EVOH Barrier Film
Kuraray Co., Ltd. is the world leader in the production and development of EVOH (ethylene vinyl alcohol copolymer) resins under the trade name EVAL™. EVAL™ EVOH is available either as a resin in pellet form, or as film for lamination. Combining the excellent gas barrier properties and resistance to organic solvents of polyvinyl-alcohol with the thermoforming and water resistance properties of polyethylene, EVAL™ is a crystalline polymer with the following molecular structure:

\[
\text{Ethylene and Vinyl Alcohol} \\
(\text{CH}_2-\text{CH}_2)_m \quad (\text{CH}_2-\text{CH})_n \quad \text{OH}
\]

**General properties**

**Superior gas barrier properties**
EVAL™ films have outstanding gas barrier properties. Without a gas barrier, oxygen may penetrate packaging and spoil the contents. EVAL™ keeps oxygen out and safeguards quality, making it especially suitable for food, medical, pharmaceutical, cosmetics, agricultural and industrial packaging applications.

**Flavour and aroma barrier**
While preventing oxygen and undesirable odours from sneaking into the package, the barrier properties of EVAL™ effectively maintain fragrances and lock the aromas in. This guarantees an extended shelf life for food and cosmetic products.

**Excellent flex-crack resistance**
High-barrier structures containing an EVAL™ layer have an excellent flex-crack resistance. An EVAL™ layer makes sure that the integrity of the barrier remains unharmed during transport, handling and storage or even when the package is folded.

**Resistance to oil and organic solvents**
An EVAL™ layer offers very high resistance to hydrocarbons, oils and organic solvents. When EVAL™ is used in a multilayer structure, it prevents the evaporation of chemical substances. This property makes EVAL™ films very suitable for use in applications involving chemicals, such as fuel tanks, chemical packaging and protective clothing.
**Food safety**

**Food regulation compliance status of EVAL™ films**

EVAL™ films are in compliance with the EC Directive for food packaging and its transposition in the national regulations of the member states. EVAL™ films have also been approved for use in direct food contact, indirect or multilayer food contact and for retort applications as outlined under the Food and Drug Administration regulations in the USA.

EVAL™ has passed the specification/standard test of Official Notice No.20 (1982) from Japan’s Ministry of Health and Welfare.

“A one millimetre thickness of EVAL™ EVOH has about the same gas barrier properties as ten metres of LDPE. With such high performance, EVAL™ layers of only 12-25 microns can add real function to multilayer laminated structures.”
EVAL™ film types

Typical applications

<table>
<thead>
<tr>
<th>Film types</th>
<th>Film grades</th>
<th>Processing</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casted grade</td>
<td>EF-F</td>
<td>Casted, Deep-draw molding</td>
<td>Foods</td>
</tr>
<tr>
<td></td>
<td>EF-E</td>
<td>Casted, Deep-draw molding, Sealable</td>
<td>Foods, Pharmaceuticals, Industrials</td>
</tr>
<tr>
<td>Oriented grade</td>
<td>EF-XL</td>
<td>Biaxially oriented</td>
<td>Foods, Pharmaceuticals, Industrials</td>
</tr>
<tr>
<td>Metalized grade</td>
<td>VM-XL</td>
<td>Biaxially oriented, Aluminium-metalized</td>
<td>Foods, Pharmaceuticals, Industrials</td>
</tr>
<tr>
<td>Pre-coated grade/wallpaper application</td>
<td>HF-ME</td>
<td>Casted, Matted, Pre-coat adhesive for PVC (substrate of wallpaper)</td>
<td>Wallpaper</td>
</tr>
</tbody>
</table>

Processing of EVAL™ film

Typical dry lamination line

Typical extrusion lamination line

Some lines have anchor coating process also here
# EVAL™ film grades and typical characteristic values

EVAL™ films have the advantage of excellent gas barrier properties, aroma preservation, oil resistance, resistance to organic solvents, gloss and transparency as well as being thermoformable, in addition to food packaging, they are employed in a wide range of applications, including packaging for chemicals and cosmetics, wallpaper and industrial uses such as for construction materials.

