



TOTAL PETROCHEMICALS

BHR Group



**HDPE anti-corrosion
pipe coating system
with
outstanding performance**

www.bhrgroup.co.uk





Who we are



- ◆ First French Chemistry
- ◆ 3 segments:

Vinyl product, industrial chemicals, performance product

- ◆ 5633 million € turnover 2008
- ◆ 80 plants in the world (EU, US, ASIA)
- ◆ 14980 employees worldwide



- ◆ World 8th-largest petrochemicals company
- ◆ Integrated within the Total group
- ◆ 13.1 B€ turnover in 2008
- ◆ 6250 employees worldwide
- ◆ 19 industrial sites (EU, US, ME, Asia)
- ◆ **Nr. 3 producer of HDPE in WE**

**Associated for delivering innovative solutions
to the pipe coating industry**



WHY to improve performances of anti-corrosion pipe coating?

Market requirements have become more severe

More and more coaters & end users request
better guarantees than specifications

Oil & gas production is extending towards
geographic areas with more extreme conditions

WHY to improve performances of anti-corrosion pipe coating?

Effective corrosion prevention requires a combination of

- 1) a Durable HDPE topcoat
- 2) a High adhesion between epoxy and PE layers



**→ Development of a new HDPE
anti-corrosion system
with outstanding performance**



How to access to higher performances?

