Monolayer EVOH film for lamination (non-food)
Kuraray Co. Ltd. is the world leader in EVOH technology and production. EVAL™ EVOH resins are widely used for producing multilayer coextruded and coinjected high barrier structures.

Kuraray is also world’s only supplier of monolayer high barrier film for lamination, composed of 100% EVAL™ EVOH. Several grades of EVAL™ film take EVOH high barrier properties to industrial, pharmaceutical and other applications not possible with coextrusion. EVAL™ film provides ultra high barrier performance from biaxially oriented and even metalized EVOH.

EVAL™ EVOH monolayer high barrier film for lamination

Superior EVOH barrier properties aren’t just for coextrusion any more

Add outstanding barrier properties to any laminate structure

EVAL™ EVOH monolayer film provides outstanding barrier properties against:

- **Gases**: Oxygen and MAP gases like CO₂ and N₂, but also Helium.
- **Aroma**: providing a plastic alternative to Al foil.
- **Grease and oil**: avoiding absorption, permeation and staining.
- **Solvents**: making it suitable for chemical packaging.
- **Contamination**: making it especially suitable for packaging sensitive substances and pharmaceuticals.

Typical high barrier laminated structures

![Diagram of a typical high barrier laminated structure](image)
Types and Grades of EVAL™ film

Biaxially oriented type

**EF-XL** Exceptionally high barrier biaxially oriented film. 12 µm or 15 µm, 500-1200mm width.

**VM-XL** Ultra high barrier metalized biaxially oriented film. 12 µm or 15 µm, custom width. Moisture barrier.

Cast film type

**EF-F** High barrier film. 32mol% EVOH film. Formable. 12, 15, 20, 25, 30, 50 µm, 500-1200mm width.

**EF-E** Barrier sealing layer film. 44mol% EVOH film. Formable. 15, 20, 25, 30, 50 µm, 500-1200mm width.

**HF-M** Matted surface. Antibacterial. For wallpaper. 12 µm, 960mm width.

Exceptional barrier performance

Grades of EVAL™ monolayer film are available in the thicknesses shown above. Custom widths also possible. Gas barrier performance shown below is for specific thicknesses as indicated. Barrier performance of EVAL™ EVOH monolayer films is significantly higher than that of films made from any other conventional polymer at equal thickness.

<table>
<thead>
<tr>
<th>Item</th>
<th>Test Condition</th>
<th>EVAL™ EVOH monolayer films</th>
<th>Other films</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Biaxially oriented</td>
<td>Cast (Non-oriented)</td>
</tr>
<tr>
<td>Thickness (µm)</td>
<td></td>
<td>VM-XL</td>
<td>EF-XL</td>
</tr>
<tr>
<td>OTR (cc/m².day.atm)</td>
<td>20°C 65% RH</td>
<td>&lt;0.05</td>
<td>0.4</td>
</tr>
<tr>
<td>WVTR (g/m².day.atm)</td>
<td>40°C 90% RH</td>
<td>0.5</td>
<td>36</td>
</tr>
<tr>
<td>Young’s modulus</td>
<td>23°C 50% RH</td>
<td>4.0</td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td>MD (Gpa)</td>
<td>3.7</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>TD (GPA)</td>
<td>-</td>
<td>0.6</td>
</tr>
<tr>
<td>Transparency haze (%)</td>
<td>23°C 50% RH</td>
<td>-</td>
<td>0.6</td>
</tr>
</tbody>
</table>
Properties and advantages of EVAL™ monolayer film

Physical properties

- Transparent with excellent gloss.
- Stable, reliable high gas barrier with excellent flex crack and pinhole resistance.
- Anti-scalping / Non-absorption of aroma, solvents or active ingredients.
- Thermoformable.
- Heat seal property: grade EF-E can be used as a barrier sealant.

Safety and environment

- Compliant with global food contact regulations.
- Halogen, BPA, stabiliser, plasticiser and anti-oxident free.
- Good energy recovery, emitting only small amounts of CO₂ and water vapour.

