COMPARATIVE PERFORMACE OF EBA COPOLYMERS

01

EVA/EBA comparative properties

EVA/EBA Compartive Properties

1 **Higher thermal stability for EBAs**
EBA is much more resistant to thermal degradation than EVA, and consequently can be processed at significantly higher temperatures (~ 280 ºC) if required.

2 **Not formation of acetic acid upon degradation in EBAs**

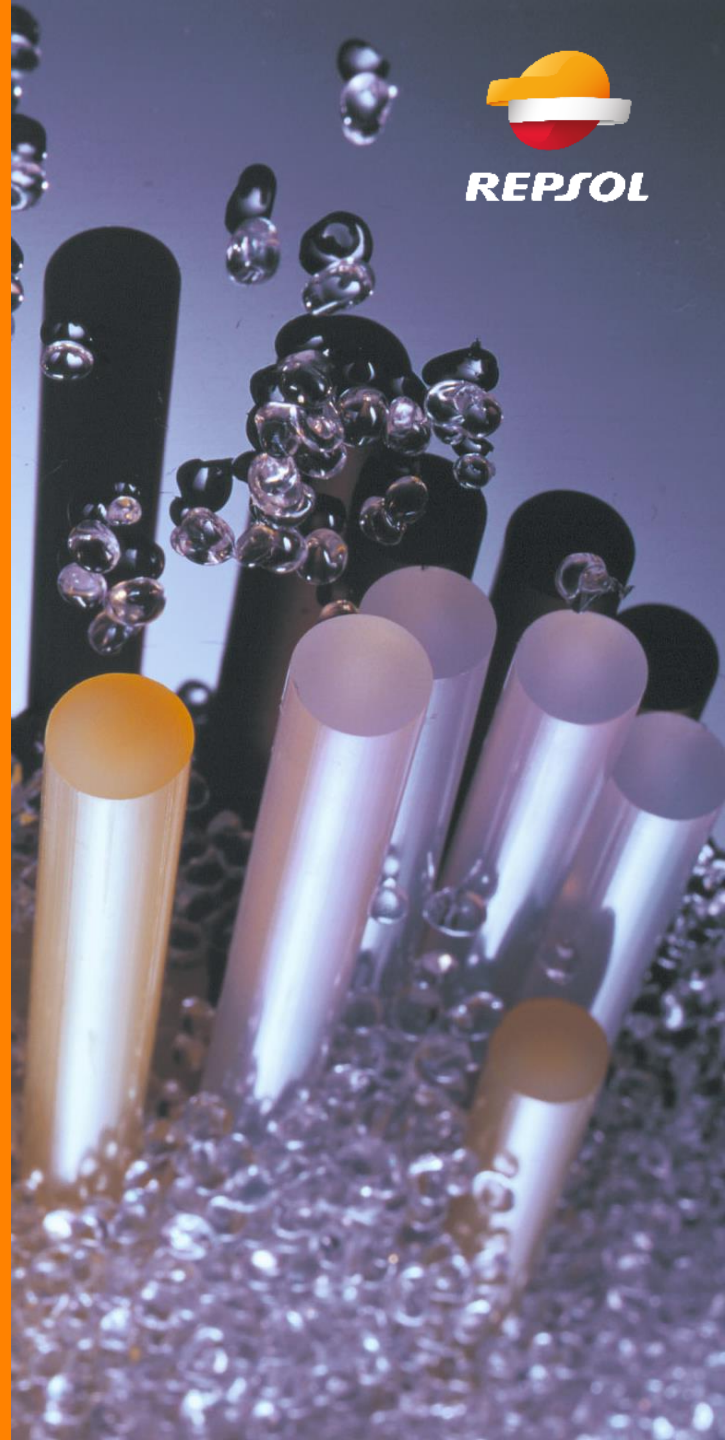
3 **Better low temperature behavior for EBAs**
Because of lower Tg (EBA: ca. - 50ºC, EVA: ca. - 30ºC) EBA maintains higher flexibility at low temperatures.

4 **High adhesion to difficult substrates**
Repsol Ebantix® for hot melt has high adhesion to those difficult substrates like polypropylene or aluminum.

5 **Lower water absorption for EBAs**
EBA shows lower water absorption at comparable comonomer contents.

6 **Lower density for EBAs**
In contrast to EVA, EBA density remains approximately constant with increasing % BA content (0.924-0.928 g/cm^3).

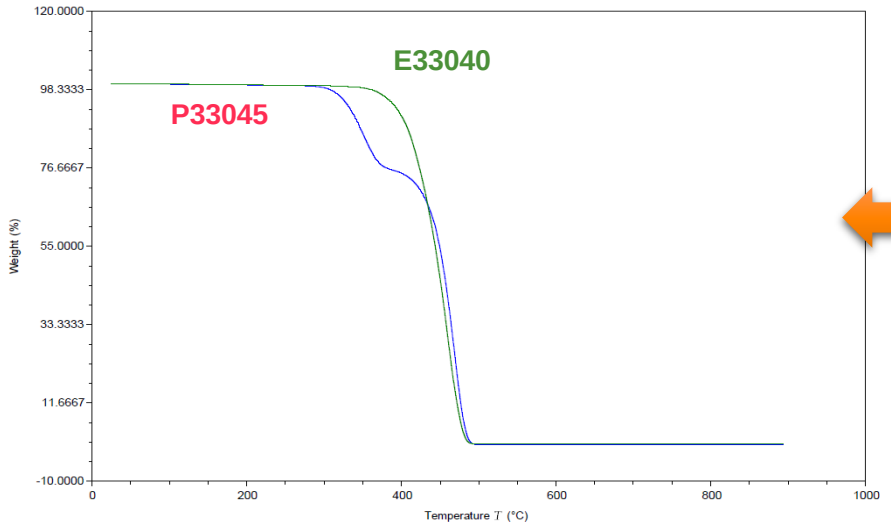
7 **All our EVA & EBA** grades are **available as circular and bio-based.**