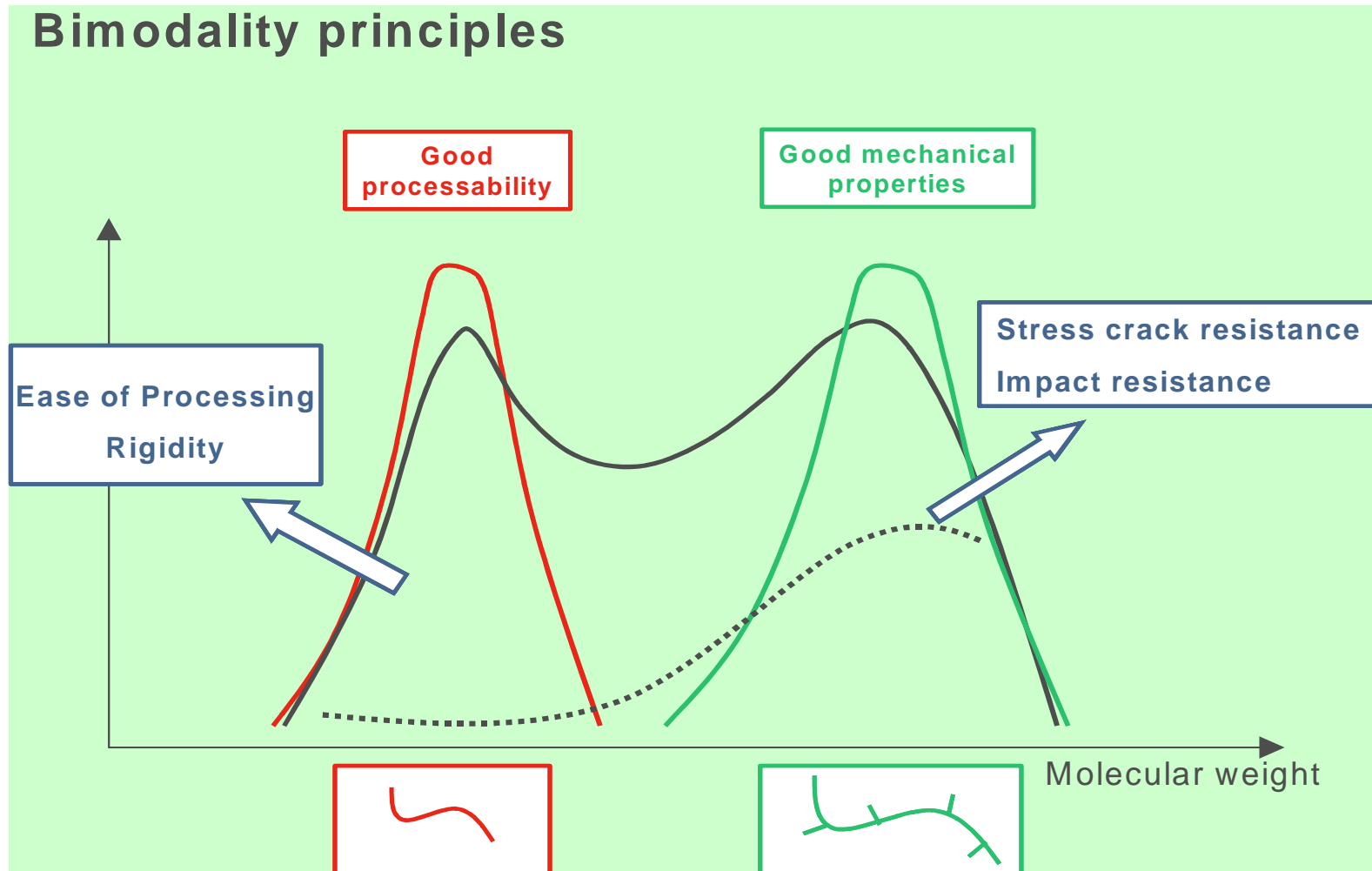
1) Development of Durable HDPE TOP COAT

Total Petrochemicals has many years of experience / know how in producing PE bimodal resins using hexene as comonomer

