



 **EVAL** EUROPE

EVAL™ for hydrogen fuel cell systems



kuraray

Introducing EVAL Europe

Kuraray and EVAL Europe

Kuraray Co., Ltd. was established in 1926 in Kurashiki, Japan, for the industrial manufacture of chemical fibres. It has long been a leader in high gas barrier technology and development, and has been manufacturing and marketing ethylene vinyl-alcohol (EVOH) copolymer resins since 1972.

The first and foremost producer of EVOH (ethylene vinyl-alcohol copolymer resins) under the name EVAL™ and the manufacturer of KURARISTER™ film, today the Kuraray Group consists of about 70 companies, employing around 7,000 people worldwide.

EVAL Europe nv was founded as a wholly owned subsidiary in Antwerp in 1997 to supply the European, Middle Eastern and African markets with EVAL™ resins. Today it is backed by over three decades of experience and with its specialised team serves European customers from its Technical and Development Centre. In October 2004 it doubled its capacity to 24,000 tons per year, continuing the commitment to local supply as Europe's largest EVOH production site.

Unique technology from Kuraray

Kuraray, Co. Ltd. has developed leading high barrier technologies that are results of Kuraray's pioneering research and development in this field.

EVAL™ resins constitute superior gas barrier properties and excellent co-extrusion processability, while being recyclable. The wide variety of grades makes them ideal for food packaging, cosmetics, construction and building, automotive and industrial applications.

Hydrogen fuel cells are a promising technology that provides energy for stationary applications, mobile use in transport, and even power generation for a laptop or camcorder. Over the next ten years, it is expected that fuel cells will be commercially introduced into several transportation and utility power markets.

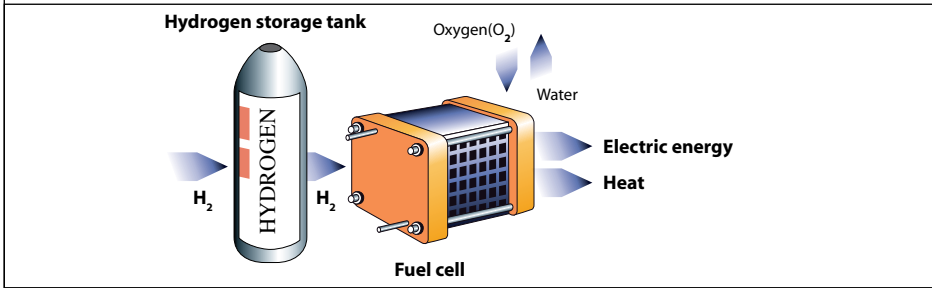
Protecting the environment

EVAL™ EVOH is an environmentally friendly plastic. It contains no chlorine, dioxin, metals or endocrine disrupters. It can be recycled, either as part of a separate coextruded regrind layer or as post-consumer regrind. And it will not disrupt polyolefin or PET recycling streams and processes.

Hydrogen fuel cells do not produce polluting emissions or greenhouse gases. Hydrogen storage and fuel cell systems need to be reliable and must provide an outstanding barrier against hydrogen gas, EVAL™ EVOH resins help ensure very low hydrogen gas permeation.

EVAL™ for hydrogen fuel cells

Schematic diagram of a polymer-electrolyte-membrane fuel cell (PEMFC) that uses hydrogen as fuel



Advantages of an EVAL™ layer in a multilayer plastic hydrogen tank:

- An outstanding barrier to hydrogen under high pressure – superior to that of other polymers.
- Reduced weight, resulting in greater fuel economy.
 - EVAL™ resins are lighter than metal.
 - Multilayer plastic hydrogen tanks are lighter than metal tanks.
- Environmentally friendly.
 - Fully recyclable.
- EVAL™ resins are easily processable by (co)extrusion, (co)extrusion blow moulding, rotomoulding, (co)injection.

EVAL™ copolymer grades

EVAL™ ethylene vinyl-alcohol (EVOH) copolymer resins are characterised by their outstanding gas barrier properties and by their excellent processing.