EVA/EBA Compartive Properties

❑ PROCESSABILITY

❑ EBA E33040 **can be processed at a higher temperature**



P33045 descomposes at lower temperature

❑ EBA E33040 **shows higher thermal stability**

❑ EBA E33040 **shows a better processability**

EVA/EBA Compartive Properties

❑ LOW TEMPERATURE BEHAVIOR

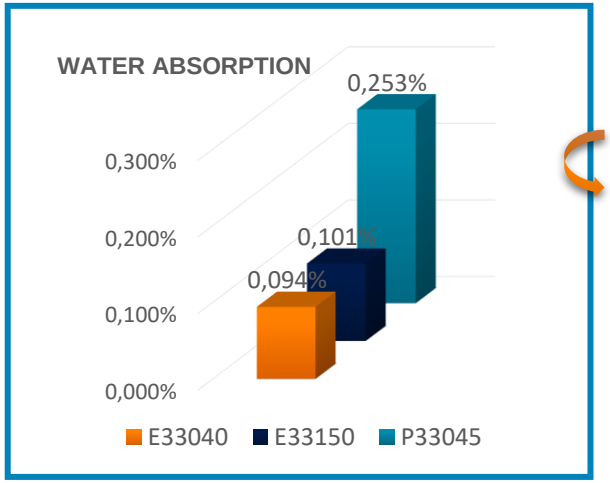
❑ **EBA E33040 shows a better behavior at low temperature and lower water absorption**

➢ **HMA application:** better behaviour for E33040 at low temperatures

Tg (E33040) = -50ºC vs. **Tg (P33045) = -30ºC**

Lower glass transition temperature (Tg) for E33040

➢ **E33040** would better retain its mechanical and electrical properties when used under wet and frozen environment.

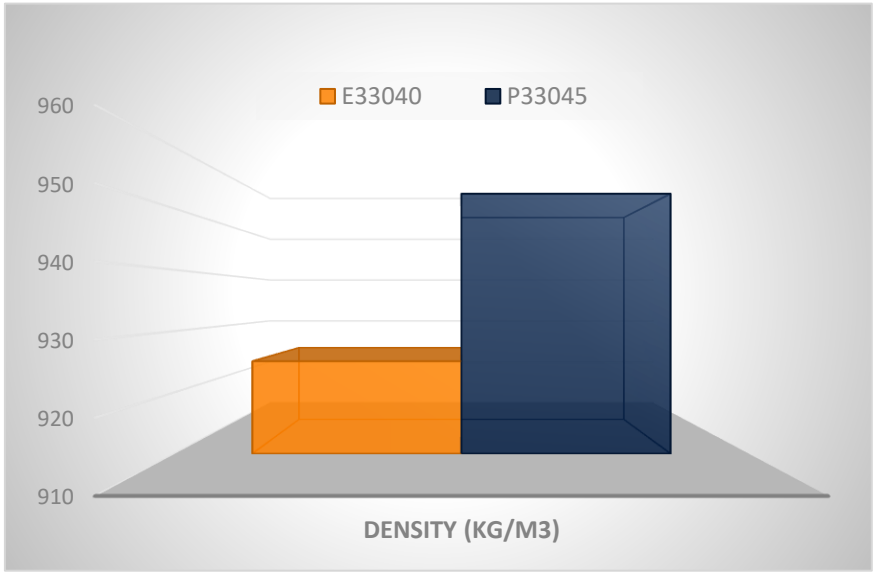


The Ebantix grades show lower water absorption than P33045

EVA/EBA Compartive Properties

❑ COST SAVINGS

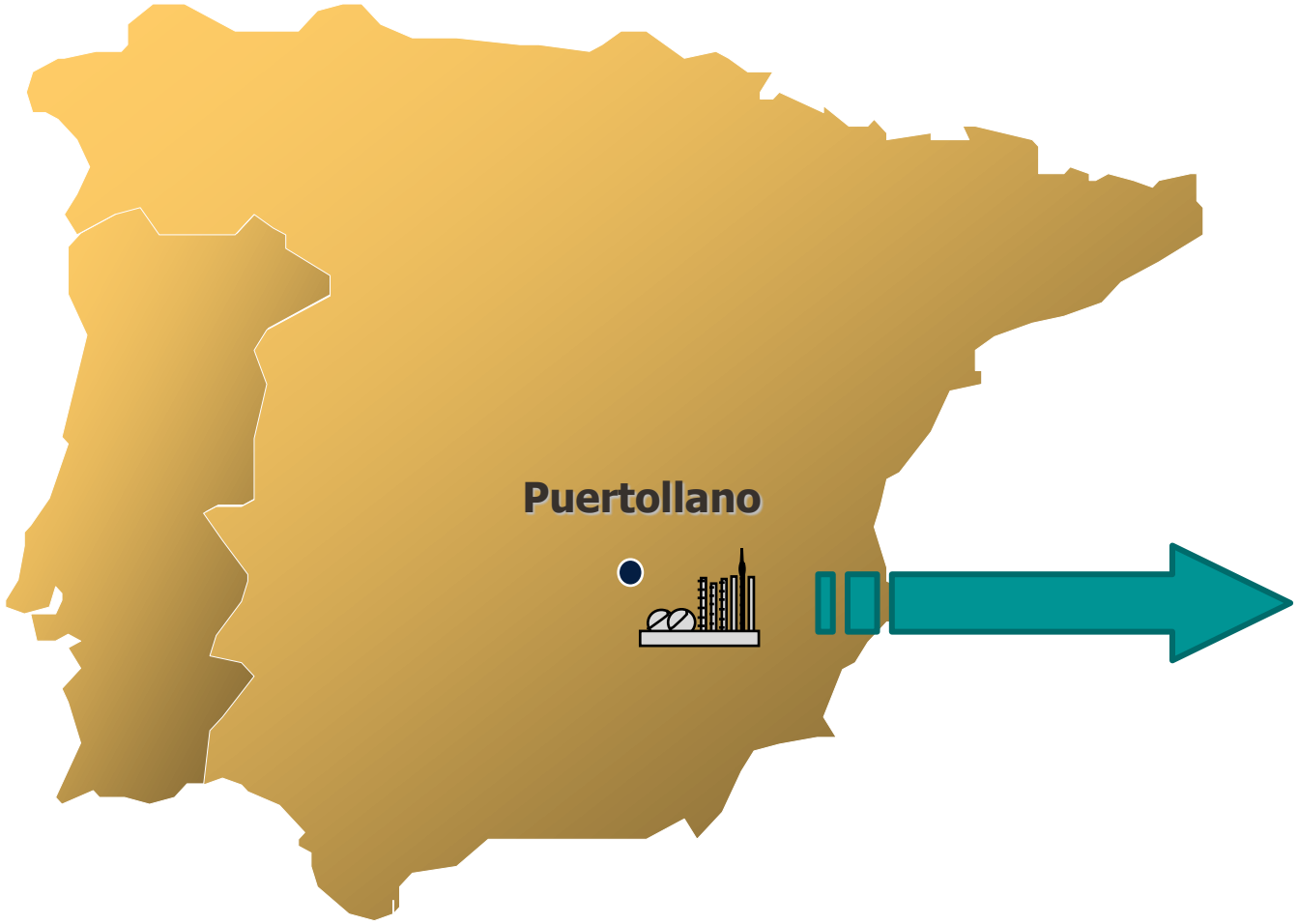
❑ EBA E33040 **involves a direct cost reduction due to material saving**