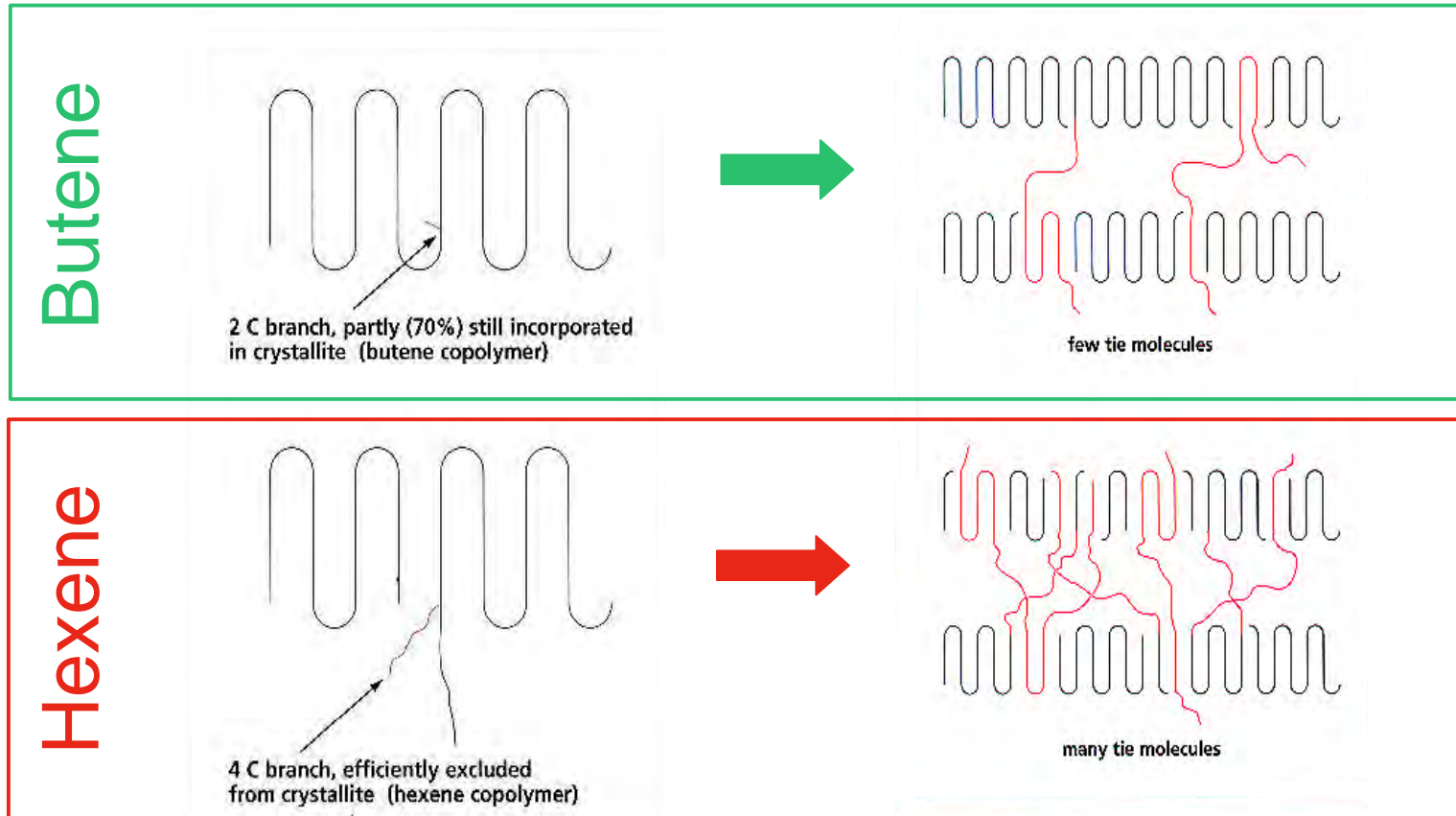
- ◆ **HDPE BIMODAL POLYETHYLENE COMPOUND**
 - combines good processability + excellent ESCR
 - has substituted LDPE, MDPE compounds thanks to higher performance

