

Advancing Hotmelt Adhesives with low VOC *Koattro* Polybutene-1 Polymers

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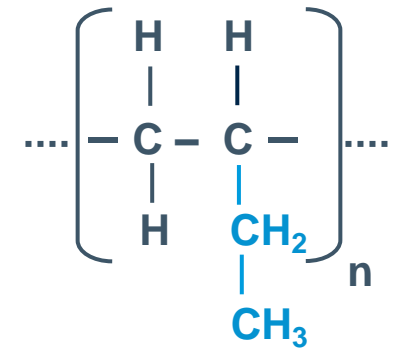
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Agenda

- **Introduction to Polybutene-1 (PB-1)**
- **Key properties of metallocene PB-1 (mPB-1)**
- **Polymer Characterization - VOC and FOG measurements**
- **Analytical results and typical applications**
- **Conclusions**

Introduction to Polybutene-1 (PB-1)

- Polybutene-1 (PB-1) is an **isotactic, semi-crystalline thermoplastic polyolefin** produced through the polymerization of butene-1
- Ethylene and/or propylene can be incorporated as comonomers
- PB-1 shows the typical characteristics of polyolefins such as:
 - chemical inertness and moisture barrier
 - unique property mix of **high flexibility** and **good mechanical properties** over a **wide temperature range**



Polybutene-1

Polybutene-1 (PB-1) is NOT Polyisobutylene (PIB)!

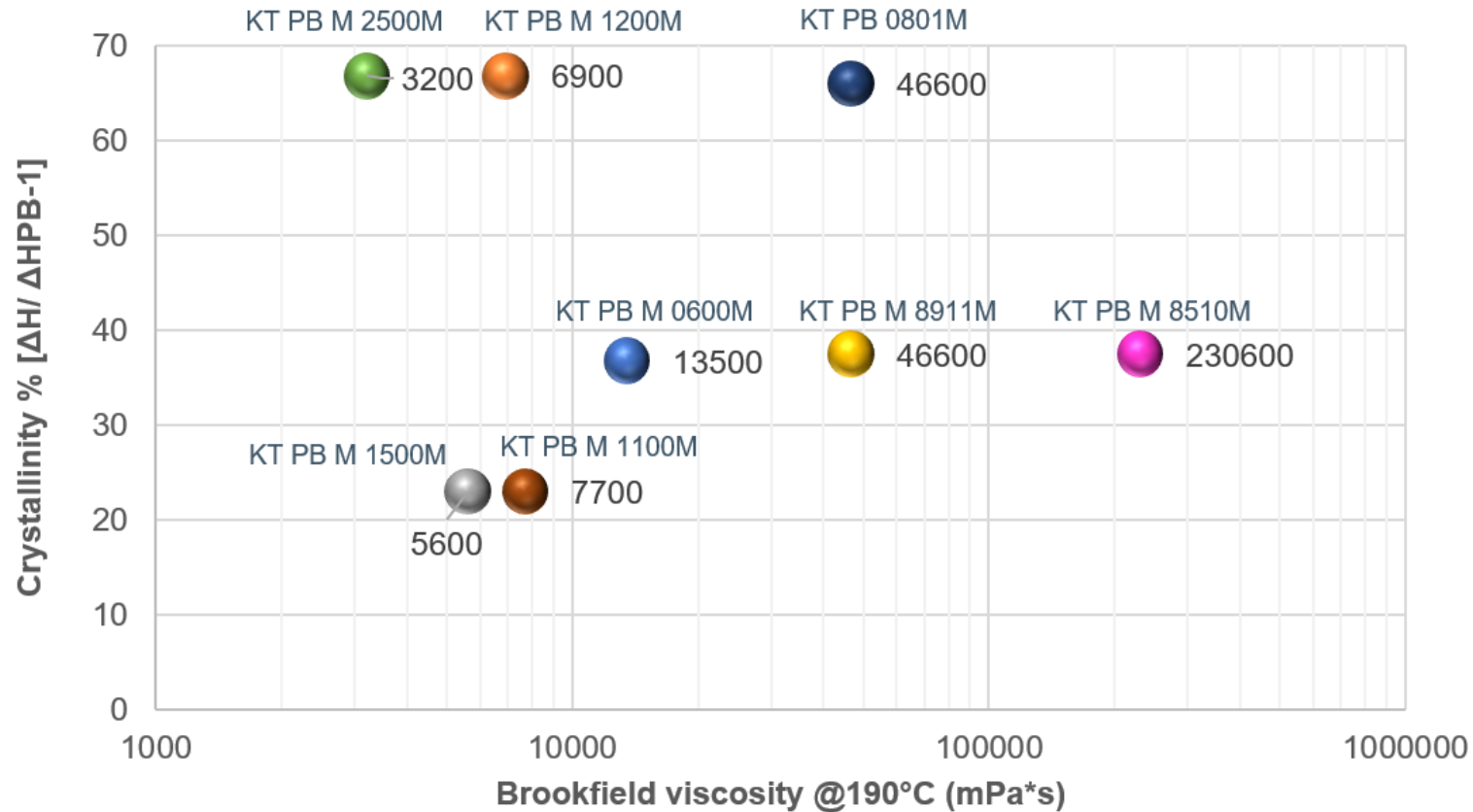
Introduction to Polybutene-1 (PB-1)

