Specialty Permeation Testing for Unique Packaging Materials

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MOCON Webinar
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Outline

- Barrier Testing Overview
- Special Coating Materials
- High Temperature Applications
- Sealant for Solar Cell Encapsulation
- Solar Panel Testing
- Mini-Package Applications
- Additional Application Examples
High Barrier Material Applications

Solar Panels

OLED Cell Phone/Tablet Screens

Flexible Displays
<table>
<thead>
<tr>
<th>Applications</th>
<th>OTR</th>
<th>WVTR</th>
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<tbody>
<tr>
<td></td>
<td>cc/(m² • day • bar)</td>
<td>g/(m² • day)</td>
</tr>
</tbody>
</table>
| General Packaging Industry      | $10^0$  
(10⁰ = 1)  | $10^0$ |
| Solar Cell Encapsulation        | $10^{-1}$  | $10^{-1}$ |
| Flexible LCD                    | $10^{-2}$  | $10^{-2}$ |
| Organic Solar Cells             | $10^{-2} - 10^{-6}$  | $10^{-2} - 10^{-6}$ |
| Flexible OLED                   | $10^{-6}$  | $10^{-6}$ |
## MOCON WVTR Methods Comparison

| Method Comparison          | ASTM E398  
ISO 15106-1 | ASTM F1249  
ISO 15106-2 | ISO 15106-3 |
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<thead>
<tr>
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<tbody>
<tr>
<td><strong>0.05-500 g/(m² • day)</strong></td>
<td>0.005-1000 g/(m² • day)</td>
<td>0.00005-5 g/(m² • day)</td>
<td></td>
</tr>
<tr>
<td>(PERMATRAN-W® 398, 1/50)</td>
<td>(PERMATRAN-W 3/33, 3/34, 700)</td>
<td>(AQUATRAN® Models 1 &amp; 2)</td>
<td></td>
</tr>
<tr>
<td>Dynamic relative humidity measurement</td>
<td>Concentration-based pulse modulated infrared sensor</td>
<td>Absolute coulometric sensor</td>
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</table>
Testing Methodology
(Oxygen Transmission Rate)
“How soon will the film reach equilibrium?”

75 gauge OPP/Print & Adhesive/48 gauge met-PET at 90%RH, 37.8°C
What Does It Look Like?

- Classic barrier sample
- Good barrier sample
AQUATRAN Model 2

G Model:
- 35-90% RH, 100% RH, 10-40°C
- Both films and packages
  - Optional environmental chamber for packages

W Model:
- 100% RH, 5-50°C
- Both films and packages
  - Optional environmental chamber for packages

Incorporates MOCON's new proprietary Aquatrace® Gold WVTR sensor, capable of measuring to 0.00005 g/(m² • day).
Case Study 1: AQUATRAN Model 2

Customer Barrier Film Results
AQUATRAN 2 vs. AQUATRAN 1

![Graph showing WVTR (Water Vapour Transmission Rate) mg/(m² • day) vs. Time (hours) for AQUATRAN 1 and AQUATRAN 2. The graph illustrates that AQUATRAN 2 has a lower WVTR compared to AQUATRAN 1 over time.](image)
Case Study 2:
AQUATRAN to measure WVTR at $10^{-6}$ level

Results to Date

Results of High Temperature Testing on AQUATRAN

- WVTR vs. Temperature
- Arrhenius Fit: $\ln [\text{WVTR}] = -9957.3 (1/T) + 29.842$  ($R^2 = 0.9989$)

<table>
<thead>
<tr>
<th>Temp (°C)</th>
<th>WVTR (mg/m²/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>0.37</td>
</tr>
<tr>
<td>50</td>
<td>0.33</td>
</tr>
<tr>
<td>60</td>
<td>2.38</td>
</tr>
<tr>
<td>70</td>
<td>4.36</td>
</tr>
<tr>
<td>80</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td></td>
</tr>
</tbody>
</table>

Test Duration 985 Hours, Independent Third-Party Test

At 20°C, 50% RH:  WVTR = 7.9 x $10^{-6}$ g/m²/day

Customer published results by AQUATRAN 1 and 2 testing
Permeation and Temperature Relationship

Arrhenius Equation:

\[ P = P_0 e^{-\frac{E}{RT}} \]

- \( P \) = Permeation rate
- \( P_0 \) = Permeability constant
- \( E \) = Activation energy
- \( R \) = Gas constant
- \( T \) = Temperature
High Temperature Test Setup

