Measuring oxygen transmission rates in perforated films

Introduction

Perforated films are commonly used in produce packaging, as well as in other applications that require the unimpeded movement of gas through a barrier. Testing the permeation rate of perforated films has historically been difficult because traditional oxygen transmission rate (OTR) testing is not designed for this purpose. While there is a way to modify the traditional test methods to test perforated films, there is another method that makes testing these films much simpler and more cost-effective.

Drawbacks to traditional test methods

Traditional permeation testing methods involve placing the test material into a test cell, purging one side of the test cell with a carrier gas (usually N_2) until there is no oxygen left, then allowing the test to run to equilibrium (Figure 1).

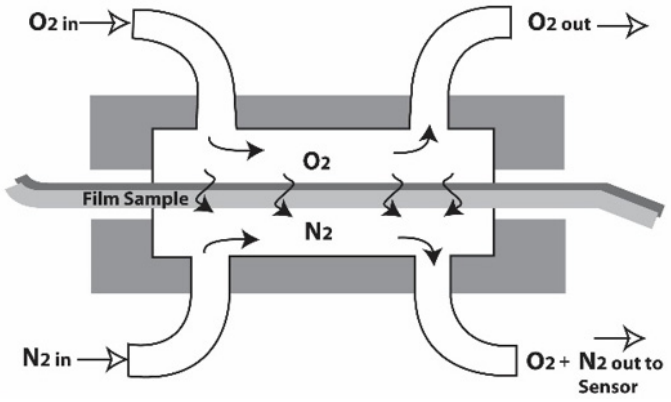

Figure 1. OTR testing using a traditional testing instrument.

These methods require the constant flow of test gas and carrier gas on either side of the test material in order to obtain an accurate measurement of the OTR. Because perforated films have such a high OTR due to the large amounts of oxygen passing through the perforations, it is very difficult to establish the required partial pressure difference in order to accurately and repeatably measure the OTR. The results are highly dependent on the partial pressure that is established at the beginning of testing due to the flow of carrier gas, which leads to widely varying results between different labs and even different tests using the same material.

Finally, the OTR of many perforated films is outside the range of the test instruments, which makes obtaining accurate test results difficult and depletes the sensor more quickly.

Other options

There is an option for testing perforated films using traditional OTR instruments, but it is not ideal for providing accurate and repeatable results. This involves testing a perforated film together with another low oxygen barrier film, as shown in Figure 2. If the OTR of the low barrier film is known, the OTR of the perforated film can then be determined using the parallel resistance equation. This method allows for the testing of perforated films using traditional OTR test methods, as long as the nonporous film is a high enough transmitter to allow all the oxygen to permeate through. However, the OTR of the nonporous film must first be determined, increasing the time and cost associated with OTR testing.

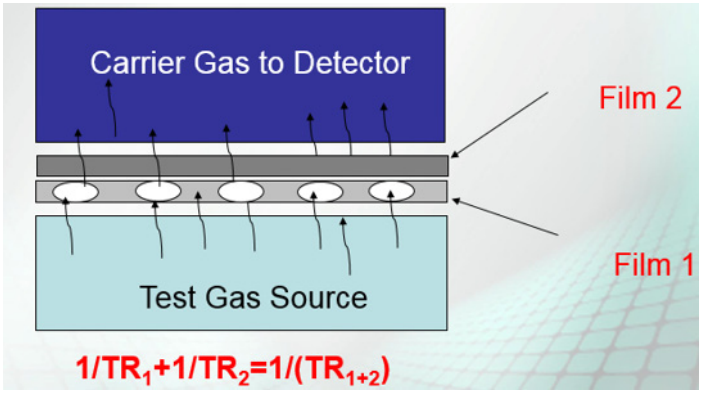

Figure 2. Testing a porous film (Film 1) alongside a nonporous film (Film 2) using the parallel resistance equation.

Testing perforated materials

A more effective method for testing the OTR of perforated films is to use optical fluorescence technology in combination with a test cell, such as that used in the OpTech®-O_2 Model P by MOCON®. This method corresponds with ASTM F3136 and can accurately and repeatably measure the OTR of medium and low oxygen barriers without the drawbacks of the traditional test methods.