EBA E33040 shows a lower density:

- *Density (E33040) = 925 kg/m3*
- *Density (P33045) = 952 kg/m3*

Repsol: EVA production



- **EVA**
- **Autoclave Process**
- **MFI: 0.7-2000**
- **% VA: 7.5-40**

Applications:
- Stretch hood
- Lamination
- Adhesives
- Solar panels
- Foams
- Injection molding and blending

Repsol: EVA production

Grades: Repsol Primeva®

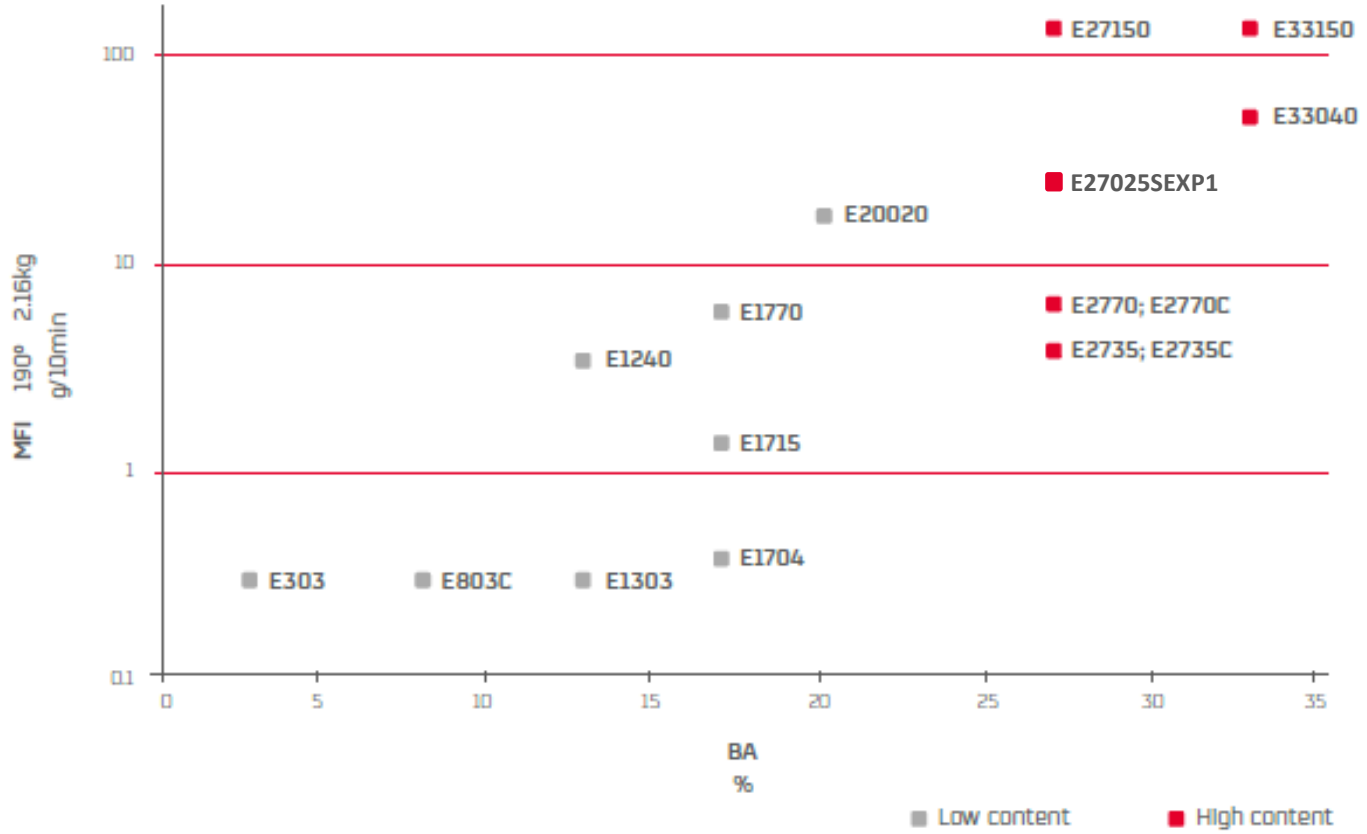
Repsol: EBA production

- **EBA**
- **Autoclave Process**
- **MFI: 0.3-150**
- **% BA: 3-33**

Applications:
- Agriculture
- Stretch hood
- Lamination
- Foams
- Injection molding and blending
- Adhesives