Industrial plant in Moerdijk – The Netherlands

- Producing metallocene PB-1 (mPB-1) grades with a wide melt viscosity range
- Capacity: 67KT
- Start-up in 2003
- Solution Polymerization technology, butene-1 is the solvent
- Dedicated R&D support in Ferrara (Italy)
- PB-1 pilot plant facility in Ferrara capable of producing adequate quantities for application development



PB-1 Product portfolio evolution fitting HMA industry needs



PB-1 product portfolio with an extended property profile for HMA offers:

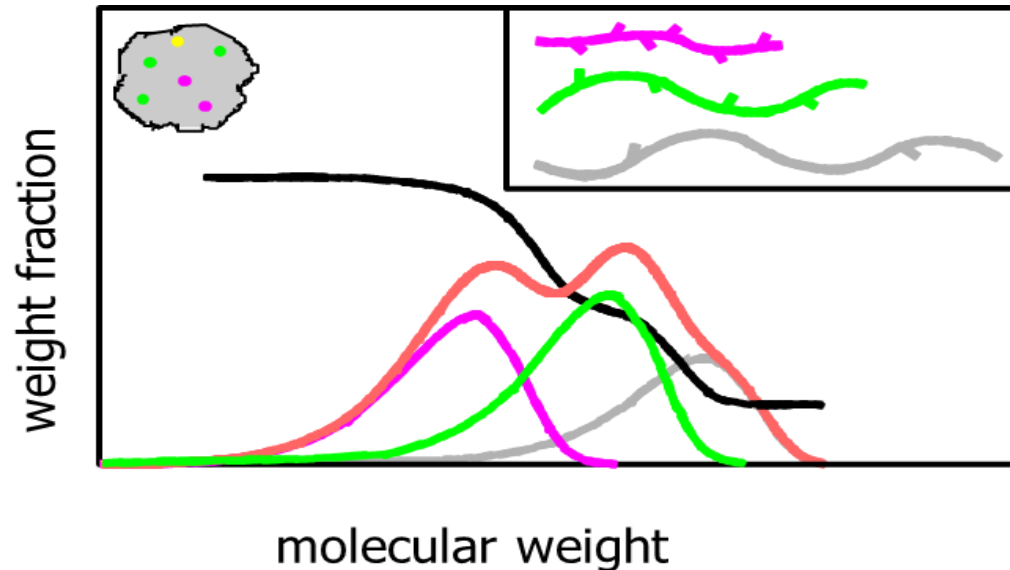
- Improved balance of crystallinity/ elongation or cohesion/adhesion
- Higher cohesive strength than most competitive grades in the market

Test Method Brookfield Viscosity (ASTM D3236)

Note: Koattro PB M 2500M is an experimental grade, Koattro PB 0801M is Ziegler-Natta grade

Ziegler-Natta vs metallocene catalyst technology

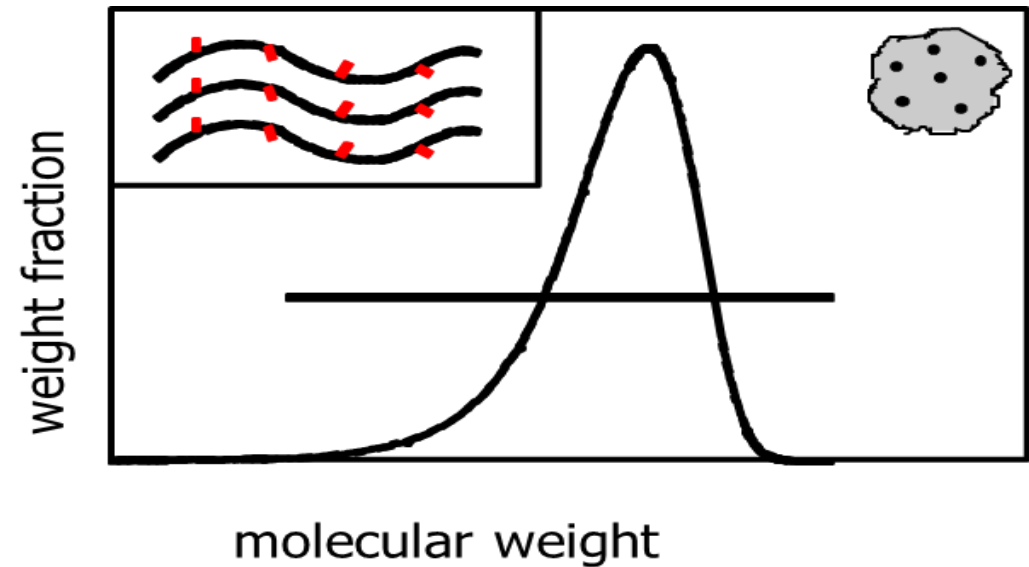
Ziegler-Natta Catalyst “Multi-Site”