- ◆ **HEXENE as COMONOMER**
 - provides benefits regarding mechanicals properties and ESCR performance

Advantages of Bimodality for PE



Advantages of Hexene Comonomer for PE



More tie-molecules with HEXENE (C6) than with BUTENE (C4)
HIGHER OVERALL PERFORMANCES

HDPE TOPCOAT: Characteristics

<i>Physical properties</i>	<i>Test method</i>	<i>unit</i>	<i>Typical value</i>	<i>Requirements</i>
Density	ISO 1183	kg /m ³	955	> 940 (950)
MFR (190 °C / 2.16 kg)	ISO 1133	g/10 min	0.4	0.1 to 0.8
Carbon black content	ISO 6964	%	2.25	2 to 2.8
Tensile strain at break 23°C	ISO 527	%	> 600	> 600
Vicat softening temperature	ISO 306	°C	124	> 120
Hardness shore D	ISO 868	/	61	> 60
ESCR (50°C / 10%)	ASTM D1693	h	F0 > 3000	F0 > 1000



No failure after more than 3000 hours
(requirement is F0 > 1000 h)

HDPE TOPCOAT: Heat Ageing Performance

Heat ageing

Topcoat exposition in a hot air oven at 100°C & 110 °C
Control of MFR and Elongation at break variations.



		<i>Requirements</i>	<i>2400 h</i>	<i>4800 h</i>
MFR variation	100 °C	< 35 %	Passed	Passed
	110 °C	No requirement	Passed	Passed
Elongation at break Variation in %	100 °C		< 10 %	< 10 %
	110 °C		< 10 %	< 10 %

HDPE bimodal compound meets the requirement even at 110°C

HDPE TOPCOAT: Light Ageing Performance

Light ageing

Topcoat exposition to UV in WOM (Atlas Ci 35A)

Control of MFR and Elongation at break variations.



<i>Time of Exposure</i>	<i>MFR variation</i>	<i>Elongation at break variation</i>
800 h (1.2 GJ/m ²)	< 25 %	< 20 %
2400 h (3.6 GJ/m ²)	< 25 %	< 20 %
4800 h (7.2 GJ/m ²)	< 25 %	< 20 %

HDPE bimodal compound

- contains finely dispersed carbon black
- has excellent Weathering and UV resistance

HDPE TOPCOAT: Hardness Performance

Surface Hardness

Measures the resistance of coating to the penetration of a test cylinder.

