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Rapid Determination of Package Water Vapor Permeability

Abstract: although barrier property is one of the key parameters affecting shelf life of products, traditional water vapor permeability test methods still fall short not only in test efficiency but also in terms of operation conveniences. For that reason, a method that can rapidly determine water vapor permeability of package is introduced in this article.

Key Words: water vapor permeability, container, test, and electrolytic method

Containers are directly used in liquid package. Since raw material of containers is often processed with high temperature and cooling, some indexes of the raw material cannot indicate the final properties of container. The special shape of container adds difficulty to its barrier property testing. In the past, gas permeance and water vapor permeability are estimated by testing package sheet material. However, container packages are not uniform in thickness and the property of materials will be changed in the process of production, which will cause certain disparity between estimated and tested results. Traditional water vapor permeability test methods still fall short not only in test efficiency but also in their operation conveniences. For that reason, a method that can rapidly determine water vapor permeability of package is introduced in this article.

1. Traditional Methods to Determine Water Vapor Permeability of Containers

The commonly used methods of package water vapor permeability testing at present are developed on the basis of gravimetric method film water vapor permeability testing, using test principle of gravimetric method. Relevant test standards are GB/T 6981-1986、GB/T 6982-1986 and ASTM D 3079-94. According to the nature of materials, there are water vapor permeability testing of flexible package and rigid package. Although these two methods vary to some extent in their detailed operation procedures, the basic test methods are similar.

Test procedures are as below: put desiccant (holding accessories can be used) into sample container and then seal the container. Quickly place the preheated specimen into constant humidity and temperature cell for moist heat testing. After that, the specimen should be weighed periodically according to water vapor permeability of materials. When the transmission reaches equilibrium, calculate water vapor permeance of the specimen using the increment of specimen's weight.

Although this method is developed on the basis of gravimetric method film testing, automatic detection is hard to realize. Therefore this method has the disadvantages of inconveniences in empirical application, lower test efficiency and lower credibility of test results, with the ones listed below being the obvious weak points:

Longer test duration. According to specifications of standards, to determine transmission equilibrium, at least three weight data should be obtained. Although weighing interval of specimen is decided by operators in accordance with water vapor permeability of packaging materials, the interval below is recommended in standards: for materials possessing high water vapor barrier property, the shortest weighing interval recommended is 2～3 days. While for lower water vapor barrier materials, a interval of 15～30days is recommended. In this way, even packages made of very lower barrier materials needs seven or eight days to complete one test. To test container package that is made of high barrier materials, several months are needed.

the test cannot be completed under a stable condition . During weighing process, the specimen (or desiccant and its holding accessories) is moved between test environment and weighing environment. In principle, transmission of water vapor should be tested under an equilibrium state. But the movement during weighing will destroy transmission equilibrium established under test state, which in turn affect accuracy of test results. Moreover, the

shorter the weighing interval, the more obvious the affection will be. There is also such explanation in standards. For example, it is clearly pointed out in standards that frequent weighing affects accuracy of test.

A stable differential pressure of water vapor is hard to maintain on two sides of specimen. Because the weight of desiccant contained in specimen container usually limits to 80-100g, moisture absorption ability of desiccant decreases after a period of test. Correspondingly, differential pressure on two sides of specimen will also change. In such a case, the desiccant should be replaced to continue test. However, the desiccant can hardly be replaced completely consistent in quantity. Therefore, test will be influenced to some extent.

4. The sealing lacks reliability, especially for container packaging that cannot be sealed repeatedly. When desiccant and its holding accessories are placed into specimen container, a opening needs to be made on the wall of package and is then sealed with seal wax after the placing of desiccant and the accessories has finished. However, such operation is repeated each time the specimen is weighed, which not only increases the difficulty of operation, but also increases the ratio of test failure.

5. Poor repeatability. Operators' habit of specimen preparation and weighing will affect test results.

In addition, because precision of gravimetric sensor is restricted by its measuring range, the precision of container package testing is much poorer than that of film testing. At the same time, unit of the test results in this method is g/m2·30d, indicating the need to accurately measure surface area of container package, which presents another problem for container package of irregular shape.

2. Test Water Vapor Permeability Using Sensor Method

Test principle of sensor method water vapor permeability testing for container package is the same with that of gas permeability testing, which forms a good basis in the actual application of sensor method.

The first thing is specimen preparation. The method of preparation is almost the same with that of package oxygen permeability test. However, specimen placement varies to specific testing position. Water vapor permeability testing of container package includes water vapor permeability test of bottle body and the integral test of bottle cap and bottle body. To test barrier property of bottle body, the package should be laid upside down and fixed onto special bottle pedestal. Then seal bottle neck by filling special glue into bottle pedestal in order to avoid the transmission of water vapor from connecting place of bottle pedestal and bottleneck into bottle body. Generally, the finished specimen is shown as figure 1. To test barrier property of bottle cap and bottle body, make a hole on the bottom of container first. It is recommended that the size of this hole just fits the inlet pipe and outlet pipe of nitrogen gas. Place the bottle upward on the center of tailor-made bottle pedestal Then fill the sealing glue evenly into between bottle body and bottle pedestal. Make sure that the space between bottom recess and input and output pipes is also filled with sealing glue. The finished specimen is shown as figure 2.

Figure 1. Finished Bottle Body Specimen for Water vapor permeability Testing
Figure 2. Finished Bottle Specimen for Integral Water vapor permeability Testing

Replace the upper test chamber of sensor method film water vapor permeability tester with special enclosure (attached with instrument), and then use the package to divide the permeation chambers into two independent airflow systems (see figure 3) with one side being flowing test gas (dry) and the other side maintain certain humidity. The concentration of water vapor on two sides of specimen is different and there is a constant concentration difference of water vapor existing (relative humidity). Under the function of concentration difference of water vapor (relative humidity), water vapor transmits through the wall of container and is then diverted into the sensor by carrier gas. Water vapor transmission rate of the package can be calculated according to the quantity of water vapor contained in carrier gas, which is accurately measured by the sensor.

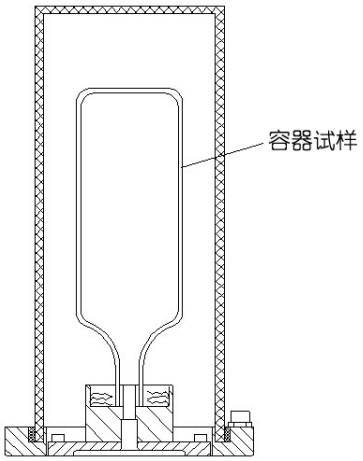

Figure 3. Test principle of package water vapor permeability testing

Labthink TSY-W3 electrolytic method water vapor permeability tester can test integral water vapor permeability of container package with the precision no less than 0.001g/pkg·d. Generally, the duration of test is only three or four days, thus realizes rapid and accurate determination of water vapor permeability testing.

Comparing with relevant parameters of tradition test method previously introduced, TSY-W3 is outstanding both in aspects of test precision and test efficiency.

3. Conclusion

Traditional test method for integral water vapor permeability testing of package is low in efficiency and precision, which impedes the development of integral water vapor permeability testing of container package. That is why the traditional method does not obtain better application in the past years. Sensor method makes a significant progress in testing integral water vapor permeability of package and can test water vapor permeability of almost all current flexible packages (including package bag, paper box and bottle), which can provide more accurate and overall test data in comprehensively investigating the influence of water vapor permeability on shelf life of inner packed matters.