The Multi-Site system produces:

- a “combination” of different chain lengths
- a broad molecular weight distribution
- a broad composition distribution

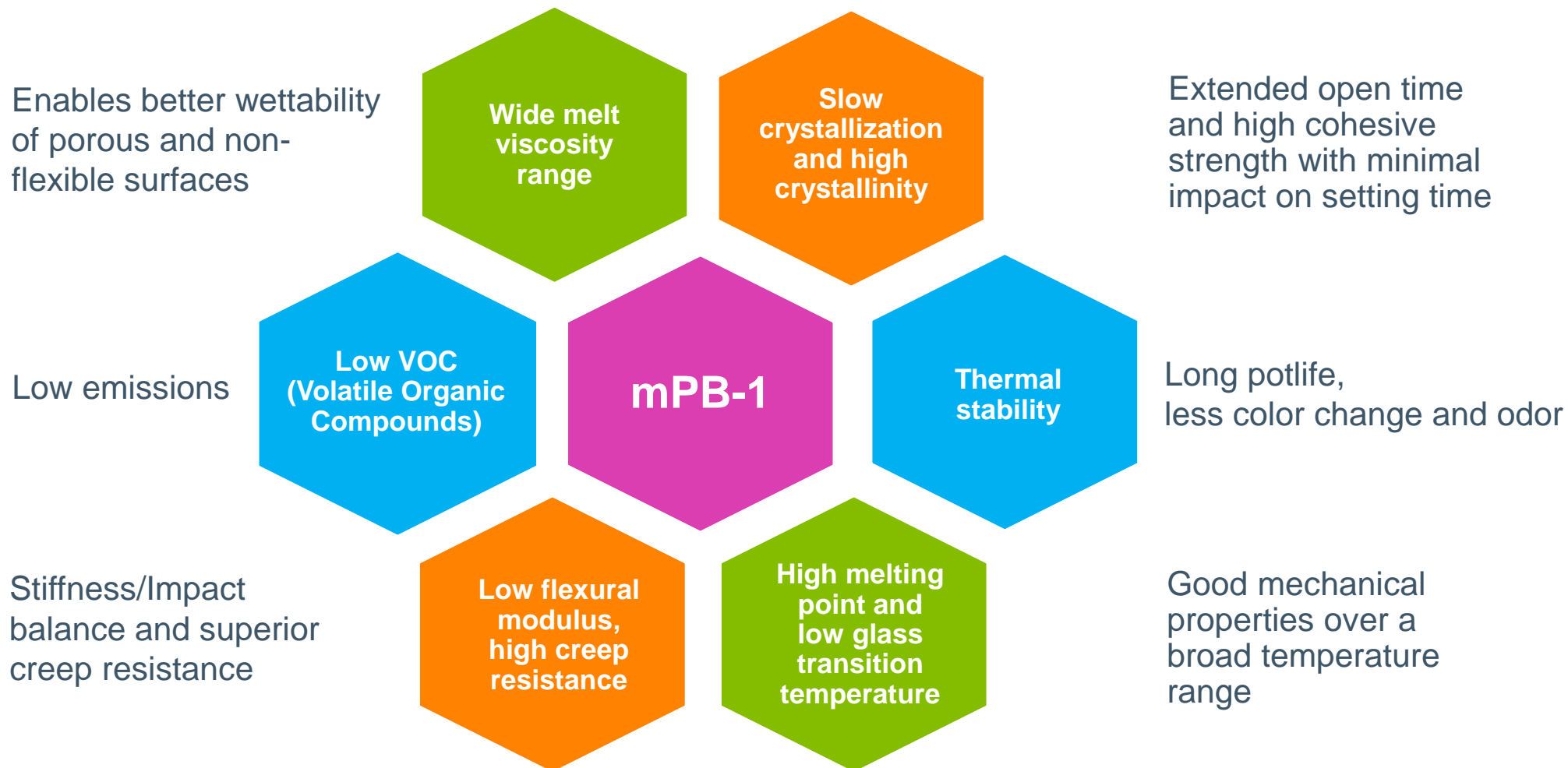
Metallocene Catalyst “Single-Site”



The Single-Site system offers:

- a narrow molecular weight distribution
- a narrow compositional distribution
- a wide melt viscosity range achievable