At different temperatures, is an indication of the mechanical properties and upper operating temperature.

<i>Indentation at</i>	<i>Requirement</i>	<i>MDPE</i>	<i>HDPE bi</i>
23 °C	< 0.2 mm	0.10	0.10
50 °C	< 0.3 mm	0.13	/
70 °C	< 0.3 mm	0.20	0.14
80 °C	/	/	0.17
90 °C	/	/	0.24
100 °C	/		0.31 (0.06)

The surface hardness is significantly better than with MDPE topcoat, with 100°C as possible upper operation temperature



HDPE TOPCOAT: Improved Performances Design

For a Durable HDPE TOP COAT

- ◆ **Optimized molecular design achieved through the polymerisation process & catalyst allows to boost the product performances.**
- ◆ **The latest generation of bimodal hexene based compound offers extraordinary tolerance to operating conditions, as demonstrated by the following results:**
 - **Excellent Resistance to UV and thermal ageing**
 - **Excellent Stress cracking resistance**
 - **Improved Surface Hardness resistance**

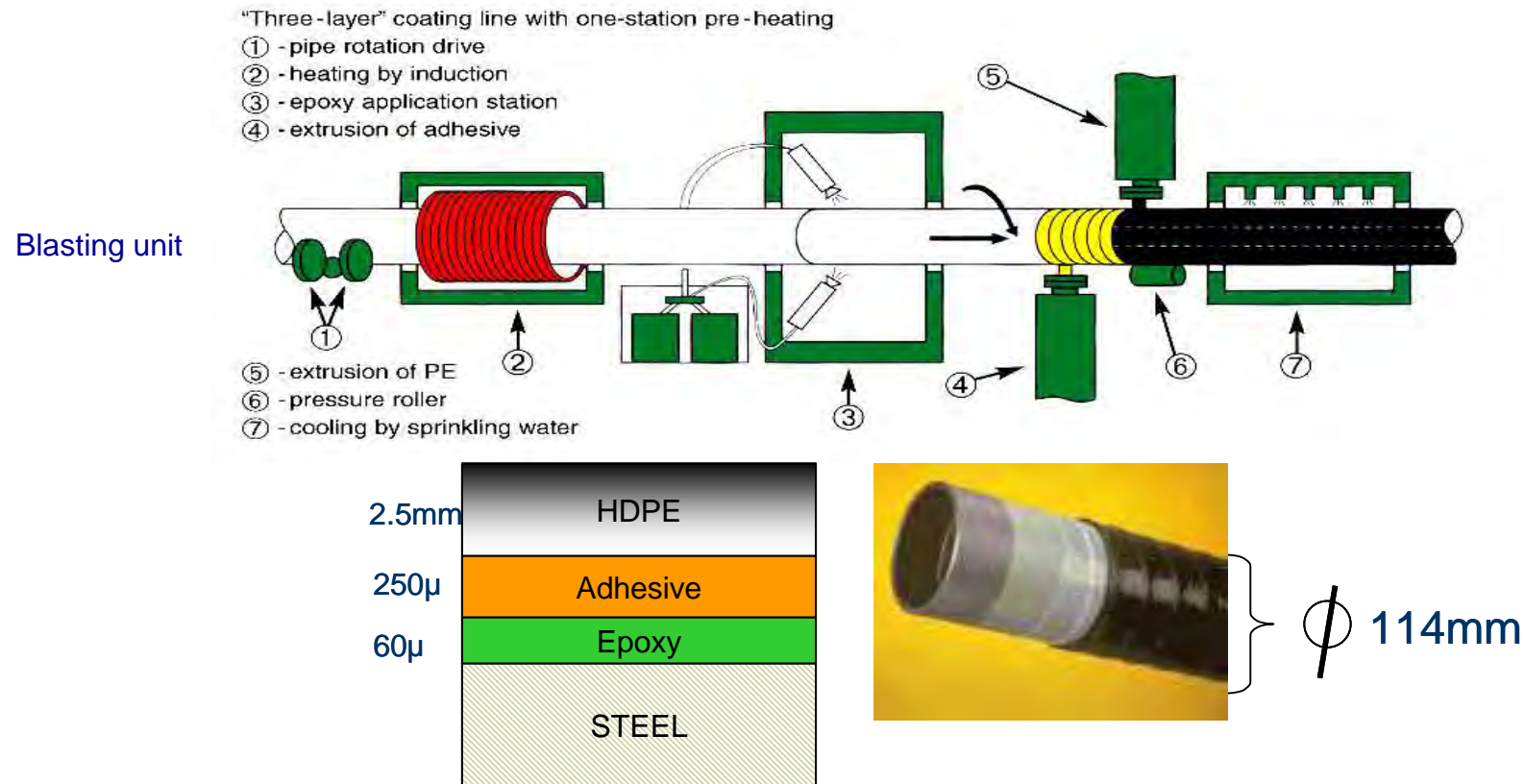
However, effective corrosion prevention requires a combination of