Repsol: EBA production

Grades: Repsol Ebantix®



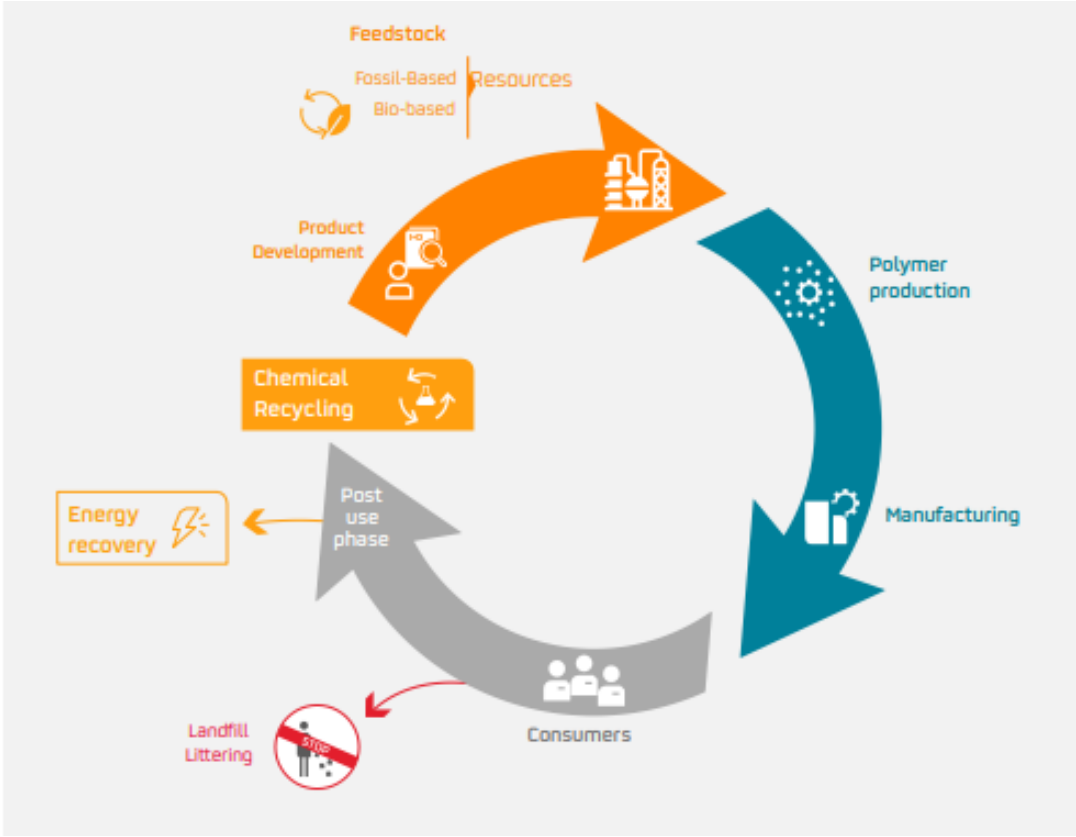
Circular and bio-based grades

Equivalent for our Repsol Primeva® P28400 standard grade:

- Repsol Reciclex® Circular: CIRCP28400
- Repsol Reciclex® Bio Circular (2G): CBIOP28400

Equivalent for our Repsol Ebantix® E27150 standard grade:

- Repsol Reciclex® Circular: CIRCE27150
- Repsol Reciclex® Bio Circular (2G): CBIOE21750



- **Full range available**
- **Properties identical to conventional grades**
- **Suitable for food and hygienic applications**
- **ISSC certified (material balance)**

03
Applications

ADHESIVES

ADVANTAGES OF EBA IN HOT MELT ADHESIVES

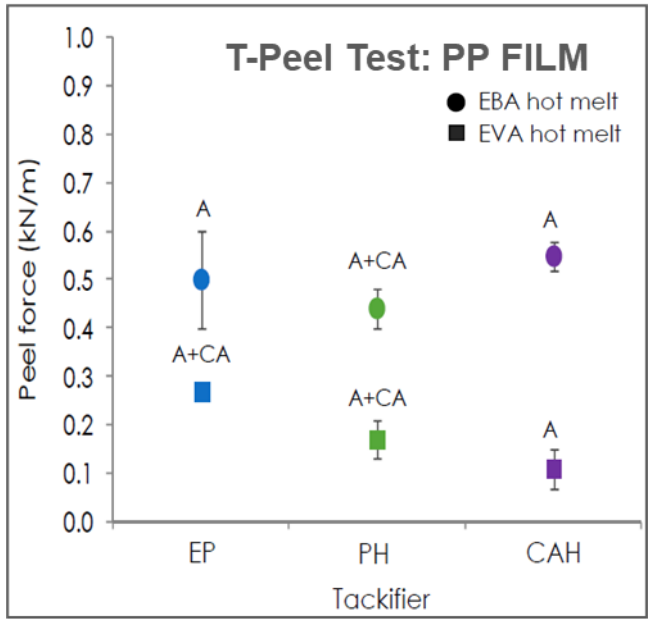
Hot-melts with **EBANTIX®** show:

- Compatibilty with most tackifiers (not with aromatic hydrocarbons)
- High thermal stability
- Short set time, high hot tack and great peel adhesion to polypropylene

PRIMEVA® and **EBANTIX®** can be blended to modulate hot-melt properties

EBA vs EVA HOTMELTS

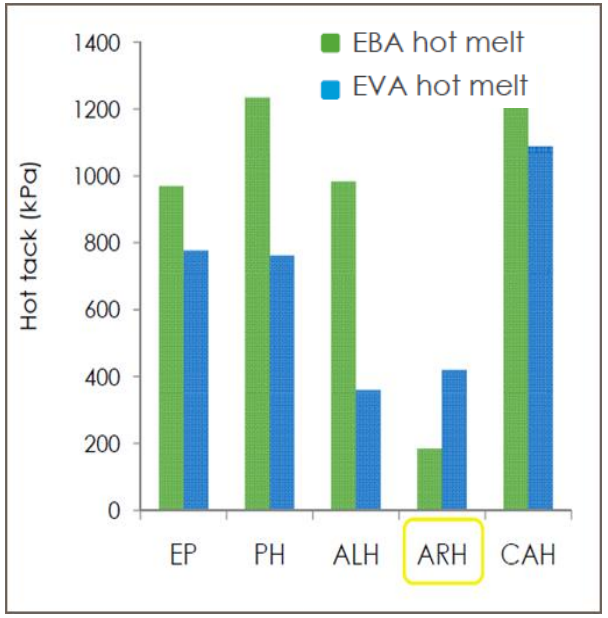
Peel test



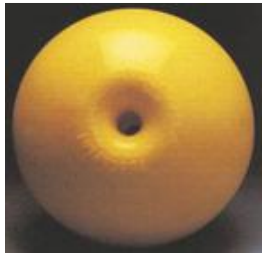
EBA hot melts provided a **greater peel adhesion to polypropylene** than EVA hot melts

CA: cohesive failure in the adhesive Hot melt
A: adhesion failure
RS: rupture of the substrate