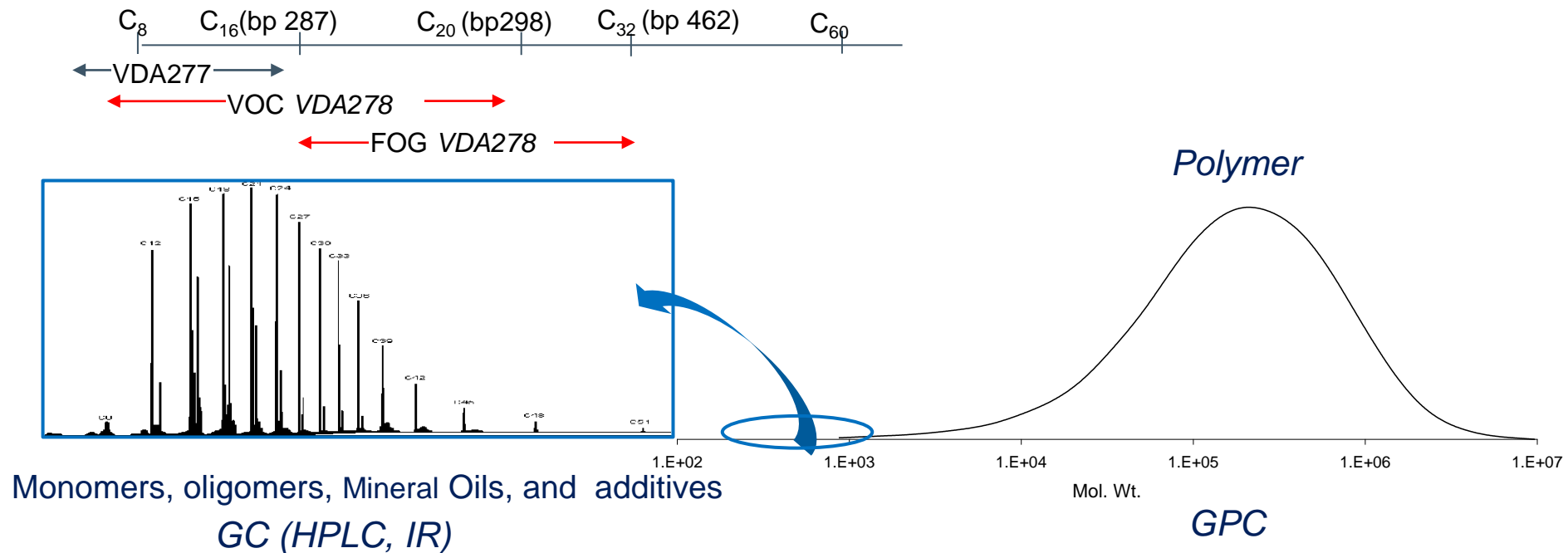
Key Properties of metallocene PB-1 (mPB-1) in HMA



mPB-1 as the cohesive component in hotmelt formulations provides enhanced properties

