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Data Report for Oxygen Permeability Test of Polycarbonate

Abstract: This article presents the foundation, testing and data analysis of oxygen permeability database established by Labthink Lab; and introduces the main functions of this database.
Keywords: polycarbonate , oxygen permeance , oxygen transmission rate , OTR

Temperature is one of the conditions of lab environment. Unless there is special requirement, constant temperature and humidity is required in the test. Temperature fluctuation can significantly influence various properties of polymer materials. Moreover, such influences will vary with the property of specific material.
One of the important works of the database being constructed by Labthink is oxygen permeability of materials at any temperature from deep cooling to high temperature.

1 Introduction to Polycarbonate

PC, also a kind of polyester, is a generic term for the high polymers that contain carbonic ester in the chains of their molecules. Bisphenol A type PC enjoys the biggest production and the widest application. It is also one of the project plastics that has witnessed the most rapid development. With excellent impact resistance, creep resistance, thermal stability and cold endurance, bisphenol A type PC is applicable in a temperature range from -100℃ to 140℃ with its permeability of visible light up to 90%. Although this kind of PC is not well enough in aspects of oil resistance, wearing resistance and processability, it performs well in tensile strength, bending strength, extensibility, rigidity, aging resistance, electric property and water absorption. It is widely used in the fields of automobile, electronics and electricity, construction equipment, office automatic equipment, package, sports appliance, medical care and household articles.

2 Test Technology

The required environment of gas permeability testing in standards is 23℃. For the reason that either the instrument doesn't possess self-temperature controlling function or its testing components cannot endure excessive low or high temperature, common oxygen permeability testers can only be used under room temperature or a litter larger temperature range.
As to non-temperature controlling testing instruments, temperature controlling can only be realized by adjusting ambient temperature of the lab. Even when those instruments possess temperature controlling function, their temperature ranges limit within 0℃～50℃.
Oxygen permeability of some materials is required, in actual practices, to be tested under special temperatures. However, their requirements to temperature ranges are not identical: some need to be tested at -5℃ (such as for fruit and vegetable fresh keeping), and some need to be tested at -30℃ or lower temperatures. Moreover, in addition to the high costs, the controlling of special temperature and the testing of gas permeability at present are difficult to realize commercially.
Labthink VAC-V1 has realized temperature controlling ranging from ambient temperature up to 50℃. Based on

the empirical test data obtained from these testing as well as to the statements on temperature influence in classical film technology, VAC-V1 is with data fitting function of oxygen permeability under various temperatures. It can meet the special test requirements and can help researchers have an integral understanding of the variation of gas permeability with temperature.

Curve fitting is a data processing method for the functional relation of coordinates indicated by discrete variable that is approximately stimulated or cut on plane surface by continuous curve. This method employs the analytic expression to approach data. In scientific test or social activity, the variable xi of data group x, y that is obtained through test or observation varies with others. People want to employ an analysis expression that corresponds the rules of its background information to represent the dependent relationship of x and y. And f(x，c) is often called fitting model, where c (c1，c2，…cn) refers to some undetermined parameters. The c presenting lineally in f is called liner model, otherwise it is called non-linear model. In practical life, the relationship of variables is not necessarily liner. Therefore, the most common method for data analysis is curve fitting. Labthink VAC-V1 is designed on the base of the fitting method of Arrhenius formula. Many materials have verified its data fitting with ideal results.

3 Oxygen Permeance of Polycarbonate Film

With Labthink VAC-V1, massive tests of oxygen permeability for polycarbonate film of 125μm are carried out within 10℃～45℃. The tests are carried out at temperatures of 10℃, 23℃, 30℃, 35℃, 40℃ and 45℃ with the effective test times at each temperature no less than three times. Moreover, relative deviations of test data are all under 3.5%.