Hot Tack



EBA adhesives show higher **hot tack** than EVA adhesives


FOAMS

Foams

Repsol EVA/EBA range

EVA grades (%VA/MFI): P1340 (13/4), P1820C (18/2), P18010 (18/10), P2430 (24/3), P2870(28/7)

EBA grades (%BA/MFI): E1240 (12/4), E1715 (17/1.5), E1770 (17/7), E2735/C (27/3.5), E2770/C (27/7)

ADVANTAGE OF THE USE OF EBA IN FOAMS

- *EBA can be foamed under similar conditions as an EVA, keeping machine parameters approximately constant*
- *Similar formulations used for foaming EVA can be used for EBA*
- *The density of the EBA grade provides saving in material compared to a similar EVA*

ADVANTAGE OF THE USE OF EBA IN FOAMS

Foams produced with Repsol's EBA E1715 have shown improved characteristics compared to similar EVA grades:

- ***Less shrinkage***
- ***Less loss due to abrasion, compared to EVA***
- ***Higher elongation***

Property	Norm	E1715	P1820C
Hardness (º Shore A, skin)	UNE-EN ISO 868-98	44/45	44/45
Density (gr./cm^3)	UNE 53526-70	0,22	0,22
Abrasion (mm^3)	UNE 53527-91 (5N)	148	226
Tensile Stress (N/mm^2)	UNE 53510	2,27	2,49
Tear strenght (N/mm)	UNE 53516-83	2,73	2,67
Elongation (%)	UNE 53510	200	140
Shrinkage (%)	-	4	12

ASPHALTS MODIFICATION

Asphalts modification

Repsol EVA/EBA range

General EVA/EBA characteristics:

- Good absorption / dispersion of fillers
- Good mechanical properties at low temperatures (cold weather)

Modified asphalts with improved performance

Improved resistance to tread formation due to heavy and intense traffic

Good oxidation stability

EVA grades (%VA/MFI): P20020(20/20), P2430 (24/3), P2870 (28/7), P28025 (28/25), P1550M (15/vis 5000cP)

EBA grades (%VA/MFI): E1240 (12/4) E20020(20/20), E2735 (27/3.5), E2770(27/7)

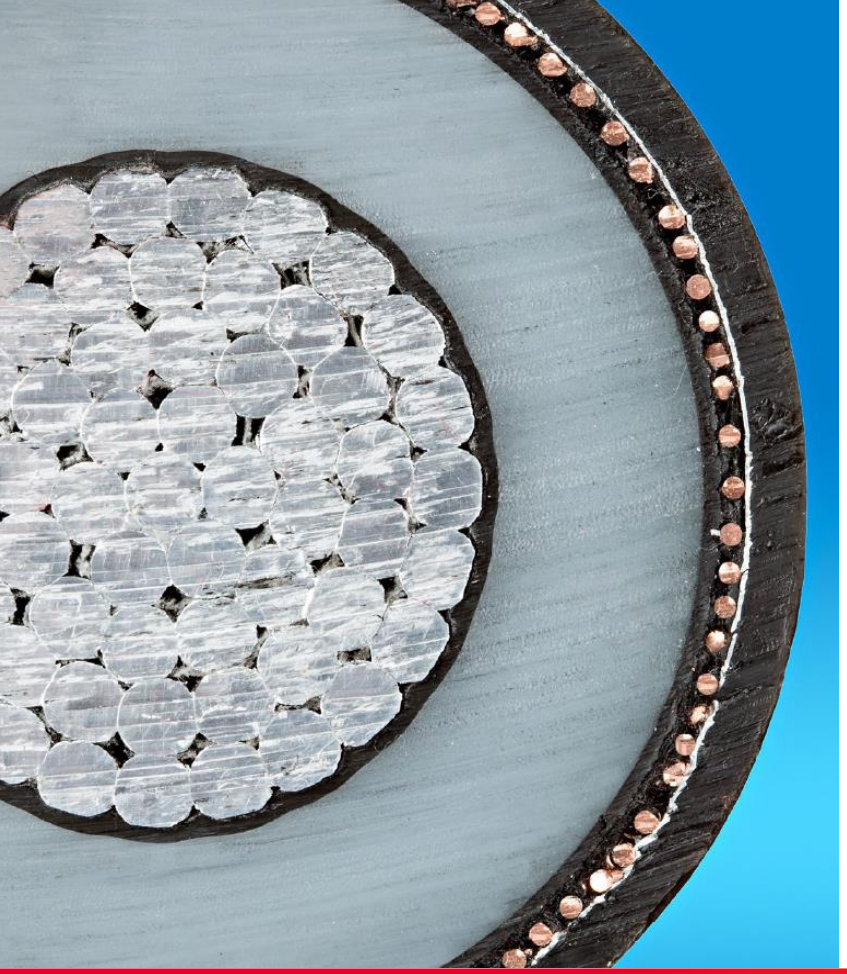
EVA & EBA MODIFIED BITUMENS

- EBA is much more resistant to thermal degradation than EVA, and therefore can be processed at a significantly higher temperature if necessary (~ 280 ºC). This is important when it comes to the application of asphalt / bitumen where exposure to high temperatures during storage and transport

- EBA shows greater flexibility at low temperatures (since its Tg is -50ºC), which is important if the situation is reversed, that is asphalt / bitumen used in cold climates.

- EBA shows lower water absorption at comparable comonomer content. Important in asphalt / bitumen modification application, where the material is outside and exposed to rain.

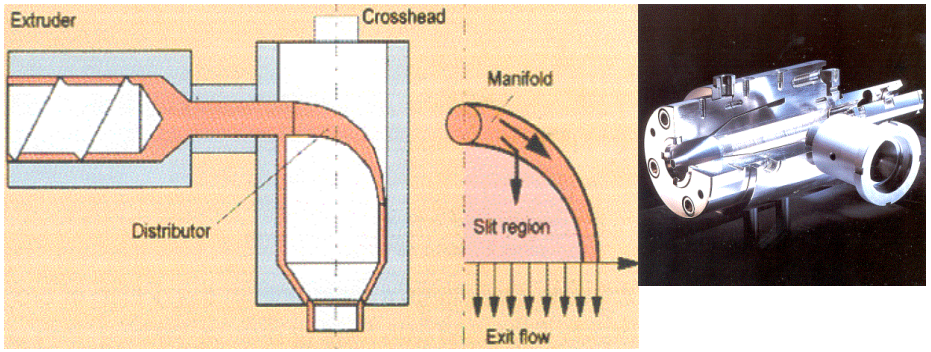
- EBA is slightly more polar than EVA, and the polarity favors a good absorption of fillers and dispersion of pigments .