Polymer characterization

Focus on Volatile Organic Compounds

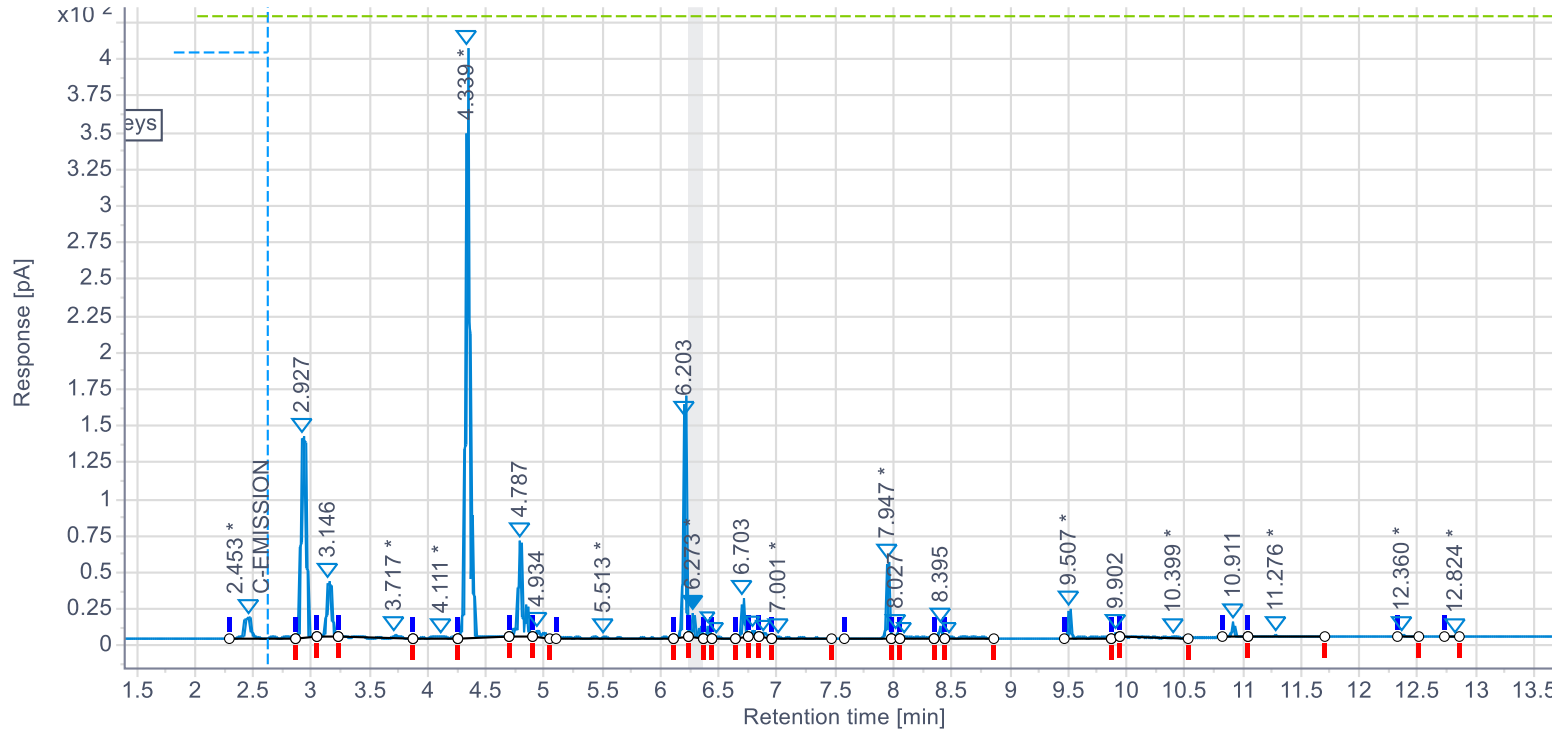


- Volatile organic compounds (VOC) are low molecular weight organic chemicals that have a high vapor pressure at room temperature
- The automotive industry adopted stringent requirements to ensure low VOC limits as prescribed by VDA 277 and VDA 278 protocols and are used as leading references for benchmarking comparison
 - VDA 277 protocol: detects species with low boiling point volatiles
 - VDA 278 protocol: provides information on VOC's including higher boiling substances (SVOC's or Semi Volatile Organic Compounds) relevant for fogging

Polymer characterization

VDA 277 C-emission: Static Head Space (SHS) Gas chromatography (GC)

Chromatogram



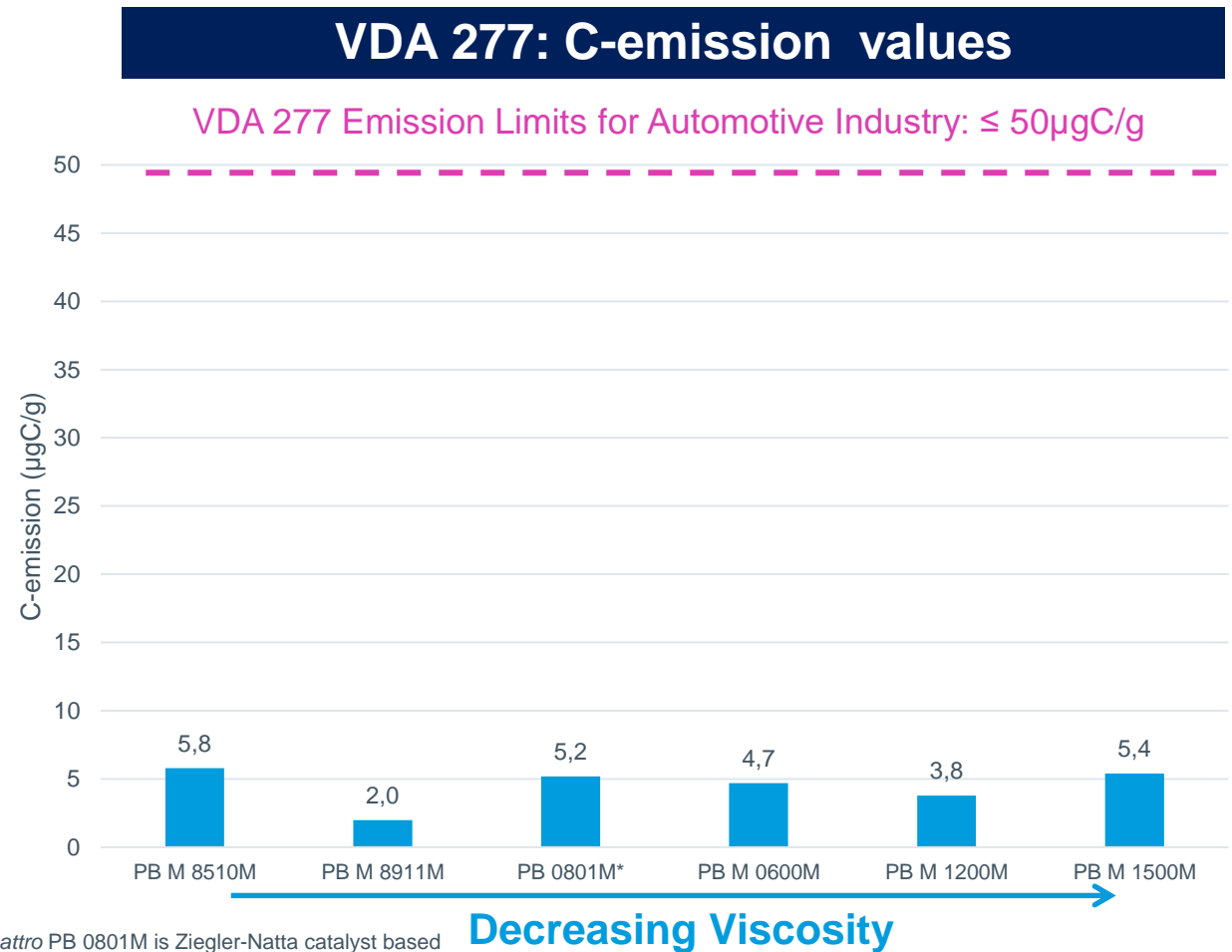
The emission potential is the sum of all values from the substances detected by Chromatography (GC) and Flame Ionization Detection (FID) analysis