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Pipe Coating Process

3-layer polyolefins



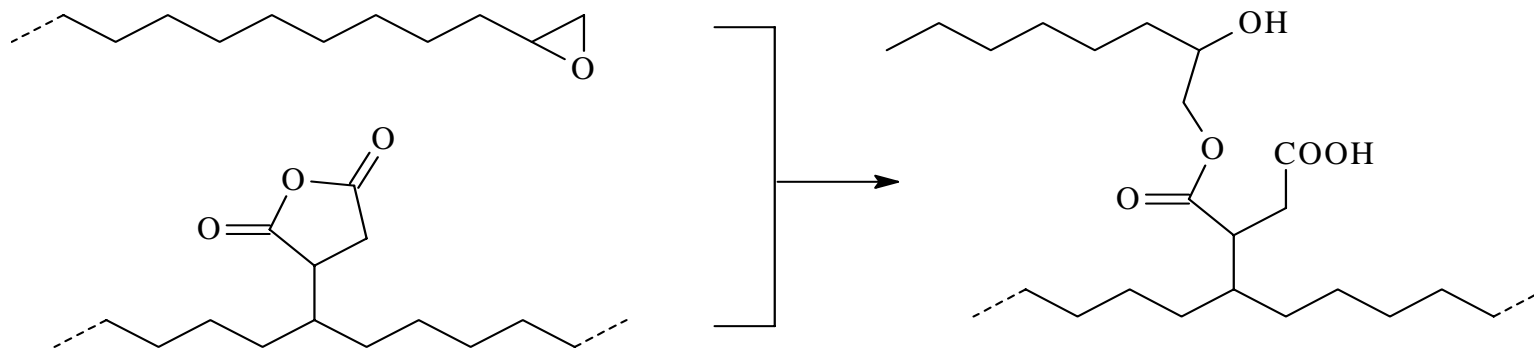
Roughness ISO 8502, class 2

NEW ADHESIVE GENERATION

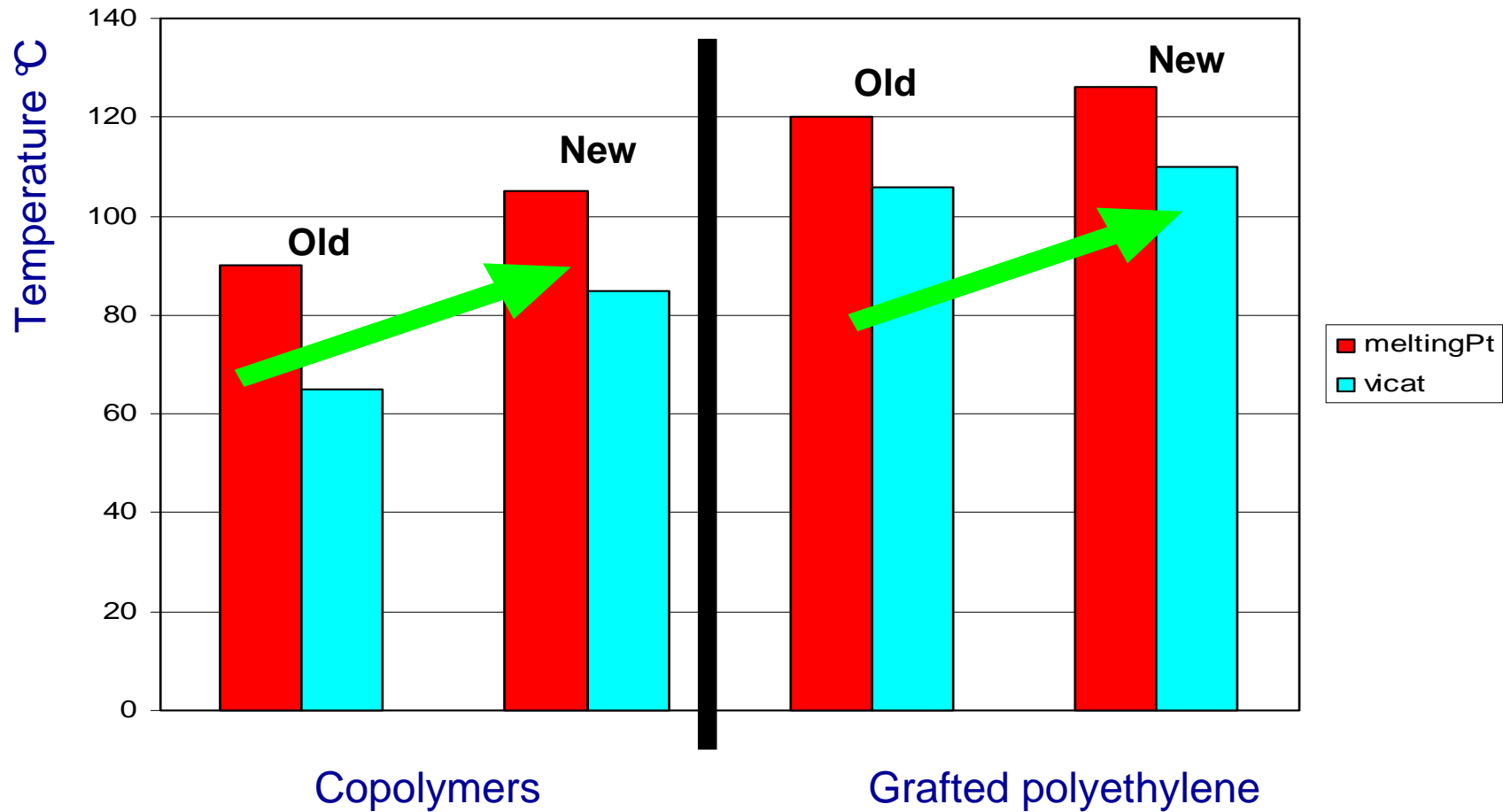
2) Development of a new product with high PE/epoxy adhesion

- ◆ ARKEMA has developed a new adhesive generation dedicated to the pipe-coating application
- ◆ Based on Polyethylene, grafted with maleic anhydrid allowing a good mobility of the chains