Flexibility of production

- EVAL™ monolayer film is compliant with FDA and EU regulations for food contact applications (2002/72/EC, FDA 21CFR).
- Wide variety of available grades and thicknesses.
- Can be used with virtually any lamination substrate.
- Suitable for assymetrical and other challenging structures.
- Quickly adaptable production. Economical even for smaller production runs.
Lamination processing

Dry lamination

Monolayer EVAL™ EVOH film is typically fed from the “No.2 feeder” for “dry” adhesive lamination to another substrate. Alternatively, the “No.1 feeder” can also be used.

Extrusion lamination

Monolayer EVAL™ EVOH film is typically fed from the “No.1 feeder” position, for extrusion lamination to another substrate. In this process, EVAL™ film must first be coated with a primer before the actual extrusion lamination step. No additional corona or other surface treatment is required.
Typical applications of EVAL™ film

Transdermal patch packaging (Barrier sealant film)
Pharmaceutical packaging (Barrier sealant film)

- Heat sealing properties
- Anti-scalping
- Chemical resistance
- Aroma preservation
- Contamination barrier

Paper // Aluminum foil // EVAL™ film (EF-E)
BOPET // Aluminum foil // EVAL™ film (EF-E)
BOPA // EVAL™ film (EF-E)

Insecticide packaging (Barrier sealant film)

- Heat sealing properties
- Anti-scalping
- Chemical resistance
- Aroma preservation
- Contamination barrier

PET // Aluminum foil // EVAL™ film (EF-E)
BOPA // EVAL™ film (EF-E)

Medical & Pharmaceutical packaging (others)

- Lid film of pre-filled syringe
- IV solution secondary bag
- Carrier substrate for transdermal patch
- Sheet for medical/pharmaceutical test kit (High wet tension)

Wallpaper

- Stain resistant/Easy to clean
- Reduced odour and smoke absorption
- Durable matt surface
- Printability
- Barrier against chemical materials
- Antibacterial

EVAL™ film (HF-M) // PVC // Paper

Agricultural film

- High transparency
- Moisture permeability
- Filter out far infrared rays

EVAL™ film (EF-XL)
Lamination tube (Tooth paste, cosmetic tube)

- High barrier plastic alternative for aluminum foil based products.
- Longer shelflife
- Chemical resistance
- Protects formula integrity

VIP (vacuum insulation panel)

- Improve insulation property
- Extend product life
- Reduced energy use
- Light weight
- Minimise metal content
- Minimise risk of manipulation
- Appliance, building, transportation, Automotive

Window spacer (warm edge)

- Non metal-based spacer
- Keeps inert gas inside and moisture outside
- Extend product life

Barrier rigid laminated container

- Variation of structure
- Good design
- Easy adjustment of barrier property
- Easy introduction

(Dry lamination)

- EVAL™ film // dry // A-PET
- EVAL™ film // dry // PP
- EVAL™ film // PE // Paper // PE

(Thermal Lamination)

- PSP // thermal // PS // dry // EVAL™ film // PE
- PP // thermal // CPP // dry // EVAL™ film // CPP
- Foamed PP // thermal // PE // dry // EVAL™ film // PE
Typical applications of EVAL™ film

Sampling bag for gas analysis

Chemical protection glove

Tape substrate for industrial/building

Balloon/Airship

Possible applications

- Plastic floor tile protection film
- Moisture absorbent/permeable film
- Lamination on metal plate (industrial parts)
- Closure/Cap liner for bottle
- Decoration film
- Laminated sheet for thermoforming
- Barrier package for rare metal
- Protection film
- Body bag
- Ink cartridge package
Flex crack resistance of EVAL™ film

Barrier after gelbo flex test (OTR)

To quantify the resistance of EVAL™ EVOH films to manipulation, the oxygen transmission rate was measured after twisting by means of a Gelbo flex test and compared to that of other barrier films. After a couple of twist cycles the oxygen transmission rate drastically increases for the different barrier films except for the EVAL™ EF-XL (bi-oriented EVOH film) and VM-XL film (vacuum metallized EVOH film). These results prove that EVAL™ EVOH films have an excellent flex crack resistance.