Gas

Analytical results

VDA 277 C-emission: Low viscosity *Koattro* PB-1 grades

- Extremely low organic emission potential measured for *Koattro* PB-1 grades
- C-emission values are much below the VDA 277 emission limits set for the automotive industry ($\leq 50\mu\text{gC/g}$)
- C-emission values have no correlation with the viscosity / molecular weight of the polymer

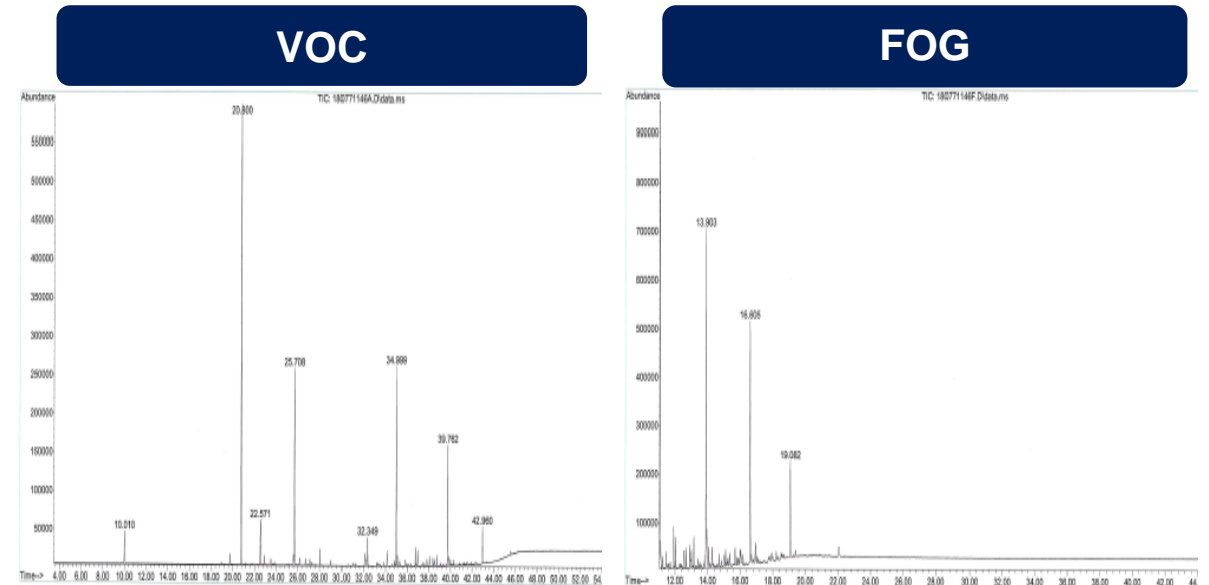


Even very low molecular weight polymers show low organic emissions

Analytical results

VDA 278: Dynamic Head Space GC and Mass spectroscopy

- Thermal desorption and emission collection on the cold trap
- Separation of emissions by capillary gas chromatography
- Two measurements are done
 - 90°C: VOC from C8 to C20
 - 120°C: FOG from C16 to C32
- Mass spectroscopy detection (identification of species)