## Characteristic values of EVAL™ films according to grade

<table>
<thead>
<tr>
<th>Grade</th>
<th>EF-XL</th>
<th>EF-F</th>
<th>EF-E</th>
<th>VM-XL</th>
<th>HF-M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>Biaxially oriented</td>
<td>Non-oriented High-barrier</td>
<td>Non-oriented Deep-draw molding</td>
<td>Biaxially oriented Aluminium-metallized Ultra-high barrier</td>
<td>Non-oriented Matt Wallpaper use</td>
</tr>
<tr>
<td>Width (cm)</td>
<td>50-120</td>
<td>50-120</td>
<td>50-120</td>
<td>custom made</td>
<td>96</td>
</tr>
<tr>
<td>Roll length (m)</td>
<td>4,000</td>
<td>2,000 - 4,000</td>
<td>2,000</td>
<td>4,000</td>
<td>4,000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Method of measurement</th>
<th>Conditions</th>
<th>EVAL™ films</th>
<th>Other films</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness (µm)</td>
<td>µm</td>
<td>ISO1184 23°C 50%RH</td>
<td>15 15 20 15 12 50 50 20 15 12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tensile strength at break</td>
<td>MPa</td>
<td>ISO1184 23°C 50%RH</td>
<td>210 110 80 210 40 50 20 130 200 160</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tensile elongation at break</td>
<td>%</td>
<td>ISO1184 23°C 50%RH</td>
<td>100 300 330 100 150 730 340 140 90 140</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young’s modulus</td>
<td>GPa</td>
<td>ISO1184 23°C 50%RH</td>
<td>4.0 3.0 2.0 4.0 1.2 0.7 0.1 1.9 1.7 3.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elmedorf tearing strength</td>
<td>N/mm</td>
<td>ISO6383-2</td>
<td>4.7 2.3 2.6 4.7 1.3 6.9 137.3 2.0 4.9 2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact strength</td>
<td>J</td>
<td>Kuraray method</td>
<td>0.8 0.2 0.5 0.8 0.0 0.6 0.4 0.9 1.0 0.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Puncture strength</td>
<td>N</td>
<td>JAS 23°C 50%RH</td>
<td>8.1 4.6 2.9 8.1 0.9 2.3 1.5 6.8 9.5 4.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture permeability</td>
<td>g/m² day JISZ0208 40°C 90%RH</td>
<td>29.0 690 27.0 0.5*</td>
<td>56.0 7.0 9.0 7.0 260.0 55.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water absorption rate</td>
<td>%</td>
<td>Kuraray method 30°C 24 hr</td>
<td>8.2 10.9 8.3 8.5 7.2 0.3 0.3 0.3 8.0 0.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moisture absorption rate</td>
<td>%</td>
<td>Kuraray method 23°C 50%RH</td>
<td>2.4 3.0 2.4 2.4 1.9 0.2 0.2 0.2 4.0 0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dimensional change on heating</td>
<td>%</td>
<td>Kuraray method 140°C 1 hr</td>
<td>-4.0 -2.7 -0.8 -4.2 1.0 - - -13.0 -1.5 -1.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxygen Transmission Rate</td>
<td>cm³/m².day.atm ISO14663-2 20°C 0%RH</td>
<td>0.2 0.2 0.8 &lt;0.05 -</td>
<td>1,300 2,700 2,100 40 85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface electrical resistance</td>
<td>Ω</td>
<td>Kuraray method 23°C 50%RH</td>
<td>2x10¹⁵ 2x10¹⁵ 2x10¹⁵ - -</td>
<td>3x10¹⁵ 3x10¹⁵ 3x10¹⁵ 5x10¹⁵ &gt;10¹⁶</td>
<td></td>
</tr>
<tr>
<td>Transparency (haze)</td>
<td>%</td>
<td>JISZ7105 23°C 50%RH</td>
<td>0.6 1.5 1.5 - 73.0 5.0 6.0 2.2 3.0 2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slip</td>
<td>°C</td>
<td>Kuraray method 23°C 50%RH</td>
<td>44 27 27 40 30 10 30 31 44 30</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*2 This value was 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.
Gas barrier properties of EVAL™ film