With the data fitting function of VAC-V1, oxygen permeability of PC film under any temperature from -120℃～350℃ (153K～623K) can be obtained. In addition to taking actual application temperature of common film materials into consideration, temperature range of the database is also selected according to the brittle temperature of common plastics and the conversion temperature of thermodynamics. Thus is a rather comprehensive temperature range. It is no doubt that if the source of test gas is nitrogen or other gas, gas permeability can also be obtained with the data fitting function of the instrument. Special attention should be paid to the limitation of fitting function, which is caused by the swelling of film when organic gases transmit through it.

For detailed information of the oxygen permeability of PC film under various temperatures, please visit www.labthink.cn, or you can contact Labthink Lab. The following is the variation curve of PC oxygen permeance. Thermodynamic temperature K is the unit of temperature, and cm3/m2·24h·0.1Mpa is the unit of oxygen permeability.

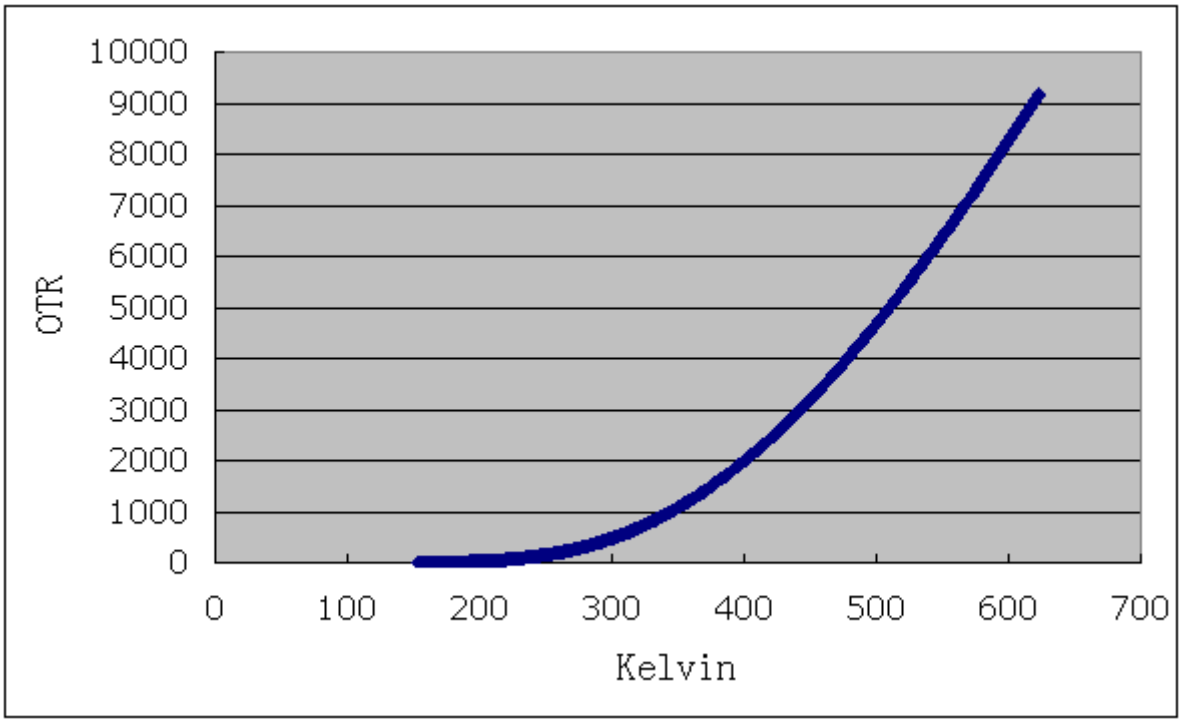

Figure 1. -120℃～350℃（153K～623K）Variation Curve of PC Oxygen Permeance

Oxygen permeability of PC film presents an obvious increase with the rising of temperature. For example, oxygen permeability of PC at 273K (0℃) is 272.952cm^3/m^2·24h·0.1Mpa, while it increases to 719.128cm^3/m^2·24h·0.1Mpa at 323K（50℃）, about 2.6 times that of 273K (0℃). At 303K (30℃), PC oxygen permeance is 507.201cm^3/m^2·24h·0.1Mpa. From Figure 1 we can see that the variation is not linear but a roughly exponential relationship.

