Food Packaging
EVAL™ EVOH adds valuable function to food packaging

Kuraray Co, Ltd. is the world leader in EVOH (ethylene vinyl-alcohol copolymer) production and development. An EVAL™ EVOH layer thickness of only a few microns helps avoid spoilage by keeping oxygen and odours out, while locking flavour, aroma and atmosphere inside where they belong. This protects quality and value, prolongs shelf life without artificial additives, and helps assure that food arrives to the consumer fresh with its vitamins intact. Fewer resources can often be used for the same packaging function. Optimised portion size, light weight and extended freshness help improve the efficiency of storage, transport and display, saving costs and preserving resources.

Oxygen permeation through various polymers

“1 mm of EVAL™ provides about the same gas barrier properties as a 10 metre thickness of LDPE.”

Typical co-extruded multilayer structure

Kuraray Co. is an active member of the Plastics Europe Association, the Food Contact Group (www.plasticseurope.org)
Using Kuraray technology, a variety of EVAL™ grades has been developed specifically for different methods of production and secondary processing of food packaging. Film or bottle, cup or pouch, tube or carton, deep thermoform or retort, there is an EVAL™ reference with the perfect balance of required properties. The result is world’s widest available range of EVOH grades.

**EVAL™ grade selection guide**

**EVAL™ M type**
has the lowest ethylene content available, and provides the highest barrier for automotive and flexible applications.

**EVAL™ L type**
has a very low ethylene content and is suitable as an ultra-high barrier grade in flexible, bottle and sheet applications.

**EVAL™ F type**
offers superior barrier performance with long-term run stability, and is widely used as the standard grade for flexible, automotive, bottle and tube applications. Specific versions exist for coating and pipe applications.

**EVAL™ T type**
was specially developed to obtain reliable layer distribution in thermoforming, and has become the industry standard for multilayer sheet and thermoformed flexible applications.

**EVAL™ J type**
offers thermoforming results even superior to those of T, and can be used for unusually deep-draw or sensitive sheet-based applications.

**EVAL™ C type**
can be used for high-speed co-extrusion coating and cast flexible applications.

**EVAL™ H type**
combines high-barrier properties with long-term run stability and thermoformability. The higher ethylene content allows easier processing and longer running times on older co-extrusion equipment, especially for blown flexible structures.

**EVAL™ E type**
has a higher ethylene content that allows for greater flexibility and even easier processing.

**EVAL™ G type**
has the highest ethylene content, making it the best candidate among standard EVAL™ grades for stretch and shrink film applications.
EVAL™ used in flexible applications

Food manufacturers have a list of requirements that flexible packaging must meet. They want their products to remain fresh for an extended period of time. The packaging should keep oxygen and odours out and lock aromas and protective modified atmospheres in. Attractive appearance, including excellent transparency, is important to give shelf appeal and give potential customers that extra incentive. Packaging should also be light in weight yet strong enough to maintain all its useful characteristics during transport and handling.

Extended shelf life
The superior barrier properties of EVAL™ add function to plastic food packaging, ensuring real value protection and extending shelf life far waste and cost reduction. As the food industry continues to target reduction of the total amount of packaging, flexible structures remain the largest EVAL™ application worldwide. This is mainly thanks to EVAL’s superior barrier performance by thickness and weight compared to all other conventional polymers.

Thermoforming qualities
EVAL™ SP grades also have thermoforming windows that are much closer to those of PP and even PS. Multilayer flexible structures containing a layer of EVAL™ SP can be laminated onto thin sheet to produce food trays, providing exceptional clarity and barrier performance even with deep thermoforming.
Processing method
Co-extrusion cast and blown film

Grades
Depending on the method and conditions EVAL™ L, F, T, H, E and G types can be used. All EVAL™ types are pasteurisable. Retortable grades are also available. Orientable EVAL™ SP grades are suitable for double bubble shrink film and deep thermoforming.

