

How to Select Gas Permeability Test Method

Abstract: Due to the essential difference between differential-pressure method and equal-pressure method, each method has its own advantages and data system. Based on the characteristics of sensor method and vacuum method, this article gives packaging enterprises, testing institutes and research institutes some suggestions on how to select gas permeability test methods.

Key Words: differential-pressure method, equal-pressure method, gas permeability

As the security of food and drug packaging is constantly attracting attention, barrier property that directly relates with quality guarantee period of products becomes one of the properties that attracts the most attention, which in turn prompts the popularization of relevant testing items. At present, gas permeability test and water vapor permeability test of materials have become rather popular.

Generally, each index of barrier property can be tested with several test methods. These methods differs to some extent in their testing principles, thus affects the data comparability of various test methods. To facilitate data comparison of barrier property testing, a unified data system is needed. As far as water vapor permeability testing is concerned, data system of various test methods can be unified after being calibrated according to relevant standards. However, for gas permeability testing, there are hardly any measures to unify data systems of different methods. Therefore, the selecting of gas permeability test method is of vital importance.

1 . Differential-pressure Method Differs with Equal-Pressure Method Essentially

Vacuum method is the most representative method in differential pressure method. In vacuum method, the diffusion of test gas through specimen is single direction and single medium, thus is considered as self-diffusion, the whole process of which can be described with Fick law. In equal pressure method (the most widely used one is sensor method), since two kinds of gases existing in the test, there is inverse transmission of carrier gas (nitrogen gas) from lower test chamber to upper test chamber, and thus the diffusion is interdiffusion. Empirical data comparison has proved that test data of differential pressure method and equal pressure method are similar instead of being completely consistent. Therefore, inverse transmission of nitrogen gas does affect oxygen transmission. So we can say that differential pressure method and equal pressure method have essential differences and they are different test methods.

2 . Advantages of Each Method

2.1 Vacuum Method

With the theoretical support of membrane technology, vacuum method has been used as the basic method in gas permeability testing. It is also a method enjoying the most universality in the world. In the various international test standards issued for gas permeability testing, vacuum method is usually adopted as the first method.

The salient advantages of vacuum method are:

1. It has no selectivity to test gas. It can test common inorganic gases such as oxygen, carbon dioxide, nitrogen and air.
2. Test gas is consumed at a small quantity during test. There are almost no consumable components in the instrument, thus having a lower cost.
3. The test theory is mature. This method found perfect explanation with classic permeation theories such as the Fick law. Essential parameters of the materials, i.e., solubility coefficient, diffusion coefficient,

permeability coefficient, can be obtained with this method. It has excellent universality without special stipulation and thus is the top choice of scientific research institutes, universities, colleges, and quality inspection institutes.

4. It is high in test efficiency. A period of evacuation is required before formal testing. Moreover, testing chamber is required to reach certain degree of vacuum. Therefore, mistakes of specimen attachment can be discovered during evacuation so that operators can timely replace the specimen and retest. In this way, invalid test period can be greatly shortened.
5. The gas in test environment of vacuum method is pure. In vacuum method, the whole test chamber is evacuated to below 27Pa before filling the upper with pure test gas. Therefore, impure gases (non-test gases) in test environment can be completely neglected and corresponding influence can be eliminated.

However, due to the pressure difference of 0.1Mpa existing on two sides of the specimen, it is rather difficult to perform gas permeability testing of package.

2.2 Sensor Method

In sensor method, a constant pressure is maintained on two sides of specimen. This lays the basis for package oxygen permeability testing and avoids the rupture of package resulting from big pressure difference on two sides of specimen. As to the profile of package, it can be bottle, bag, or box. Nearly all kinds of package being applied in the market can be tested. This method can efficiently avoid the error caused by mistake estimation of sheet testing.

However, sensor method needs improvement in terms of types of test gas and test cost.

1. The unicity of test gas results in high test cost. Oxygen sensor is most frequently used in gas permeability testing. Of course, when oxygen sensor is replaced by carbon dioxide sensor, the instrument can be used to test carbon dioxide permeability of materials. Since nitrogen gas is used as carrier gas, permeability of nitrogen gas cannot be tested with sensor method. However, even if customers plan to test oxygen permeability and carbon dioxide permeability with one same instrument, they should purchase carbon dioxide sensor in addition. Moreover, gas sensor belongs to consumptive type, which results in higher test cost.
2. The calibration period is shorter. Because gas sensor belongs to consumptive type, the calibration factor should be calibrated periodically. Otherwise, the accuracy of test result will be affected.
3. There are several kinds of gases existing in test environment of sensor method. Inverse transmission of carrier gas will affect forward transmission rate of test gas (oxygen gas). Moreover, such influence varies with specific material and cannot be quantified. Therefore, sensor method is only applicable to reservation testing of specific property of materials, for example, oxygen (or carbon dioxide) permeability testing. It may not be applicable to the testing of barrier parameters of materials.

3 . How to Select Gas Permeability Test Methods

Which method should be selected by packaging manufacturers and relating research institutes for gas permeability testing? Here are some suggestions on this point:

First, instruments should adopt methods in accordance with relevant policy of the country as well as the industrial standard. For instance, in current national investigation of food plastic packing, package and tool products, the prescribed method for gas permeability testing of plastic film is differential-pressure method (GB/T 1038). Therefore, relevant institutes and film manufacturers should adopt gas permeability instruments of differential pressure method. To other testing institutes and scientific research institutes, the national standards

should be carried out.

Secondly, the situation of market should be taken into consideration in selecting test methods. Differential pressure method and equal pressure method have their own data system. Although many institutes attempt to unify these two data systems, they haven't made any practical conclusion or achievements. Therefore, it is preferable that customers purchase gas permeability instrument that is based on the same test principle with that of national institutions to avoid the influence of different test methods on the evaluation of material property.

Thirdly, for customers having special test requirements, it is necessary they have better understanding of the advantages of differential-pressure method and equal-pressure method. For example, package manufactures can select equal pressure method instruments and add accessories for overall testing of packages in order to get more practical test data. If there are several kinds of test gases to be tested, customers should purchase differential pressure method instrument. When test cost is taken into consideration, differential pressure method instrument becomes more economical and practical choice.