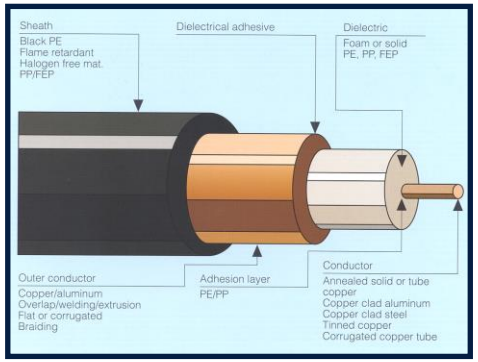


CABLES

Cables

Repsol EVA/EBA range





EVA/EBA grades for **HFFR compounds**:

- Cable sheath: P1820C (18/2), P2430C (24/3), P2735C (28/3,5), P2870C (28/7)
- Fillers: P40055(40/55), P33025C (33/25), P33015C(33/15), E1770 (17/7)

EVA/EBA grades for **semiconductor compounds**:

- P33025C (33/25), P33015C (33/15), E1770 (17%BA/7)

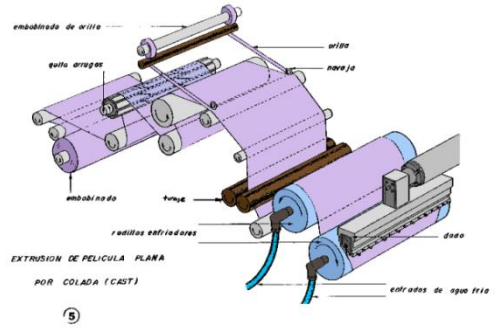
ADVANTAGE OF THE USE OF EBA IN CABLES

- In EBA grades there is no generation of acetic acid due to degradation, so they have the advantage of being able to be used in adverse climatic conditions.
- The lower water absorption of EBA copolymers allows for better performance in humid environments
- The lower Tg of EBA makes it more suitable for installation in cold areas

EXTRUSION COATING

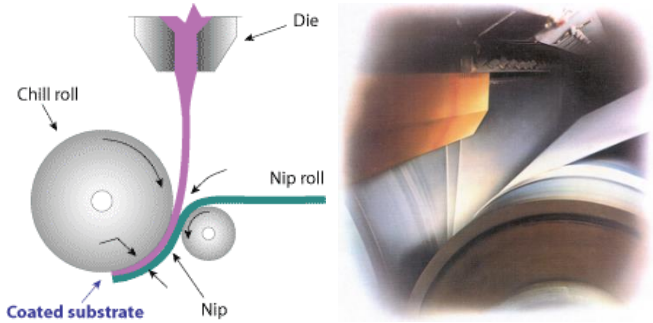
Cast film and extrusion coating

Grade	% VA/BA	MFI, g/10min (190ºC; 21,6 kg)	Applications
P33045S	33 VA	45	Photovoltaic
P28025S	28 VA	25	Photovoltaic
P20020D	20 VA	20	Extrusion Coating (high quality film)
E1770	17 BA	7	Extrusion Coating
E20020	20 BA	20	Extrusion coating, blends

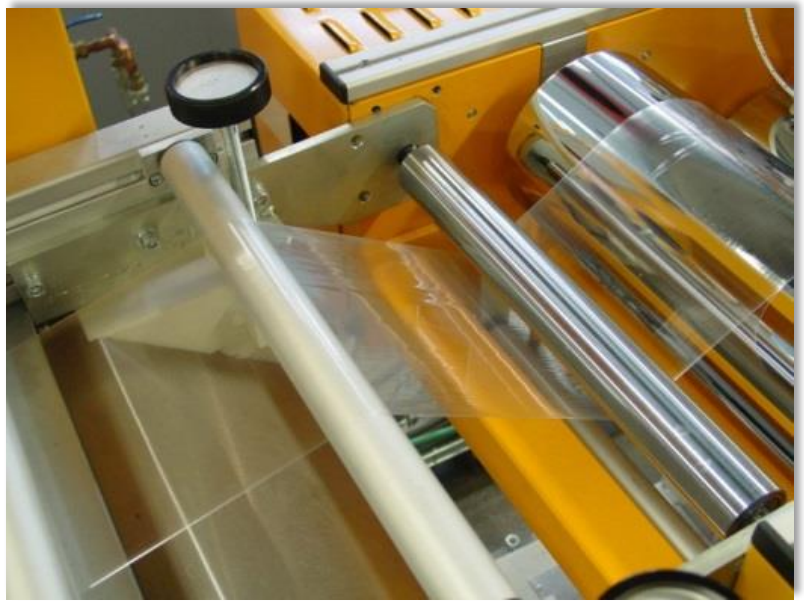


Cast Film

Extrusion coating



ADVANTAGE OF THE USE OF EBA IN EXTRUSION COATING



EBA ADVANTAGE

- ✓ Especially suitable where high extrusion temperatures are needed (up to ca. 280 ºC) EBA is much more resistant to thermal degradation than EVA.
- ✓ Lower density than EVA; material savings.

SOLAR

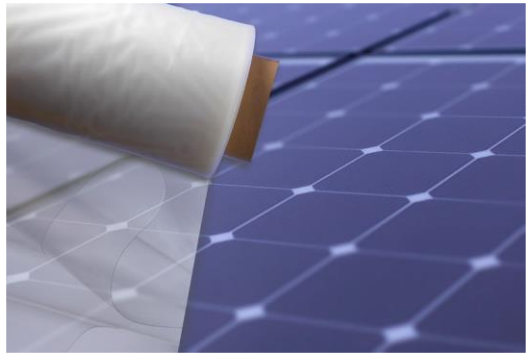
EBA FOR SOLAR PANELS

- Repsol has designed a specifically range of EVA (Repsol Primeva®) and EBA (Repsol Ebantix®) copolymer grades recommended for the photovoltaic industry

- Due to their high comonomer content, our EVA and EBA grades have good film quality, showing significantly low gel content and good adhesion to glass