<table>
<thead>
<tr>
<th>Typical applications</th>
<th>Typical structure (out/in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-barrier laminate pouch/package</td>
<td>EVA/tie/EVAL™/tie/PE/PET</td>
</tr>
<tr>
<td>Fresh red meat</td>
<td>PE/PE/tie/EVAL™/tie/PE/PET</td>
</tr>
<tr>
<td>Fish</td>
<td>PE/tie/EVAL™/tie/PE/PA</td>
</tr>
<tr>
<td>Cheese</td>
<td>PE/tie/PA/EVAL™/PA</td>
</tr>
<tr>
<td>High-barrier formable structures</td>
<td>Ionomer/tie/PA/EVAL™/PA</td>
</tr>
<tr>
<td>Fresh pasta</td>
<td>PE/tie/PA/EVAL™/PA/tie/PE</td>
</tr>
<tr>
<td>Pouch</td>
<td>EVA/tie/EVAL™/tie/PE</td>
</tr>
</tbody>
</table>
EVAL™ resins used in flexible applications:

- Provide an excellent oxygen barrier to protect valuable food ingredients.
- Ensure that packaged contents remain fresh throughout the entire supply chain and during prolonged storage, often reducing or eliminating the need for added preservatives.
- Give food packaged under modified atmosphere a longer shelf life without loss of quality.
- Can be easily printed with high-quality and eye-catching graphics in order to give the buyer an extra incentive to purchase.
- Can be processed economically and easily.
- Present excellent transparency.
- Allow thickness reduction, resulting in more economical structures and reducing impact on the environment.
Adding function
to fresh meat packaging

Shrink films and bags are widely used for packaging fresh meat, both for business-to-business distribution and for end consumers. When heat is applied the film/bag shrinks to fit firmly around the portion of meat. Packaging is reduced to a minimum, and adapts itself to the individual shape of the product.

Shrink film/bags are convenient since standard sized bags adapt themselves to the individual sizes of each portion. They provide clarity and enhance the appearance of the packaged meat. They are tamper evident and maintain product quality. By adding a high-barrier layer of EVAL™ to the shrink film/bag structure, oxygen permeation is blocked and shelf life is extended. The packaged product retains its freshness longer, protecting value and reducing waste.

Technological innovation has created the world’s widest range of available EVOH grades, suitable for the production and secondary processing of fresh food packaging.

EVAL™ SP types are orientable, and especially suited to double bubble processing. They offer superior barrier properties while maintaining desired clarity and shrink ratios.

EVAL™ G type has a higher ethylene content, which allows excellent flexibility and easy processing.

EVAL™ H type combines high-barrier properties with long-term run stability and thermoformability. The higher ethylene content allows easier processing and longer running times on older co-extrusion equipment, especially for blown flexible structures.

<table>
<thead>
<tr>
<th>Type</th>
<th>EVAL™ SP482B</th>
<th>EVAL™ SP292B</th>
<th>EVAL™ G156B</th>
<th>EVAL™ H171B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethylene content (mol%)</td>
<td>32</td>
<td>44</td>
<td>48</td>
<td>38</td>
</tr>
<tr>
<td>Density (g/cm³)</td>
<td>1,16</td>
<td>1,13</td>
<td>1,12</td>
<td>1,17</td>
</tr>
<tr>
<td>MFR (g/10 min)</td>
<td>2.0</td>
<td>2.1</td>
<td>6.9</td>
<td>1.7</td>
</tr>
<tr>
<td>Tm (°C)</td>
<td>181</td>
<td>161</td>
<td>160</td>
<td>172</td>
</tr>
<tr>
<td>Tg (°C)</td>
<td>41</td>
<td>48</td>
<td>50</td>
<td>53</td>
</tr>
<tr>
<td>OTR (cm³·20µm/m²·day·atm)</td>
<td>0.6</td>
<td>3.1</td>
<td>3.2</td>
<td>0.7</td>
</tr>
</tbody>
</table>

(1) 20°C  (2) 190°C, 2160g  (3) dry  (4) OTR, 20°C, 65% RH (ISO 14663-2)
**EVAL™ used in bottle applications**

*Food packaging today is expected not only to preserve its content until it is consumed, but to also make sure that the product can be consumed in a safe and convenient way. Freshness and valuable vitamin content are at a premium, but must be protected.*

**Building better barriers**
Plastic bottles provide the benefits of being convenient, squeezable and safe to use. However, PE, PP and even PET don’t always have enough barrier properties to shield contents over extended shelf lives. Oxygen and odour can permeate in, and flavour and CO₂ can permeate out. Just a few microns of EVAL™ in a multilayer bottle structure can extend shelf life, eliminate the need for artificial additives, and often avoid the need for cold chain storage and distribution.

**Lighter weight, less waste**
Optimised portion size, lightweight and extended freshness help improve the efficiency of storage, transport and display, saving costs and preserving resources. Co-extruded bottles containing EVAL™ can be recycled either on stream as a regrind layer or as post-consumer waste.