- Remote test cells
- High temperature oven
- Important: Check whether high temperatures are appropriate for real applications
- Film melting temperature
- Polymer Tg (glass transition temperature)
Remote Diffusion Cell
Optional: Bottomless Remote Cell

- Cell provided by MOCON
- Used in an oven that can be purchased from other suppliers
High Temperature Testing

• MOCON provides testing services
• WVTR up to 85C with 100% RH
• OTR up to 85C with dry oxygen
Common Substrates for Coatings

• Many modern barrier materials contain special coatings
  – Called “thin films” in electronic device industries
• Common substrates include: PET, PEN, PS, PC, PI
• Depends on compatibility between coating and substrates
**Test Method Example:**

**How to Calculate Coating WVTR**

\[ TR_{coating} = \frac{1}{1/TR_{total} - 1/TR_{sub}} \]

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>WVTR of OLED Total (coating &amp; substrate) mg/(m² • day)</th>
<th>WVTR of Coating mg/(m² • day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rep#1</td>
<td>Rep#2</td>
</tr>
<tr>
<td>Substrate</td>
<td>520</td>
<td>524</td>
</tr>
<tr>
<td>Coating</td>
<td>2.58</td>
<td>2.75</td>
</tr>
</tbody>
</table>
Case Study 3: WVTR of Solar Cell Encapsulation Sealant

- A company manufactures photovoltaic sealants (PVS)
- Needed to test WVTR at: 38C, 85C, 100% RH
- The sealant cannot hold its shape at higher temperatures
- Special setup needed to test this type of material
Case Study 3: WVTR of Solar Cell Encapsulation Sealant

- Cut the sample into a 30 cm² circle
- Use two pieces of 20 cm² aluminum foil mask to the sample
- Secure the sample between two pieces of 30 cm² porous material (provide physical support)

30 cm² sample with porous films on both sides

20 cm² Al mask
Case Study 3: WVTR of Solar Cell Encapsulation Sealant

- Instrument: PERMATRAN-W 3/34
- Remote cells
- High temperature oven
## Case Study 3:
**WVTR of Solar Cell Encapsulation Sealant**

| Sample       | WVTR  
|--------------|--------
| PVS 107      | 0.14 g/(m² • day)  
| At 38°C, 100% RH |        
| PVS 107      | 5.0 g/(m² • day)  
| At 85°C, 100% RH |        

*Note: WVTR = Water Vapour Transmission Rate*
Test the sealant that is applied around edges of the solar panel.
Solar Panel Testing at 85C and 100% RH
Whole Package Testing of Barrier Samples
Case Study 5: Mini-Packages WVTR on AQUATRAN 2

- A company makes diagnostic reagents for blood testing
- The company wants to evaluate the moisture barrier of the reagent card

- Small amount of water pre-filled into each sample before sealing
- Monitor how much moisture permeates from inside of the sample
Case Study 5:
Mini-Packages WVTR on AQUATRAN 2

- Instrument: AQUATRAN Model 2
- Test method
  - Fit 1-3 cards into the carrier gas side
  - Cover with aluminum foil
  - Same test procedure as testing a film
## Case Study 5: Mini-Packages WVTR on AQUATRAN 2

<table>
<thead>
<tr>
<th>Test ID</th>
<th>Sample Size</th>
<th>WVTR mg/(package • day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 card</td>
<td>0.0022</td>
</tr>
<tr>
<td>2</td>
<td>3 cards</td>
<td>0.0067 (average: 0.0022)</td>
</tr>
</tbody>
</table>

**Benefits:**

- Non-destructive, no plumbing, no epoxy
- Small dead volume for a more efficient test
- TruSeal® minimizes test cell leakage
- High sensitivity detects trace levels of permeation
OX-TRAN® 10X Review

- Test Range
  - 0.0005 to 200 cc/(m² • day)
  - New default units: 0.5 to 200,000 µL/(m² • day)
- New Gold Couloxx Sensor
- New sensor board
- New plumbing
- New test cell – TruSeal
- **Next Generation** OX-TRAN 10X will use the same sensor
Case Study 6:
OTR of Blister Packages with OX-TRAN 10X

• A company manufactures medicine that requires very good oxygen barrier packages
• The single dose blister packages (all foil) must be tested for OTR

Note: Blister package also known as PTP (push through package)
Case Study 6: OTR of Blister Packages with OX-TRAN 10X
Other Package Testing Examples
Other Package Testing Examples
Other Package Testing Examples
Other Package Testing Examples
THANK YOU

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