# Shelf life and the importance of testing the whole package

The shelf life of a product in a package can be very different from the projected shelf life obtained from testing a flat film.

**Introduction**

Most packaging R&D work is done using flat films, which is essential for identifying suitable packaging materials. However, when a film is formed into a package, defects created during the manufacturing process as well as during shipping or distribution can weaken the barrier provided by the package as a whole. This must be taken into account during development or the shelf life of the product may be less than expected, which can lead to problems such as recalls or even legal action. Many companies avoid this issue by overpackaging their products. This is not an effective solution since it leads to increased production costs, higher costs for the customer, and a negative environmental impact. A more effective solution is to determine the permeation rate of the finished package to ensure that it remains an effective barrier while avoiding the costs of overpackaging. The following case studies illustrate the importance of testing the whole package, as well as providing examples of how this type of testing can be done.

**Case study 1: Flat film vs. finished package**

An infant formula manufacturer wanted to switch from the traditional canister packaging to a multi-layer flexible pouch. There were five candidate materials for these pouches, as described in Table 1. Infant formula is moisture- and oxygen-sensitive, so the water vapor transmission rate (WVTR) and oxygen transmission rate (OTR) into the pouches must both be determined. Since the destination market is in a tropical region, the test conditions for the films and packages were set as described in Table 2 using dry nitrogen as a carrier gas. All tests were performed on MOCON® permeation testing instruments.

Table 1. Candidate materials

| ID | Sample Structure |
|---|---|
| A | PET / Al / Nylon / LLDPE |
| B | PET / Al / PE |
| C | PET / Al / PETMET / PE |
| D | PET / Al / Nylon / PE |
| E | PET / PE (extruded) / Al / PE (extruded) / PE |

Table 2. Test conditions and equipment

| Test Item | Test Conditions | Test Instrument |
|---|---|---|
| Pouch OTR cc/(pkg•day) | Temperature: 37C<br>Test gas: 100% $O_2$ with 90%RH | OX-TRAN® 2/61 |
| Film OTR cc/(m²•day) | Temperature: 37C<br>Test gas: 100% $O_2$ with 90%RH | OX-TRAN 2/21 |
| Pouch WVTR g/(pkg•day) | Temperature: 37C<br>Test gas: 100% RH water vapor | PERMATRAN-W® 3/31 |
| Film WVTR g/m²•day) | Temperature: 37C<br>Test gas: 100% RH water vapor | PERMATRAN-W 3/31 |

The film test results were all below the instruments' detection limits, indicating that they were effective barriers to both oxygen and water vapor. Using these film results and the actual size of the pouches, the pouches were predicted to have an OTR below 0.0004 cc/(pkg•day) and a WVTR below 0.0004 g/(pkg•day). However, once the completed pouches were tested, both the OTR and WVTR were significantly higher than anticipated (Table 3).

Table 3. Pouch test results

| Material ID | OTR cc/(pkg•day) | WVTR g/(pkg•day) |
|---|---|---|
| Projected | 0.0004 | 0.0004 |
| A | 0.011 | 0.0021 |
| B | 0.032 | 0.0010 |
| C | 0.040 | 0.0022 |
| D | 0.036 | 0.0034 |
| E | 0.052 | 0.0015 |

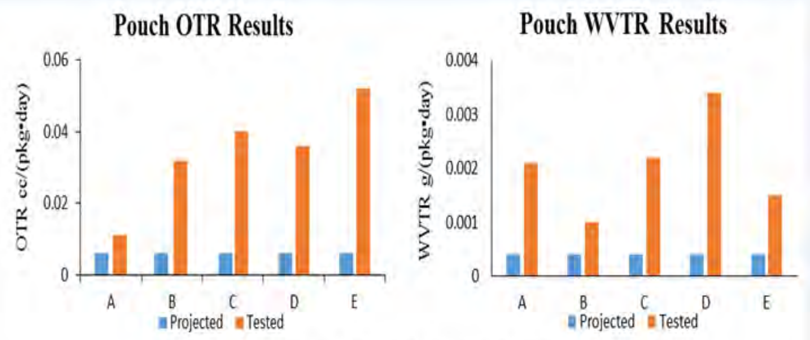


Figure 1. Projected vs. tested results

Examination of the pouches revealed that there were defects along the crease of the package side wall, which allowed more water vapor and oxygen to permeate into the package than was expected (Figure 1). It was only through testing completed pouches that the manufacturer was made aware of this issue.

**Case study 2: Bottle vs. closure**

A health supplement is packaged in polymer bottles with simple cap closures. Permeation testing was conducted on bottles with and without these closures to determine how they impact the WVTR. To test bottles with closures, nitrogen gas lines were inserted into the bottle as shown in Figure 2. After the bottles were purged of oxygen, the tests were allowed to run to equilibrium. To test only the bottle body with no closure, the bottle was affixed to a metal plate using epoxy as shown in Figure 3, after which it was purged of oxygen and allowed to run to equilibrium.