Emissions are differentiated into VOC and FOG

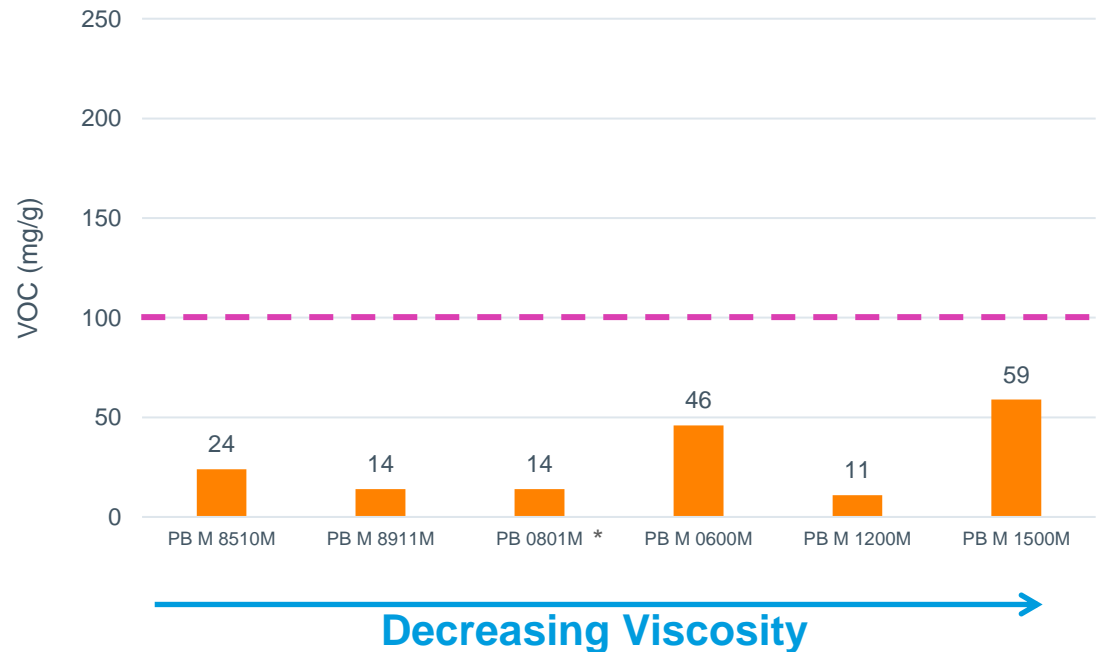
Data source: SGS INSTITUT FRESENIUS GmbH

Analytical results

VDA 278: (VOC/FOG): Low viscosity *Koattro* PB-1 grades

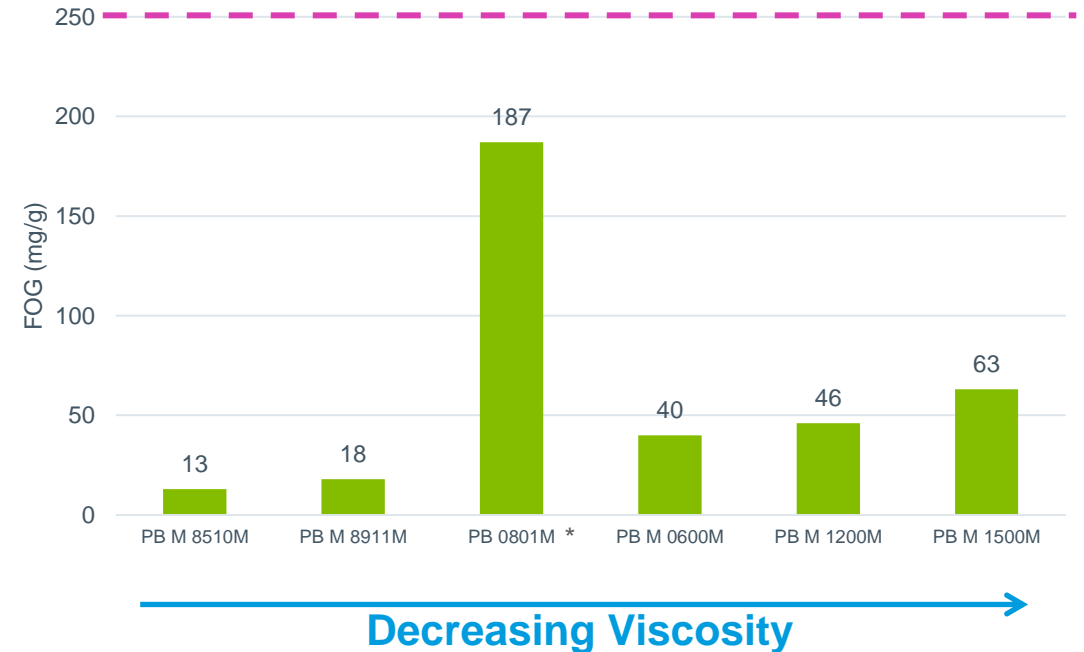
VDA 278: VOC

VDA 278 Emission Limits for Automotive Industry: ≤ 100 ppm



VDA 278: FOG

VDA 278 Emission Limits for Automotive Industry: ≤ 250 ppm



**Koattro* PB 0801M is Ziegler- Natta catalyst based

- **FOG values are affected by Molecular weight and Molecular weight distribution**
- **High sensitivity towards polymerization technology and molecular structure**