Relative humidity and oxygen transmission rate of various materials

<table>
<thead>
<tr>
<th>Material</th>
<th>OTR (cc.20µm/m².day.atm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDPE</td>
<td>ISO 14663-2 standard (65% RH)</td>
</tr>
<tr>
<td>BOPP</td>
<td></td>
</tr>
<tr>
<td>PVC-U</td>
<td></td>
</tr>
<tr>
<td>OPET</td>
<td></td>
</tr>
<tr>
<td>OPA6</td>
<td></td>
</tr>
<tr>
<td>PAN</td>
<td></td>
</tr>
<tr>
<td>PVDC</td>
<td></td>
</tr>
<tr>
<td>EVAL™ E type (44% ethylene)</td>
<td></td>
</tr>
<tr>
<td>EVAL™ F type (32% ethylene)</td>
<td></td>
</tr>
<tr>
<td>EVAL™ FILM (EF-XL)</td>
<td></td>
</tr>
<tr>
<td>MXD-6</td>
<td></td>
</tr>
</tbody>
</table>

EVAL™ layer thickness and OTR

Conditions: EVAL™ EF-F multilayer film 35°C, 0% RH

OTR (cm³/m².day.atm) vs Thickness of EVAL™ layer (µm)
Relative humidity of EVAL™ layer in laminated structures

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit</th>
<th>Measurement</th>
<th>Flavours</th>
<th>Material</th>
<th>EF-E</th>
<th>LDPE</th>
<th>CPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flavour absorption (liquid)</td>
<td>ppm</td>
<td>Kuraray method</td>
<td>d-Limonene</td>
<td>280</td>
<td>1,480</td>
<td>2,040</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>n-Butyl acetate</td>
<td>80</td>
<td>420</td>
<td>610</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ethyl acetate</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>Kuraray method</td>
<td>1-Menthol</td>
<td>0.2</td>
<td>9.6</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Salicylic acid methyl</td>
<td>1.7</td>
<td>26.0</td>
<td>35</td>
<td></td>
</tr>
</tbody>
</table>

b. Heat seal curve of EVAL™ film

Seal strength (N/15mm) vs. Sealing temperature (°C)

- LLDPE-50µm
- CPP -50µm
- EVAL™ EF-E - 30µm
Examples of use and structure of EVAL™ film

<table>
<thead>
<tr>
<th>Typical applications</th>
<th>Typical structure (out/in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Dried Bonito flakes</td>
<td>- OPP/EVAL™ film/PE</td>
</tr>
<tr>
<td>- Miso paste and bouillon</td>
<td>- OPP/EVAL™ film/PE</td>
</tr>
<tr>
<td>- Soup</td>
<td>- OPA/EVAL™ film/PE</td>
</tr>
<tr>
<td>- Rice cakes</td>
<td>- EVAL™ film/PE</td>
</tr>
<tr>
<td>- Fruit jelly (lid material)</td>
<td>- OPA/EVAL™ film/PE</td>
</tr>
<tr>
<td>- Cooked rice (lid material)</td>
<td>- OPA/EVAL™ film/PE</td>
</tr>
<tr>
<td>- Sweet bean jelly</td>
<td>- OPA/EVAL™ film/PP</td>
</tr>
<tr>
<td></td>
<td>- OPA/EVAL™ film/PE</td>
</tr>
<tr>
<td>Typical applications</td>
<td>Typical structure (out/in)</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>- Bean sprouts</td>
<td>- CPA/EVAL™ film/CPP</td>
</tr>
<tr>
<td>- Drip coffee packs</td>
<td>- PET/EVAL™ (VM-XL)/LLDPE</td>
</tr>
<tr>
<td>- Ketchup for restaurant use</td>
<td>- OPA/EVAL™ film/PE</td>
</tr>
<tr>
<td>- Long-lasting balloons</td>
<td>- PET/EVAL™ (VM-XL)/PE</td>
</tr>
<tr>
<td>- Wallpaper</td>
<td>- EVAL™/PVC/Paper</td>
</tr>
<tr>
<td>- Vacuum insulation panels</td>
<td>- OPA/VM-PET/EVAL™ (VM-XL)/PE</td>
</tr>
</tbody>
</table>
A one millimetre thickness of EVAL™ EVOH has about the same gas barrier properties as ten metres of LDPE. With such high performance, EVAL™ layers of only a few microns can add real function to multilayer structures. Barrier performance previously only available from metal or glass can thus be added to lightweight structures based on other recyclable and energy recoverable plastics, or renewable resources like PLA and paperboard.