EVAL™ SP grades can be used for making co-injected barrier pre forms and stretch-blow moulded bottles. They offer excellent delamination resistance and superior oxygen and CO₂ barrier, ideal for beer and carbonated soft drink PET bottles that protect quality and taste, and extend shelf life. EVAL™ resins do not disrupt PET and polyolefin recycling streams.

**EVAL™ resins used in bottle applications:**
- Prevent oxygen ingress.
- Ensure preservation of valuable vitamins, aroma substances, fatty acids (e.g. Omega 3) and other highly oxidation-sensitive ingredients.
- Permit a prolonged shelf life even in non-refrigerated conditions.
- Prevent oxygen-related discolouration of the packaged goods (e.g. tomatoes, apples, mustard and sauces).
- Make for virtually unbreakable bottles.
- Are easy to squeeze.
- Are light in weight: convenient for consumers and allow for an environmentally-friendly reduction of the costs of handling and transport.
- Offer an excellent CO₂ barrier for prolonged freshness of beer and CSD.
- Do not impair PET or polyolefin recycling streams.
Typical applications
Ketchup bottles, sauce bottles
Juice and milk bottles
Beer, carbonated beverages
Dry food e.g. coffee, nuts

Typical structure (out/in)

<table>
<thead>
<tr>
<th>Typical applications</th>
<th>Typical structure (out/in)</th>
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<tbody>
<tr>
<td>Ketchup bottles, sauce bottles</td>
<td>PP/tie/EVAL™/tie/regrind/PP</td>
</tr>
<tr>
<td>Juice and milk bottles</td>
<td>EVAL™/tie/PP</td>
</tr>
<tr>
<td>Beer, carbonated beverages</td>
<td>PE/tie/EVAL™/tie/regrind/PE</td>
</tr>
<tr>
<td>Dry food e.g. coffee, nuts</td>
<td>PET/EVAL™/PET/EVAL™/PET</td>
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<tr>
<td></td>
<td>PET/EVAL™/PET</td>
</tr>
</tbody>
</table>
EVAL™ used in thermo-formed sheet applications

Food presented in cups made of thin, transparent plastic is particularly appetising. Crystal-clear and unbreakable barrier cups and trays are safe to use, and represent a fast-growing segment in the packaging market. The most important requirement for this thermoformed sheet packaging is that it protects the flavour of the contents, keeping it fresh for a long period of time, even in non-refrigerated conditions.

Protecting colour and flavour
EVAL™ has especially developed EVAL™ types T and J to provide an excellent oxygen barrier and superior transparency and to ensure that the food retains its flavour and colour for a long period of time.

Even under deep forming conditions, these two EVAL™ types provide a good and even layer distribution, which makes them particularly suited for thermoformed packaging applications.

Deformation resistant
Co-extruded multilayer thermoformed cups with an oxygen barrier layer of EVOH can easily be pasteurised and show a remarkable resistance against deformation upon thermal treatment including sterilisation.

Thermoforming qualities
EVAL™ SP grades have thermoforming windows that are much closer to those of PP and even PS. SP grades are orientable, providing excellent clarity even when thermoforming deep or unusual shapes. Despite the improved forming properties, SP grades do not compromise on barrier properties, and usually allow for economical and environmentally-friendly thickness reduction of multilayer structures.
EVAL™ resins used in thermoformed sheet applications:

- Keep oxygen out.
- Keep packaged product appetising and fresh for long periods of time even in non-refrigerated conditions.
- Present excellent transparency.
- Distribute thickness equally even under extreme forming conditions, which allows a wider processing window for thermoforming.
- Are microwaveable, unbreakable and safe in use.
- With SP grades provide excellent clarity for deep and unusual form shapes, and usually allow for economic and environmentally-friendly thickness reduction.
- Are recyclable.

Processing methods
Sheet co-extrusion and thermoforming

<table>
<thead>
<tr>
<th>Typical applications</th>
<th>Typical structure (out/in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retortable food trays</td>
<td>PP/tie/EVAL™/tie/regrind/PP</td>
</tr>
<tr>
<td>Sauces</td>
<td>PP/regrind/tie/EVAL™/tie/regrind/PP</td>
</tr>
<tr>
<td>Baby food</td>
<td>PE/regrind/tie/EVAL™/tie/regrind/PS</td>
</tr>
<tr>
<td>Soup</td>
<td>PS/tie/EVAL™/tie/PS</td>
</tr>
<tr>
<td>Prepared meals</td>
<td>PE/tie/EVAL™/tie/PS</td>
</tr>
<tr>
<td>Dairy</td>
<td>PP/tie/EVAL™/tie/PP</td>
</tr>
<tr>
<td>Beverages</td>
<td>PET/tie/EVAL™/tie/PE</td>
</tr>
<tr>
<td>Coffee</td>
<td></td>
</tr>
<tr>
<td>Fruit cups</td>
<td></td>
</tr>
<tr>
<td>Meat trays</td>
<td></td>
</tr>
<tr>
<td>Pet food</td>
<td></td>
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</tbody>
</table>
EVAL™ used in coating applications

