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**Test Method for Determining Gas Permeability of
Polymer Membrane Materials**

高分子膜材料气体渗透性能测试方法

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Test Method for Determining Gas Permeability of Polymer Membrane Materials

1 Scope

This Standard specifies the test method for determining the gas permeability of homogeneous dense membranes of polymer membrane materials by the constant volume method.

This Standard is applicable to the test of the gas permeability of flat polymer homogeneous dense membranes made of polymer membrane materials. Other forms of polymer dense membranes may take this as a reference.

2 Normative References

The content of the following documents constitutes indispensable clauses of this document through normative references in the text. In terms of references with a specified date, only versions with a specified date are applicable to this document. In terms of references without a specified date, the latest version (including all the modifications) is applicable to this document.

GB/T 2918-2018 Plastics - Standard Atmospheres for Conditioning and Testing

GB/T 6672-2001 Plastics Film and Sheeting - Determination of Thickness by Mechanical Scanning

3 Terms and Definitions

The following terms and definitions are applicable to this document.

3.1 Polymer Homogeneous Dense Membrane

Polymer homogeneous dense membrane refers to a non-porous membrane, which is made of polymer materials and has a uniform overall structure.

3.2 Gas Solubility Coefficient

S

Gas solubility coefficient refers to the amount of gas solubilized in the membrane materials per unit volume under the unit pressure.

NOTE: gas solubility coefficient S reflects the solvency of gas molecules by membrane

materials. It is the volume of gas that can be solubilized in a unit volume of the membrane under a unit pressure difference under standard conditions, i.e., the volume at the temperature of 0 °C and the pressure of 101.325 kPa.

3.3 Gas Diffusion Coefficient

D

Gas diffusion coefficient refers to the volume of gas diffused through a unit membrane area in a unit time under a unit concentration gradient.

3.4 Gas Permeability Coefficient

P

Gas permeability coefficient refers to the capability of gas to permeate the polymer dense membrane, i.e., the product of the gas solubility coefficient and the gas diffusion coefficient.

NOTE: gas permeability coefficient *P* is the volume of gas that permeates a unit area of a specimen per unit time at a constant temperature and unit pressure difference under standard conditions during stable permeation, i.e., the volume at the temperature of 0 °C and the pressure of 101.325 kPa.

3.5 Ideal Separation Coefficient

α

Ideal separation coefficient represents the difference in the permeability of the membrane to different gases, i.e., the ratio of the permeability coefficients to two pure gases.

4 Test Principle

Use a specimen to separate the infiltration cell with a constant volume into two independent spaces; fill one side (high-pressure side) with a certain pressure of test gas to form a pressure difference between the cavities on both sides. The test gas permeates through the specimen from the high-pressure side and enters the low-pressure side and causes pressure changes on the low-pressure side. By recording the pressure changes, the gas permeation rate of the specimen can be calculated. The capability of the gas to permeate a polymer homogeneous dense membrane is expressed by the gas permeability coefficient. In accordance with the solubilization - diffusion mechanism, the gas permeability coefficient equals to the product of the gas solubility coefficient and the gas diffusion coefficient: $P = S \times D$ (*P*: the gas permeability coefficient; *S*: the gas solubility coefficient; *D*: the gas diffusion coefficient). The ideal separation coefficient *α* is obtained through the ratio of the permeability coefficients of

5---safety valve;

6---pressure sensor;

7---gas storage tank;

8---vacuum pump;

9---gas cylinder.

Figure 1 -- Schematic Diagram of Gas Permeability Tester

6 Specimen

6.1 Prepare polymer membrane material into polymer homogeneous dense membrane. See Appendix B for the preparation method.

6.2 The polymer homogeneous dense membrane shall have uniform thickness, and without wrinkles, pinholes or stains.

6.3 In accordance with the conditions specified in Chapter 6 of GB/T 2918-2018, place the membrane in the desiccator for more than 48 h.

6.4 Cut a circular specimen with a diameter of 20 mm ~ 35 mm on the membrane. Use a circle cutter to cut a circular ring with an outer diameter of about 70 mm and an inner diameter smaller than the diameter of the membrane sample on the aluminum tape. Paste the specimen on the circular aluminum tape; the sticking surface shall be flat, and without wrinkles, so that the specimen is concentric with the tape ring.

7 Test Procedures

The test procedures of the gas permeability coefficient are as follows:

- a) Take more than 10 different positions of the specimen; use the thickness measuring instrument to measure the thickness. The arithmetic mean value of the measurement results is the thickness of the specimen L . Use the Vernier caliper to measure the inner diameter of the aluminum tape; take the arithmetic mean value of the measurement results of more than 3 different positions as the diameter of the specimen d ;
- b) Internally place non-woven fabric or chemical analysis filter paper in the test cavity of the infiltration cell; evenly paste the specimen in the infiltration cell;
- c) Close the needle valves F1 ~ F8 and the gas cylinder (9); open the vacuum pump (8); successively and slowly open valve F7 and F3;

- d) Successively and slowly open valve F5, F1, F8 and F6; vacuumize and degas the entire system for at least 24 h, so that the system vacuum indicated by the vacuum gauge (1) is ≤ 4 Pa; close valve F7, then, close the vacuum pump (8);
- e) Stabilize it for 2 h; successively close valve F1, F5 and F8. Slowly open the test gas cylinder (9) and valve F8, so that the gas enters the gas storage tank (7). When the pressure sensor (6) shows that the pressure is above 0.1 MPa, lightly open valve F2 to empty the system. When the pressure of the pressure sensor (6) is greater than 0.1 MPa, quickly close valve F2. Repeat the opening, emptying and closing of valve F2 for 3 times to replace the residual gas in the gas storage tank (7).
- f) Close valve F6; adjust valve F8; when the pressure value displayed by the pressure sensor (6) reaches 1.1 times of the test pressure p_0 , successively close the gas cylinder (9) and valve F8;
- g) Set the test temperature T on the temperature sensor (3) and turn on the heating; after 1 h ~ 2 h, when the gas temperature in the gas storage tank (7) is consistent with the test temperature T , start the test;
- h) Close valve F3; open valve F6; lightly open valve F2; when the pressure value displayed by the pressure sensor (6) reaches the test pressure p_0 , close valve F2;
- i) Record the test gas test pressure p_0 , test temperature T , specimen thickness L , specimen diameter d and test start time t . Slowly open valve F1; meanwhile, actuate the recorder to collect the pressure on the underside of the specimen at different times; record the variation curve of the downside pressure of the specimen and the test time. When the curve manifests linearity, then, it reaches stable permeation and the test is finished.

Repeat step c) ~ i) for 3 times.

8 Test Data Processing

8.1 Gas Permeability Coefficient

The gas permeability coefficient P shall be calculated in accordance with Formula (1):

$$P = \frac{V}{\pi \times \left(\frac{d}{2}\right)^2} \times \frac{273.15}{273.15 + T} \times \frac{10^6 L}{1.013 \ 25 \times 10^5 p_0} \times \frac{dp}{dt} \dots\dots\dots (1)$$

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