**Protecting quality and value**

Although product development tends to focus specifically on EVAL™’s functional barrier properties, EVAL™ helps conserve resources and avoid waste throughout a product’s life cycle. Reducing waste, and thus avoiding the loss of all resources invested in the production and distribution of fresh food, is the best way to reduce environmental impact.

When used in laminated structures for food packaging, EVAL™ film layers of just 15-25 microns providing valuable barrier function, usually allowing a decrease in the total amount of packaging materials used. Optimized portion size, lightweight and extended freshness help improve the efficiency of storage, transport and display, saving costs and preserving resources.

**Reduced emissions**

When used in barrier structures for construction, agricultural and automotive fuel system applications, EVAL™ helps create lightweight structures that help protect the environment from gas, fuel or chemical emissions.

**Recyclable and recoverable**

EVAL™ EVOH is recyclable as post-consumer plastic waste, and will not disrupt polyolefin or PET recycling streams.

EVAL™ has excellent and safe energy recovery properties, often reducing the amount of extra fuel necessary for energy generation from the thermal disposal of sorted waste. Under perfect combustion, the few microns of EVAL™ in the package emit only small amounts of CO$_2$ and water vapour.

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**Environmental benefits of EVAL™ resins and film**

As the impact we create on our environment becomes an ever greater concern, the world continues to look for solutions that are truly sustainable. EVAL™ EVOH resins and films can help, providing valuable function while conserving resources, improving efficiency and avoiding waste, often throughout the entire life cycle of the product.
Introducing Kuraray and EVAL™

Kuraray Co., Ltd. was established in 1926 in Kurashiki, Japan, for the industrial manufacture of chemical fibres. As the world’s largest producer of vinyl acetate monomer (VAM) derivatives, Kuraray has long been a leader in high gas barrier technology and development. Today the Kuraray Group consists of about 70 companies, employing around 7,000 people worldwide.

Kuraray has been manufacturing and marketing ethylene vinyl-alcohol copolymers (EVOH) under the name EVAL™ since 1972, and remains the world leader in EVOH production and market development.

EVAL™ is one of Kuraray’s core businesses. EVAL™ resins are produced in Japan, the USA and Europe. EVAL™ films are produced in Japan. The sales and technical development of EVAL™ resins and films is supported by specialised local teams in each region.

Building better barriers
EVAL™ adds superior barrier functionality to multilayer plastic structures. Even very thin EVAL™ layers provide excellent results. EVAL™ is widely used as a functional gas and flavour/ aroma barrier in food, medical, pharmaceutical and cosmetic packaging, and as a gas and solvent barrier in industrial, construction, agricultural and automotive fuel system applications.
EVAL™ the world’s leading EVOH

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

Americas
EVAL Company of America (Pasadena, Texas, USA)
Capacity: 35,000 tons/year
The world’s largest EVOH production facility

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

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, loss, 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, methods and recommendations for the purpose intended prior to use.

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EVAL™ resins are produced worldwide under unified Kuraray product and quality specifications.