Packaging made of renewable resources like paper and carton board can help reduce the environmental impact of packaging. However, they lack basic barrier properties required to extend freshness and shelf life. This can be solved by adding a very thin functional layer of EVAL™. Paper/plastic structures are reliable and pin-hole resistant when folded, and allow for easy and safe energy recovery at end of life.

EVAL™ resins used in coating applications:
- Extend shelf life while keeping the product fresh and appetising.
- Prevent penetration of oxygen into the package, while keeping aroma and flavour inside.
- Resist flavour scalping that commonly occurs with other plastics.
- Offer good thermal stability, which allows high-speed packaging, without the formation of pinholes, both during processing, assembly, filling and transport.
- Present excellent printability and glossiness.

Processing methods
Co-extrusion coating

<table>
<thead>
<tr>
<th>Typical applications</th>
<th>Typical structure (out/in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spice and cereal packages without an additional inner bag</td>
<td>PE/paper/PE/tie/EVAL™/tie/PE</td>
</tr>
<tr>
<td>Wine, juice, dairy products, mineral water and edible oil</td>
<td>PE/paper/PE/tie/EVAL™/tie/PE</td>
</tr>
<tr>
<td></td>
<td>Paper/PE/tie/EVAL™/tie/PE</td>
</tr>
</tbody>
</table>
EVAL™ used in tube applications

Tube packaging applications can offer a welcome alternative for certain food products that are traditionally packaged in bottles. One of the multiple advantages of overall plastic tubes containing an EVAL™ layer is that they provide an excellent gas barrier to preserve the quality of the contents. The tubes are also flexible and easy to squeeze without losing their shape, even after frequent usage. Attractive appearance allows tubes to be sold directly on the store shelf, without the need for a protective carton box.

EVAL™ resins used in tube applications:
- Prevent penetration of oxygen, which could cause premature spoilage of the product.
- Ensure preservation of vitamins, aroma substances, fatty acids and other highly oxidation-sensitive ingredients.
- Allow no oxygen-related discoloration of tomato-based products, chocolate, mustard, apple-based products.
- Ensure attractive and functional tube appearance.
- Are light in weight and flexible: convenient for consumers and it reduces the cost of handling and transport.
- Offer excellent printability to increase the visibility and the attractiveness of the package.

Processing methods
Tube co-extrusion

<table>
<thead>
<tr>
<th>Typical applications</th>
<th>Typical structure (out/In)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ketchup, mustard, sauces, tomato paste</td>
<td>PE/tie/EVAL™/tie/PE</td>
</tr>
</tbody>
</table>
Environmental benefits of EVAL™ resins

The best way to reduce impact on the environment is to minimise both product and packaging waste. EVAL™ EVOH resins can help, providing valuable function often while reducing the total amount of packaging. This generates savings by conserving resources, improving efficiency and avoiding waste, often throughout the entire life cycle of the product.

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 lighter weight structures based on other recyclable and energy recoverable plastics, or renewable resources like PLA and paperboard.

Reducing waste
Although packaging 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.

More function, less packaging
When used in packaging, EVAL™ layers of just a few microns allow to use fewer resources while providing valuable barrier function. Optimised portion size and light weight help improve the efficiency of storage, transport and display. Extended freshness and the protection of quality help reduce waste, conserving resources.

Recyclable and recoverable
EVAL™ EVOH is recyclable, and is commonly used in regrind structural layers rigid food packaging such as bottles, cups and trays. It can also be used for post-consumer recycling, 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 a package emit only small amounts of CO₂ and water vapour.

In addition to ISO 9001:2000, EVAL Europe nv is compliant with ISO 14001:2004 and ISO/TS16946 standards. More info at www.eval.eu
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 nearly 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 and is produced worldwide in Japan, the USA and Europe. The sales and technical development of EVAL™ is supported by specialised local teams in each region.

Building better barriers
EVAL™ adds superior barrier functionality to multilayer plastic structures. Since 1 mm of EVAL™ provides about the same gas barrier properties as a 10 metre thickness of LDPE, 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
Kuraray America Inc. (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

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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, 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.