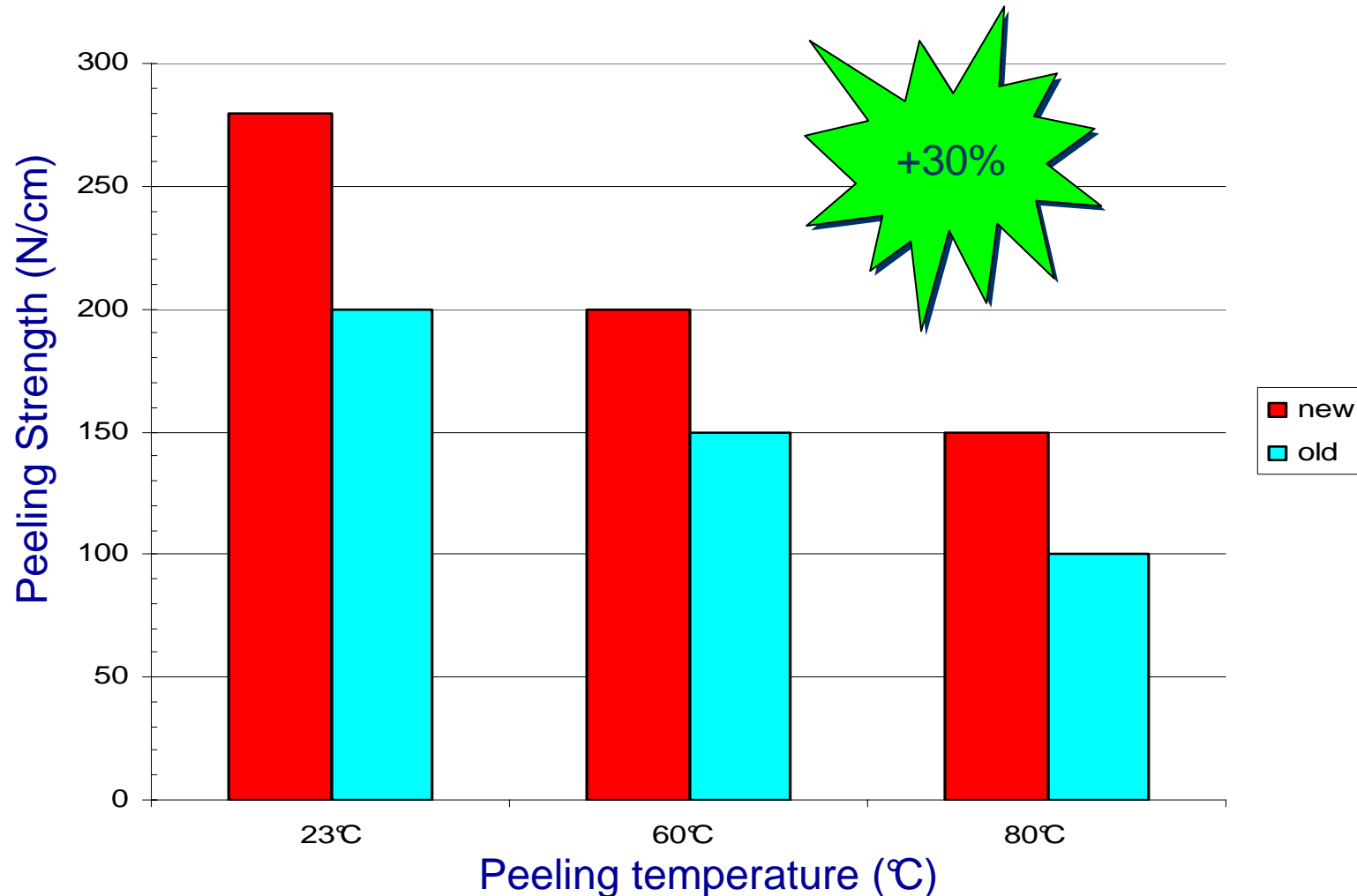
Simplified reaction between Epoxy and Anhydrid groups