Figure 2. Testing the bottle with closure

Figure 3. Testing the bottle body

Table 4: Bottle test results

| Sample Name | WVTR g/(pkg • day) |
|---|---|
| W-1 (body and closure) | 0.0070 |
| W-2 (body and closure) | 0.0089 |
| W-3 (body and closure) | 0.0099 |
| W-4 (body and closure) | 0.0042 |
| W-5 (body and closure) | 0.0107 |
| W-6 (body only) | 0.0030 |

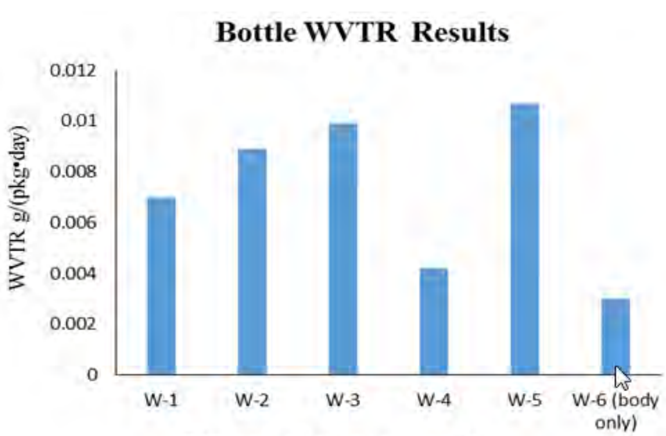


Figure 4: Bottle test results

Sample W-6 (without the closure) demonstrated the lowest WVTR, while that of the sample with the closure was much higher due to permeation through the closure (Table 4 and Figure 4). It is essential in the packaging development process to take this into account so that the supplement remains safe and effective when used by the customer.

**Case study 3: Retort packaging, OTR testing, and shelf life**

Retort is the process of sterilizing a packaged food or beverage product in a modified pressure cooker containing hot water, steam, or a combination of both. During the retort process the oxygen barrier can change significantly through exposure to high heat and humidity, as shown in Figure 5. The OTR of the samples was analyzed immediately after retort and remained in test until post-retort values were obtained.

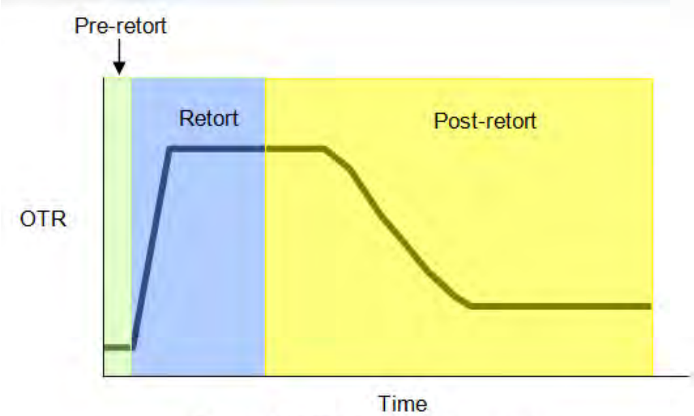


Figure 5: OTR pre- and post-retort

Figure 6 demonstrates the modeling of oxygen ingress over time by using the tested OTR value. A higher post-retort OTR can lead to a shorter shelf life for the product. For this reason, post-retort studies must be completed to determine the amount of oxygen entering the package following retort.

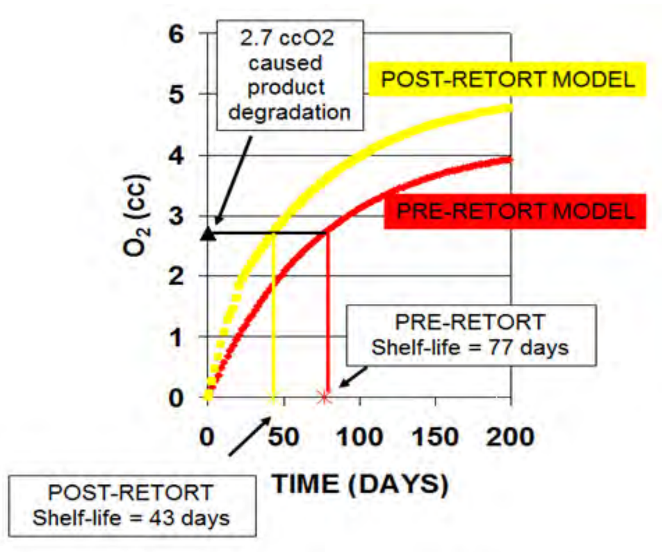


Figure 6: Shelf life prediction

**The package testing process**

Testing packages operates on the same principles as testing films, but requires a special test setup. Figure 7 shows a common method for testing packages; while it shows a test measuring OTR, a similar test setup can be used for WVTR.

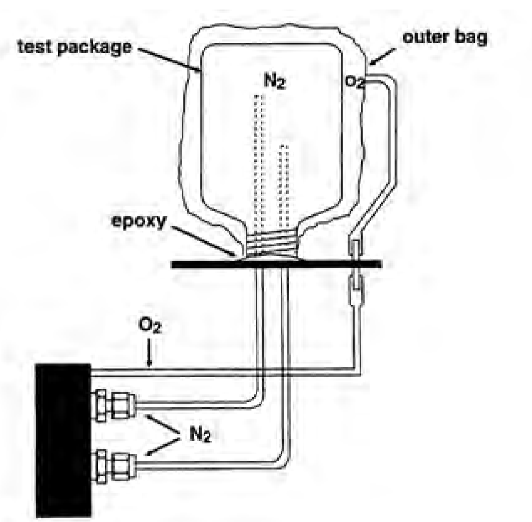


Figure 7: Package testing setup

An empty package is sealed inside a bag or capture vessel and epoxied to a metal plate with gas lines going into the bag and package. The inside of the package is purged with N2, and the test gas is then introduced into the bag or capture vessel surrounding the package. Another option is for the gas lines to be inserted directly into the package to test the integrity of the closure, as shown in Figure 8 relating to case study 2. This setup can be adapted to test a variety of packages, such as rigid containers, flexible bags, tubing samples, and blister packages.

**Conclusion**

Analyzing films to determine their OTR and WVTR is an essential part of the R&D process, but permeation rates in finished packages can be much higher due to damage caused during manufacturing, shipping, and distribution. To obtain the true permeation rates into a package, it is essential to conduct permeation testing on the package as a whole.

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