Oxygen transmission rate (20°C, 65%RH) after Gelbo flex test

Barrier after gelbo flex test vs aluminium foil
Technical data of monolayer EVAL™ film

Barrier data against moisture and temperature

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Method of measurement</th>
<th>Conditions</th>
<th>BO EVAL films</th>
<th>Cast EVAL films</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>VM-XL EF-XL</td>
<td>EF-XL EF-F EF-E</td>
</tr>
<tr>
<td>Thickness</td>
<td>µm</td>
<td></td>
<td></td>
<td>15µm</td>
<td>15µm 12µm 12µm 30µm 30µm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ISO14663-2</td>
<td>20°C 65%RH &lt;0.05</td>
<td>0.3 0.4 0.6 0.2 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20°C 85%RH &lt;0.05</td>
<td>1.0 1.3 2.5 1.0 2.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>40°C 90%RH &lt;0.05</td>
<td>- - - - - -</td>
<td></td>
</tr>
<tr>
<td>Moisture permeability</td>
<td>g/m².day</td>
<td>JIS Z0208</td>
<td>20°C 90%RH 0.5</td>
<td>29 36 86 34 18</td>
<td></td>
</tr>
</tbody>
</table>

*1 Oxygen Transmission Rate (ISO14663-2). *2 Water Vapour Transmission Rate (ASTM E96). *3 Less than the measuring limit.
Values determined by eliminating from the measured value obtained from laminated products using PET or polyolefin film, the influence of the moisture permeability of the PET or polyolefin film.

Heat seal curve of EVAL™ film

Flavour absorption resistance of EVAL™ EF-F and EF-E film

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Flavours</th>
<th>Material</th>
<th>EVAL™ EF-F</th>
<th>EVAL™ EF-E</th>
<th>LDPE</th>
<th>CPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flavour absorption (liquid)</td>
<td>ppm</td>
<td>d-Limonene</td>
<td>140</td>
<td>280</td>
<td>1,480</td>
<td>2,040</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>n-Butyl acetate</td>
<td>160</td>
<td>80</td>
<td>420</td>
<td>610</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ethyl acetate</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td>&lt;50</td>
<td></td>
</tr>
<tr>
<td>Flavour absorption (gas)</td>
<td>mg/g</td>
<td>1-Menthol</td>
<td>0.07</td>
<td>0.2</td>
<td>9.6</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Methyl Salicylate</td>
<td>0.15</td>
<td>1.7</td>
<td>26.0</td>
<td>35</td>
<td></td>
</tr>
</tbody>
</table>

Permeation of organic solvents

<table>
<thead>
<tr>
<th></th>
<th>15µm EF-XL</th>
<th>15µm EVAL™ F</th>
<th>15µm PA6</th>
<th>15µm PET</th>
<th>15µm PP</th>
<th>15µm LDPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xylene</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>1.58</td>
<td>2.95</td>
<td>467.00</td>
<td>433.00</td>
</tr>
<tr>
<td>MEK</td>
<td>&lt;0.05</td>
<td>0.12</td>
<td>4.50</td>
<td>2.58</td>
<td>16.00</td>
<td>98.70</td>
</tr>
<tr>
<td>Kerosene</td>
<td>&lt;0.05</td>
<td>0.05</td>
<td>0.63</td>
<td>0.77</td>
<td>70.70</td>
<td>101.30</td>
</tr>
<tr>
<td>Chloroform</td>
<td>&lt;0.05</td>
<td>0.27</td>
<td>22.50</td>
<td>517.00</td>
<td>4987.00</td>
<td>3680.00</td>
</tr>
</tbody>
</table>

Unit: g/m².day.atm
### Barrier against gas (cast grades)

