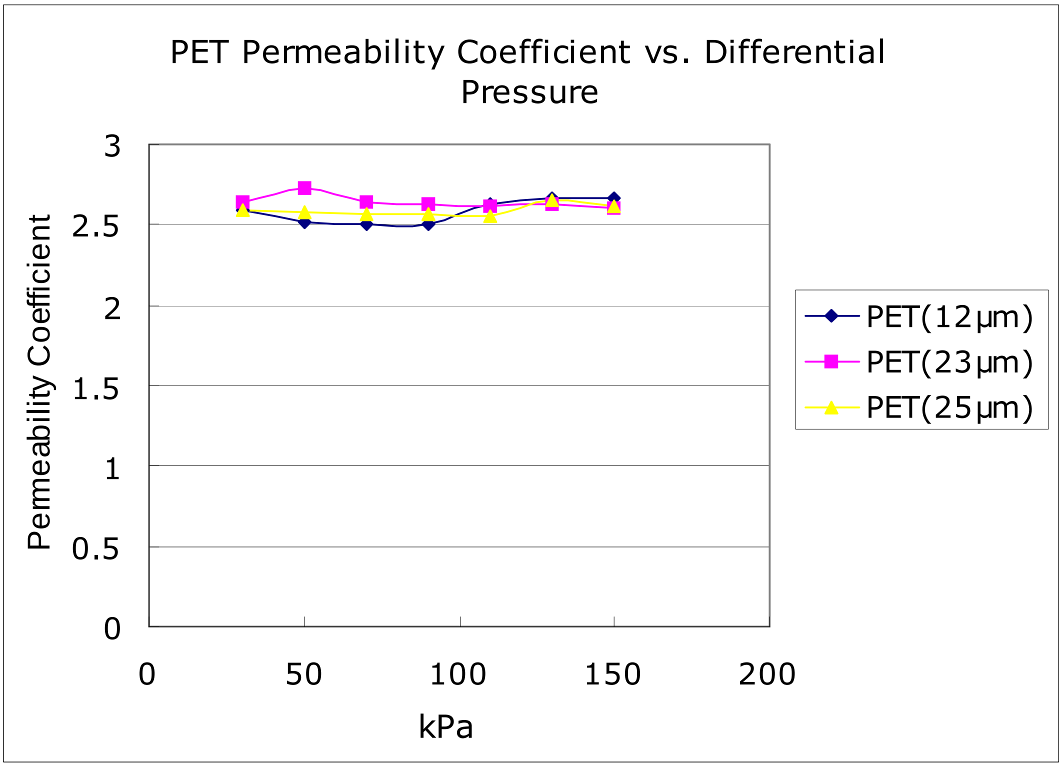

Figure 2

The unit of permeability coefficient is (E-12) $cm3 \cdot cm/cm^2 \cdot s \cdot cmHg$

Test results obtained in the tests show better repeatability. Analysis of the data clearly shows that differential

Labthink Instruments CO.,LTD.
144 Wuyingshan Road, Jinan, China
Tel: +86-531-85811021 85864214
Fax: +86-531-85812140
E-mail: trade@labthink.cn

pressure in differential-pressure method does not destroy materials structure and it has no effect on gas transmission rate and permeability coefficient of specimen.

3. IAPRI Views and Development of Similar International Research

IAPRI, the abbreviation for International Association of Packaging Research Institutes, is the international research institute of packaging technology. In September 3rd to September 5th 2007, IAPRI technology meeting is held in London. In this meeting, it is widely recognized by experts and scholars from various countries that pressure difference imposes no influence on test data(IAPRI thesis : *Study on Gas Permeability of Plastic Packaging Materials- The Influence of Pressure Difference on Gas Permeability* has been published in Labthink Lab Forum in two issues on September 24th and October 15th) however this is not a unique instance, but has its counterpart that an association member far away in Chile also conducted similar research and obtained the same conclusion.