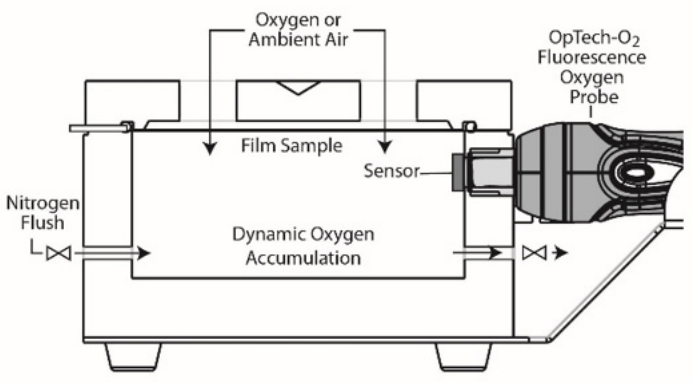

Figure 3. OTR testing with the OpTech-O_2 and a test cell.

The material is placed inside a test cell that is connected to the OpTech-O_2 (Figure 3). The inside of the test cell is flushed with a carrier gas (usually N_2), then isolated at ambient pressure so there is no gas flow through the cell. Room air is then allowed to permeate through the material and into the test cell until it reaches equilibrium. The OpTech-O_2 emits fluorescent light that is quenched in proportion to the oxygen concentration in the test cell. If the permeation rate is outside the test limits for the OpTech-O_2, some of the perforations in the film can be taped off to decrease the permeation rate, similar to masking.

The units of measurement should be in cc/day, allowing for easy calculation of the permeation rate of any size film by determining the cc/day per perforation (Figure 4).

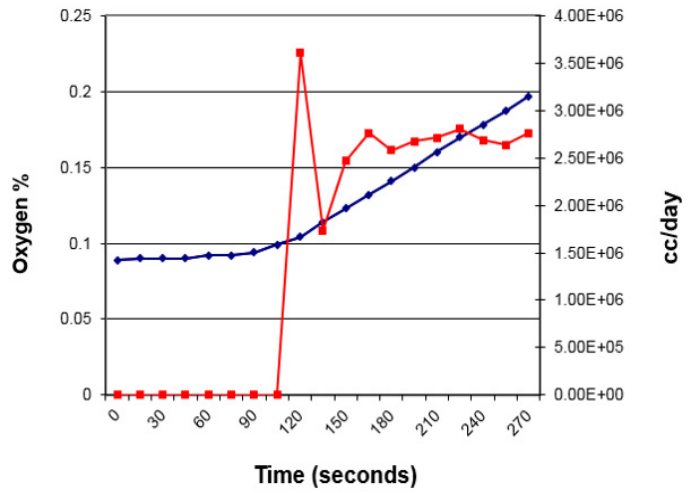

Figure 4. Measuring OTR for perforated films using the Op-Tech O_2 and a test cell.

This method provides a way to directly and reliably measure the OTR of perforated films, since the testing does not depend on establishing a partial pressure based on gas flow at the beginning of the test.

It also allows for the determination of how many perforations a package should contain. Once the cc/day per perforation is known, this information can be used to calculate the number of perforations necessary to give the OTR that will provide the desired shelf life (Figure 5).

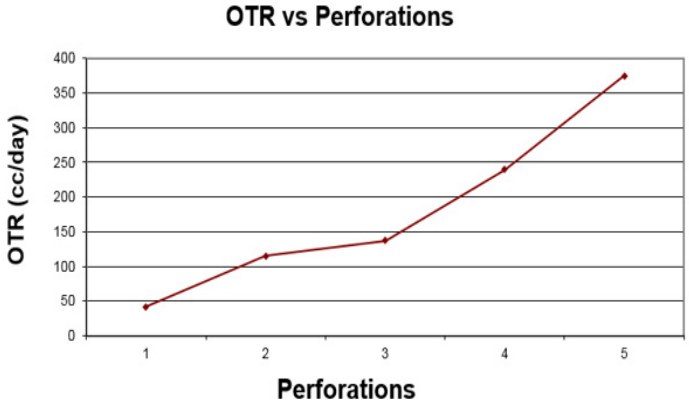

Figure 5. The OTR compared to the number of perforations in the test film.

The OpTech-O_2 is also a more cost-effective option for OTR testing. It is faster than traditional OTR testing, both in the time to result and because the setup time is much less, leading to reduced costs associated with OTR testing.

Conclusion

Optical fluorescence technology provides a more accurate and repeatable method of measuring the OTR of perforated films than the traditional test methods. For more information on how this type of testing can benefit your company, contact your MOCON representative.

To learn more about ASTM F3136, see our application note "New ASTM Standard F3136."

Minneapolis, MN 55428 USA
Phone: 763.493.6370
Email: info@mocon.com
www.mocon.com

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