<table>
<thead>
<tr>
<th>Films</th>
<th>Gas Transmission Rates at 0% RH (cm³.20µ/m².day.atm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N₂ 25°C</td>
</tr>
<tr>
<td>EF-F</td>
<td>0.017</td>
</tr>
<tr>
<td>EF-E</td>
<td>0.13</td>
</tr>
<tr>
<td>OPA 6</td>
<td>12</td>
</tr>
<tr>
<td>Cast PA 6</td>
<td>-</td>
</tr>
<tr>
<td>PET</td>
<td>8</td>
</tr>
<tr>
<td>OPP</td>
<td>730</td>
</tr>
<tr>
<td>LDPE</td>
<td>3,100</td>
</tr>
</tbody>
</table>

### Barrier against CO₂ (cast vs. Biaxially oriented)

<table>
<thead>
<tr>
<th>Condition</th>
<th>CO₂ TR (cc.20µm/m².day.atm)</th>
<th>Other films</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EF-XL</td>
<td>EF-F</td>
</tr>
<tr>
<td>20°C 65%RH</td>
<td>0.8</td>
<td>1.2</td>
</tr>
<tr>
<td>20°C 85%RH</td>
<td>5.5</td>
<td>12.0</td>
</tr>
</tbody>
</table>

### Barrier against helium

<table>
<thead>
<tr>
<th>Retention Rate over time (%)</th>
<th>(%)</th>
<th>0 h</th>
<th>2 days</th>
<th>5 days</th>
<th>10 days</th>
<th>20 days</th>
<th>40 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>VM-CPP (25)</td>
<td></td>
<td>100</td>
<td>75</td>
<td>30</td>
<td>20</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>VM-OPA (12) / LDPE (16)</td>
<td></td>
<td>100</td>
<td>96</td>
<td>90</td>
<td>81</td>
<td>62</td>
<td>37</td>
</tr>
<tr>
<td>EF-XL (12) / LDPE (16)</td>
<td></td>
<td>100</td>
<td>98</td>
<td>96</td>
<td>90</td>
<td>76</td>
<td>57</td>
</tr>
<tr>
<td>VM-XL (12) / LDPE (16)</td>
<td></td>
<td>100</td>
<td>99</td>
<td>98</td>
<td>94</td>
<td>89</td>
<td>75</td>
</tr>
</tbody>
</table>

### Barrier of metalized grade

Structure: PET12/dry/VM-XL/dry/LLDPE50

<table>
<thead>
<tr>
<th>OTR(cc/m².day.atm)</th>
<th>WVTR (g/m².day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20°C 65%RH</td>
</tr>
<tr>
<td>VM-XL12</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>VM-XL15</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>
**EVAL™ the world’s leading EVOH**

**Asia-Pacific**
Kuraray Co. Ltd. (Okayama, Japan)
Capacity: 10,000 tons/year
The world’s first EVOH production facility

**Americas**
Kuraray America Inc. (Pasadena, Texas, USA)
Capacity: 35,000 tons/year*
The world’s largest EVOH production facility

**Europe**
EVAL Europe nv (Antwerp, Belgium)
Capacity: 24,000 tons/year**
Europe’s first and largest EVOH production facility

* 58,000T/year in mid 2018
** 35,000T/year in early 2017

**NOTICE**
The information, specifications, procedures, methods and recommendations herein are presented in good faith, are believed to be accurate and reliable, but may well be incomplete and/or not applicable to all conditions or situations that may exist or occur. No representation, guarantee or warranty is made as to the completeness of said information, specifications, procedures, methods and recommendations or that the application or use of any of the same will avoid hazards, accidents, losses, damages or injury of any kind to persons or property or that the same will not infringe patents of others or give desired results. Readers are cautioned to satisfy themselves as to the suitability of said information, specifications, procedures and recommendations for the purpose intended prior to use.

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EVAL™ monolayer films are produced in Okayama, Japan.
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