Grade	VA	MFI
	[%] Internal method FTIR	ISO 1133 g/10 min 190 ºC 2,16kg
P28025S	28	25
P33045S	33	45

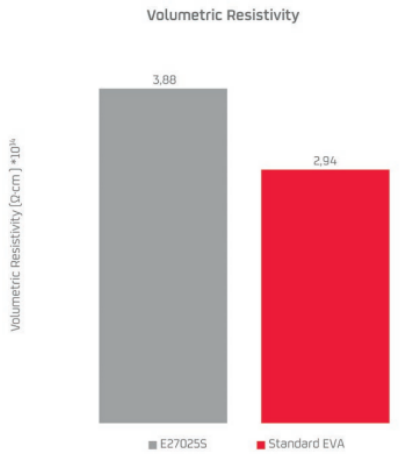
	Grade	BA	MFI
		[%] Internal method FTIR	ISO 1133 g/10 min 190 ºC 2,16kg
	E20020	20	20
NEW!	E27025S	27	25

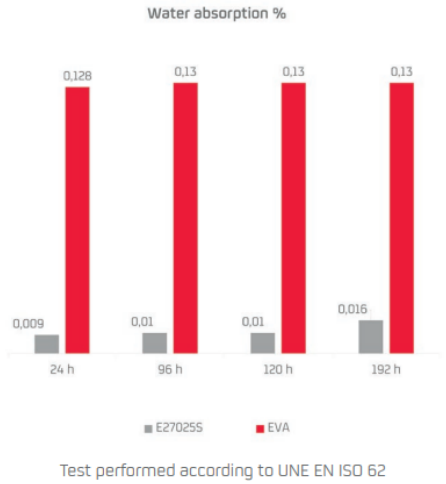


EBA FOR SOLAR PANELS

EBA copolymers main advantages

- Good thermal stability
- No acetic acid generation and low water absorption: no risk of corrosion
- Good behavior at low temperature, maintaining mechanical and electrical properties in cold and wet conditions
- High volumetric resistivity and good performance as electrical insulator. Important to avoid potential induced degradation phenomenon in solar panels
- Especially suitable for encapsulants of solar panels with special requirements of corrosion resistance
- Good adhesion to glass and backsheet
- Cost effectiveness





Test performed according to UNE EN ISO 62

EBA FOR SOLAR PANELS

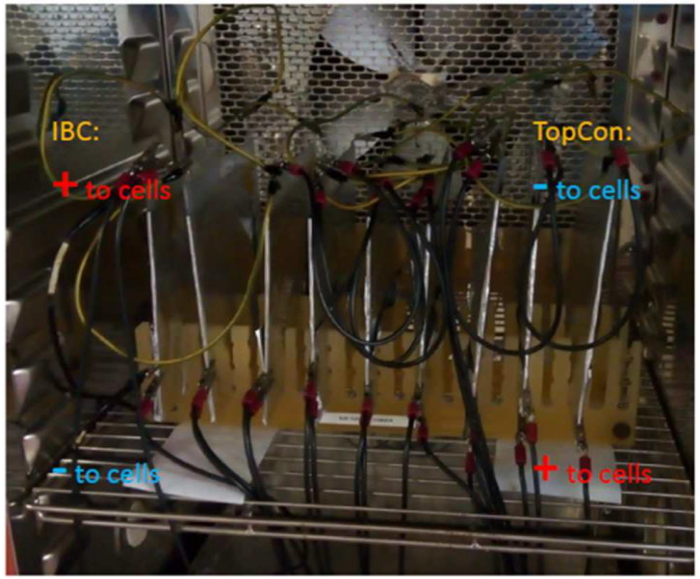
Reliability studies of PV minimodules using the Ebantix E20020 copolymer based encapsulant and high efficiency PV cells

The main goals of these reliability study can be summarized as follows:

- Perform aging studies of minimodules manufactured with this new **EBA** encapsulant and two different high efficiency cells (**IBC** & **TopCon**)

- Investigate the **PID protection** ability of this new **EBA** based encapsulant compared to other materials available in the market (**EVA**, **EPE** & **POE's**)

- Investigate the resistance of the new **EBA** based encapsulant under accelerated **Damp Heat** and **Thermal Cycle** tests (tests in progress)