Since VAC-V1 uses the vacuum method, according to technological theory of film, solubility coefficient of material and diffusion coefficient of gases can be simultaneously tested with the oxygen permeability testing and oxygen permeance testing of materials. In Figure 2, diffusion coefficient of materials increases with the rising of temperature. Its unit is e-8cm^3/cm^2·s·cmHg.

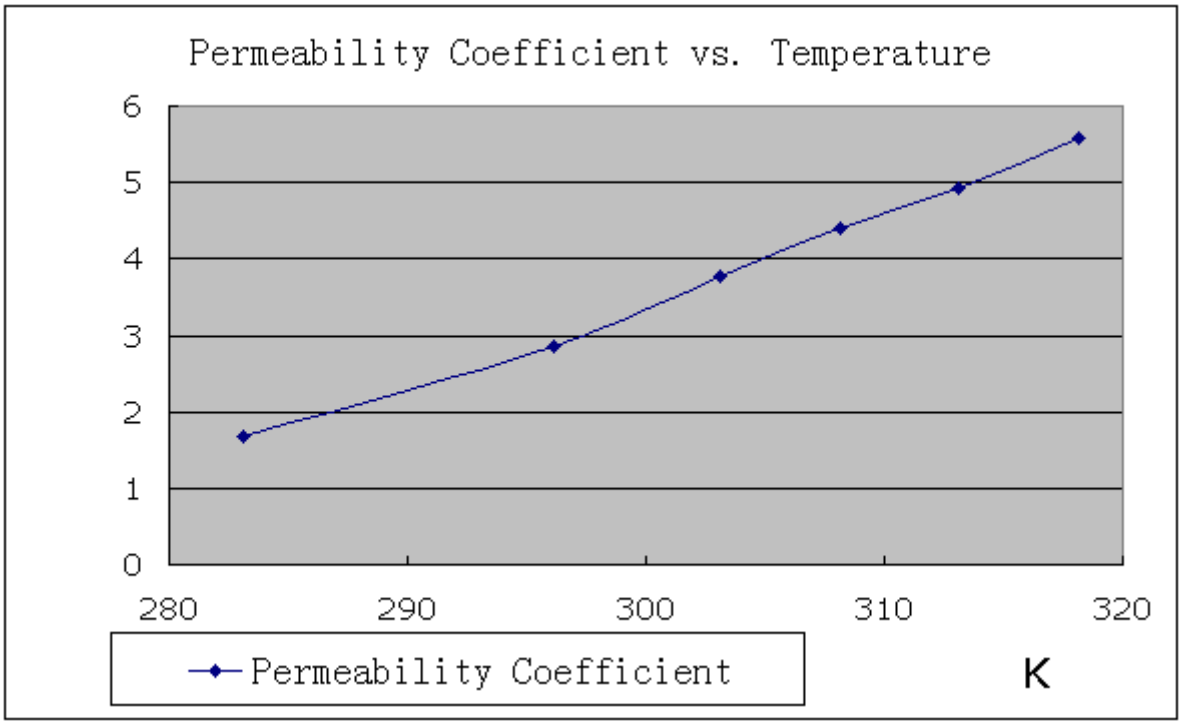

Figure 2. Diffusion Coefficient–time Curve of PC

Of course, Permeability coefficient of materials is in direct proportion to the oxygen permeance. Therefore its variation tendency with temperature corresponds with that in Figure 1.

4 Conclusion

Labthink has established oxygen permeance database of PC film at any temperature within -120℃～350℃. This database can help research personnel to reasonably and effectively design the structure of package materials. In the near future, Labthink will carry out tests to the commonly used packing materials such as polyester, the polyethylene, and the polypropylene. Moreover, Labthink Lab will establish oxygen permeance database of corresponding materials from -120℃ to 350℃. When the structure of materials is designed referring to these databases, their barrier property can better satisfy the packing requirements under special temperatures.