Chile side published an essay named *INFLUENCE OF HIGH PRESSURE PROCESSING (HPP) OVER MECHANICA*L, *THERMAL AND BARRIER PROPERTIES ON FLEXIBLE FOOD PLASTIC PACKAGING*. This essay briefs on the influence of HPP treatment over mechanical, thermal and barrier properties on flexible food plastic packaging, in which its research on barrier property of HPP materials can supplement our research subject: on one hand, the pressure range can be enlarged. At present, all the tests are performed within normal pressure range. Due to the limitations of test instruments, high pressure and ultra high pressure testes cannot be simulated. On the other hand, its research on special coated materials provides valuable data to our research about whether pressure difference affects barrier property of coated materials. HPP and ultra HPP are methods for food storage, which can reduce the activity of enzymes in food, kill the microscopic organisms, and change the interactions among food elements. At present, such methods have been applied in the storage of grain, fruits, sea products and processed foods. The key of such technology is to storage the product in high pressure environment for some time and then stored in normal pressure. The test and test result are described as follows: Pouches of different structures (PET/PE; PET-met/PE; PE/EVOH/PE and PPSiOx) containing distilled water or olive oil as food simulants were subjected to 400MPa, 30min and 20 or 60℃. Metalized and Si-covered materials were highly affecting its barrier properties, PET-met/PE increased its water vapour permeability nearby 40%, value depending on nature of phase contact (water or oil), and an increase of 50％ for oxygen permeability. Similar results were found for PPSiOx. No great modifications were found for PE/EVOH/PE and PET/PE. For detailed test data please see table 2. During HPP treatment, the applied pressure is 4000 times that in differential-pressure method, but the coated materials remain better barrier property under such pressure. Therefore, gas barrier property of materials is not affected by pressure difference.

Table.2 Measured Data of Barrier Property Test before and After Processing

		Permeability WVTR (g/m^2/24h)			Permeability OTR (ml/m^2/24h)		
Packaging material	Phase Contact	Control	400 MPa, 20°C	400 MPa, 60°C	Control	400 MPa, 20°C	400 MPa, 60°C
PE/EVOH/PE	Non	3,3	3,4	3,5	0,9	1,0	0,8
	Aqueous	2,9	2,8	2,8	0,8	1,1	0,9
	Olive oil	2,1	2,0	2,2	0,9	1	1,1
PET/PE	Non	4,2	4,0	4,2	7,2	7,1	7,3

Labthink Instruments CO.,LTD.
144 Wuyingshan Road, Jinan, China
Tel: +86-531-85811021 85864214
Fax: +86-531-85812140
E-mail: trade@labthink.cn

	Aqueous	4,1	4,0	3,8	7,5	7,0	7,1
	Olive oil	4,2	4,0	4,1	7,0	6,8	7,1
PETmet/PE	Non	7,2	6,9	7,1	19	47	55
	Aqueous	7,0	8,6	10,9	18	35	48
	Olive oil	6,7	8,4	9,6	5,2	7,8	8,1
PP/SiOx	Non	6,2	7,0	7,2	n.d	n.d	n.d
	Aqueous	6,0	9,0	9,3	n.d	n.d	n.d
	Olive oil	5,9	8,7	9,0	n.d	n.d	n.d

*Control = non-HPP-treated

*n.d. = not determined

4. Conclusion

In conclusion, for the majority of films (including laminated films), pressure difference does not affect barrier property of materials. As to some coated materials (such as aluminum coated film), its barrier property will change obviously only when a very big pressure (400MPa)is imposed. But within the pressure range of differential-pressure method, there will be no influence. To obtain more scientific and comprehensive conclusion, Labthink lab is carrying out verification test in a boarder range.

Data stability closely related with precision, repeatability, reliability, test condition, specimen condition and test operation of instrument. No conclusion can be made without objective, scientific and comprehensive test. It is very ridiculous for somebody to believe that there is no differential pressure existing in equal-pressure method and thus test data are not affected while the pressure difference in differential-pressure method has an effect on test data.