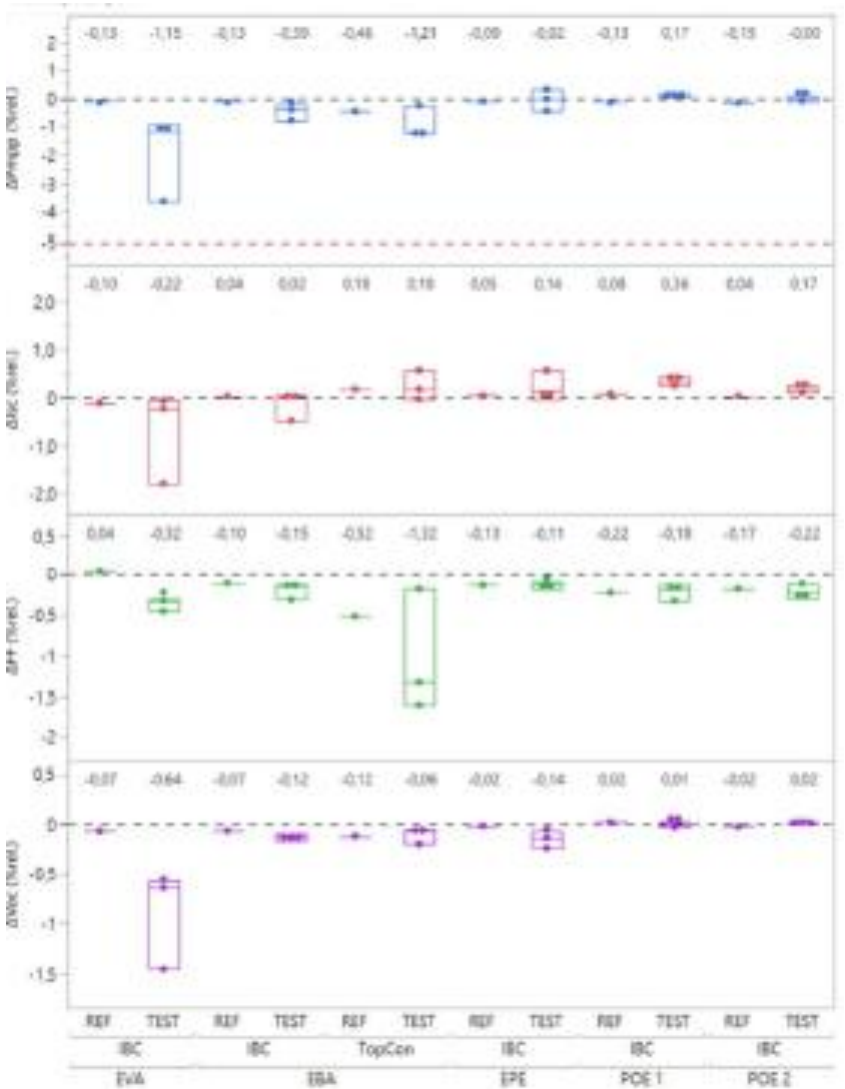


Potential Induced Degradation (PID) Results

Summary of preliminary PID results:

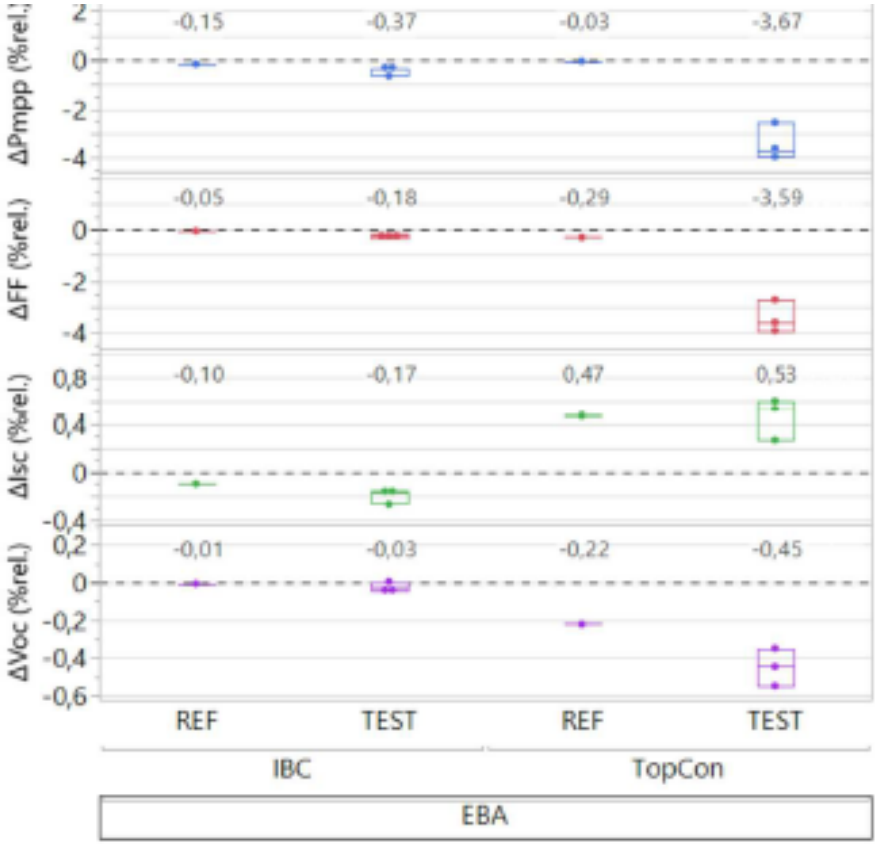
- Performance of EBA in glass/backsheet construction:
  - Passing (loss in PMPP < 5%)
    - PID 192h for IBC
    - PID 96h for TopCon
- Comparison with other encapsulants with IBC cells:
  - **EVA < EBA ~ EPE < POE1 ~ POE2**

96h in PID test



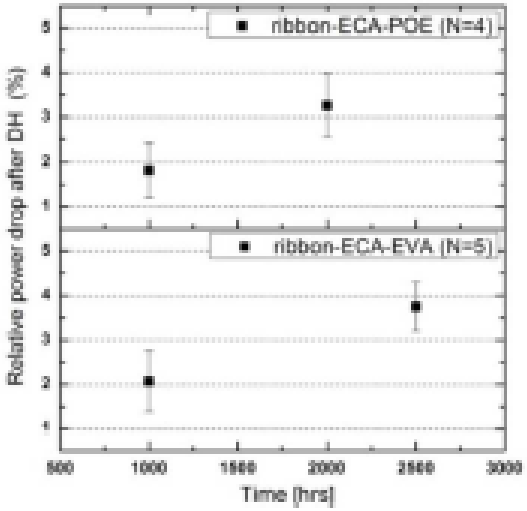
Thermal Cycle Preliminar Results (TC 200) (further testing ongoing)

- IV preliminary results after TC 200 show:
  - All material-cell combinations pass test with **less than 5% degradation in P_{MPP}**
  - No significant degradation with IBC cells
  - IBC cells shows better performance compared to TopCon with EBA



Damp Heat testing

- Damp Heat testing is currently in progress
- Target: complete 3000h (x3 IEC 62904)
- Previous results in the literature[5] (2015 EU PVSEC paper) demonstrate that both EVA and EBA passed 2500h and 2000h in DH85/85 respectively with IBC cells[6]
- Comprehensive publication of these results after completion of this study



DH testing for EVA (2500h) and EBA (2000h) with IBC cells[5]

5. SCHNEIDER, Andreas, et al. Material Developments allowing for new applications, increased long term stability and minimized cell to module power losses. 31st EU PVSEC 2015 (1BV.6.36)

EBA FOR SOLAR PANELS

- According to these preliminary results EBA is a promising candidate for the encapsulation of high efficiency solar cells
- EBA can be processed using existing extrusion technology for standard EVA encapsulants
- EBA has demonstrated good performance with IBC cells in different aging tests:
  - PID: 192h with neglectable power loss in glass/backsheet construction
  - 2000h in DH (prior art) and 200 TC (this work) (further testing ongoing)
- Performance comparable to EPE encapsulant when using IBC cells and:
  - EBA is more competitive in terms of pricing
  - Shorter lamination cycle time for EBA* compared to EPE and POE's

Thank you!