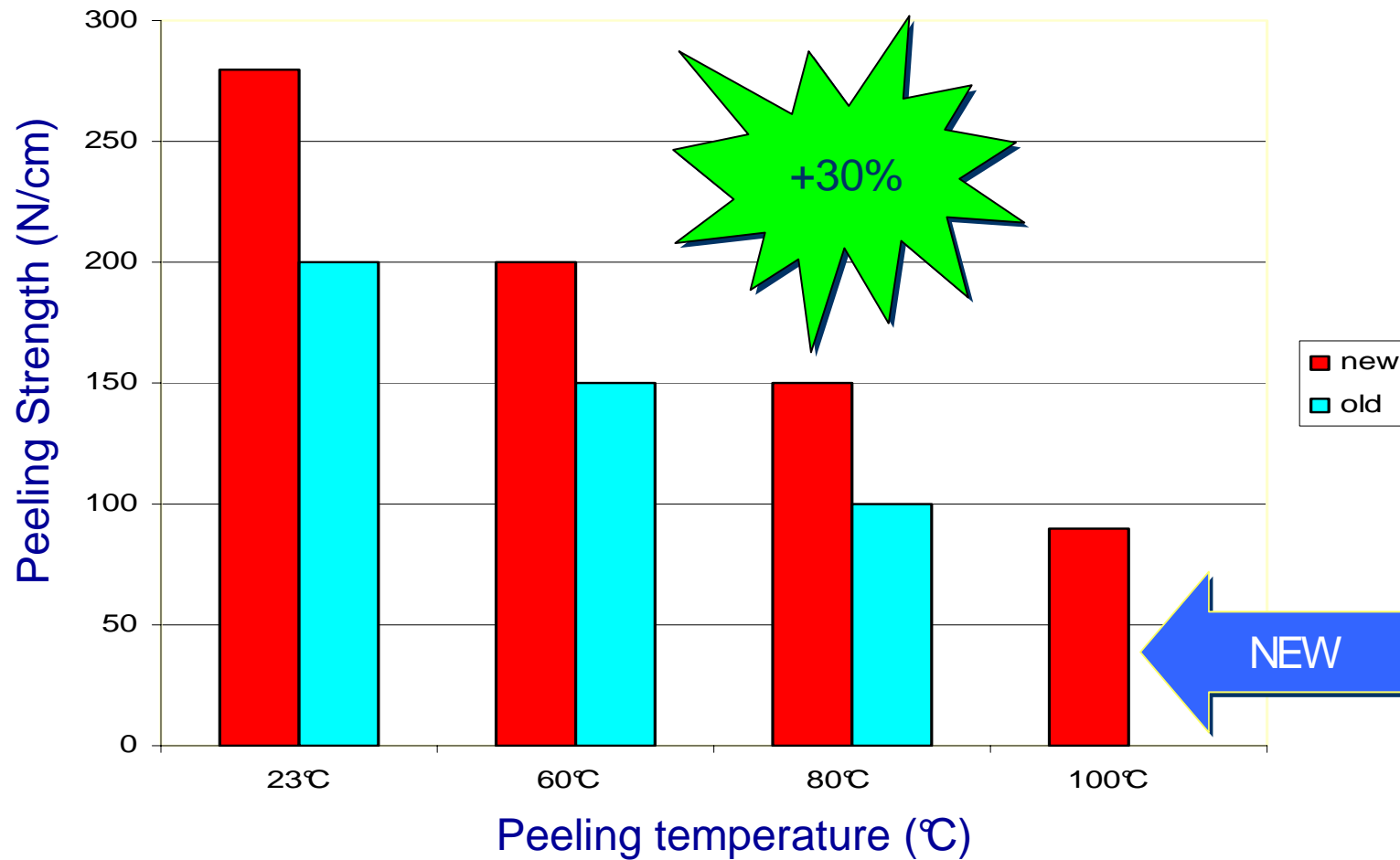
NEW ADHESIVE: Evolution of Properties



Adhesion Properties: Higher Peeling Strength



Adhesion Properties: Higher Temperature limit



Adhesion Properties: Testing system

Equipment: peeling system (dynamometer)