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

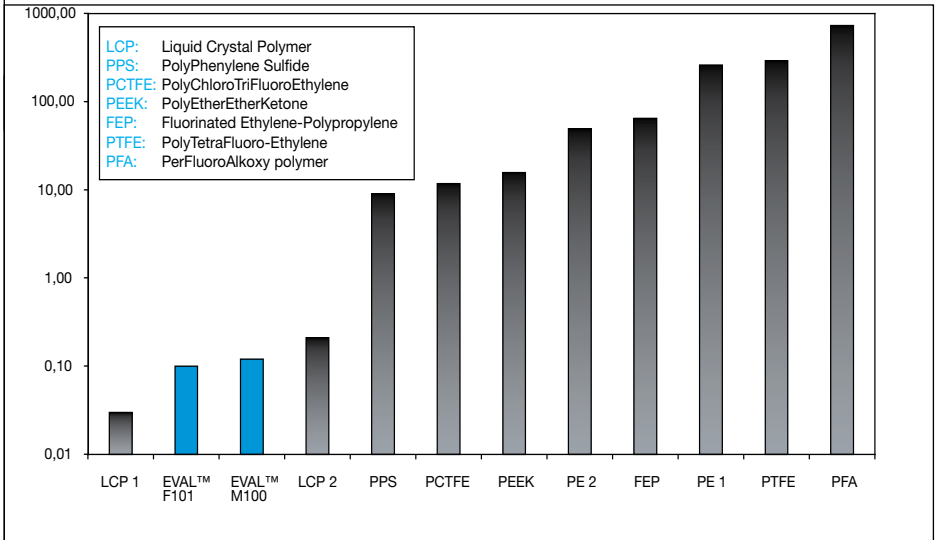
EVAL™ F type offers superior barrier performance and is widely used for automotive, bottle, film, tube and pipe applications.

Properties of EVAL™ resins

EVAL™ resins offer outstanding hydrogen barrier properties, superior to those of other polymers.

H₂ permeability coefficient (cm³ (STP).mm/m².d.atm) at 23-30°C, at 1 atm absolute

Samples: monolayer films with a thickness of 0.1-0.2mm; EVAL™ monolayer films with a thickness of 0.1mm



Modified after a presentation at IQPC Conference "Automotive Fuel Tank System Forum" 2006, with permission of Mecadi GmbH, www.mecadi.com.

The hydrogen barrier properties of EVAL™ are influenced by several factors: the ethylene content, the temperature, the relative humidity, the thickness of the layer, and the pressure. Whatever the condition, EVAL™ offers outstanding hydrogen barrier properties compared to other materials.

Influence of the ethylene content

A lower ethylene content results in a better hydrogen barrier.

Influence of the temperature

The hydrogen barrier performance versus temperature follows the Arrhenius law, i.e. the gas permeability of polymers increases as the storage temperature increases.

EVAL™ grade	Temperature °C	Hydrogen gas transmission rate (H ₂ GTR) cc/m ² .d.atm for 0.1 mm at 20°C and 0% RH
EVAL™ M100	20	3
	40	5
	60	15

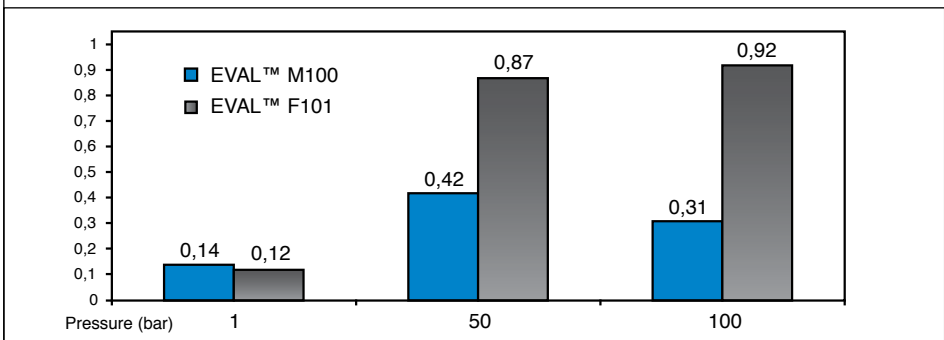
Influence of the layer thickness

The gas barrier properties of EVAL™ resins are inversely, linearly proportional to the thickness of the EVAL™ layer. When the thickness of the EVAL™ layer is doubled, the H₂GTR is halved.

Influence of the pressure

A lower pressure results in a better hydrogen barrier.

Hydrogen permeability coefficient at 23°C and 0% RH (cm³.mm/m².d.atm) at different pressures



Measurements carried out at Mecadi GmbH.
 Measurement of monolayer films: 0.1 mm thick, medium value of three independent specimen, applied pressure difference over the film is 0 bar, 50 bar and 100 bar.
 Reference measurement on sintered metal: < 0.025 for 1 bar, < 0.001 cc(STP).mm/m².d.atm for 50 and 100 bar.



EVAL EUROPE

EVAL AMERICAS

EVAL™ - the world's leading EVOH

KURARAY CO., LTD. (Shanghai)

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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

EVAL EUROPE

Building better barriers

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

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

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