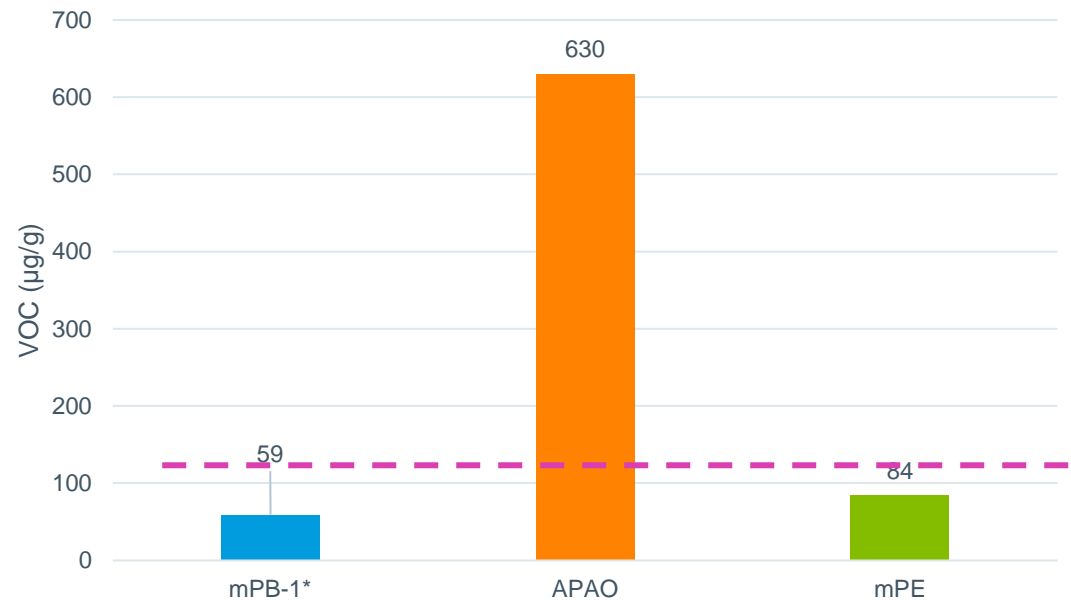
Data source: SGS INSTITUT FRESENIUS GmbH

Analytical results

VDA 278: (VOC/FOG): Comparing different Polymer types

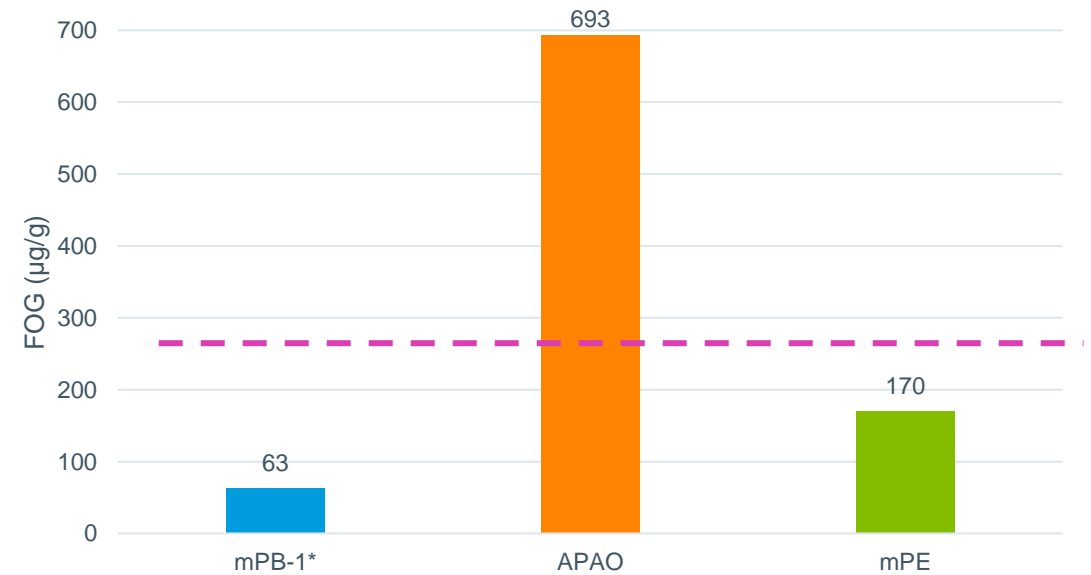
VOC

VDA 278 Emission Limits for Automotive Industry: ≤ 100 ppm



FOG

VDA 278 Emission Limits for Automotive Industry: ≤ 250 ppm

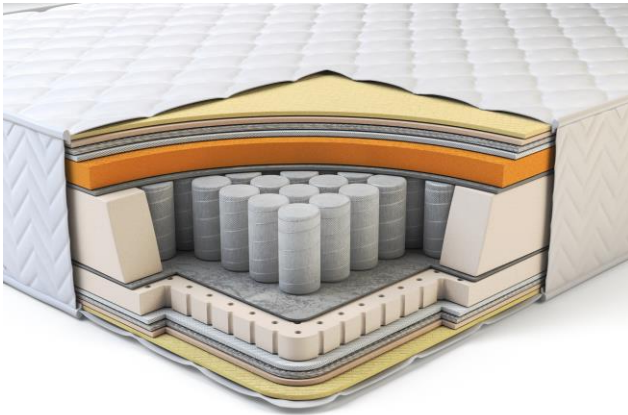


mPB-1*: Koattro PB M 1500M

mPB-1 has low VOC and FOG values in comparison with other polymers

Data source: SGS INSTITUT FRESENIUS GmbH, APAO = Amorphous Poly Alpha Olefin, mPE = metallocene Polyethylene

Typical applications



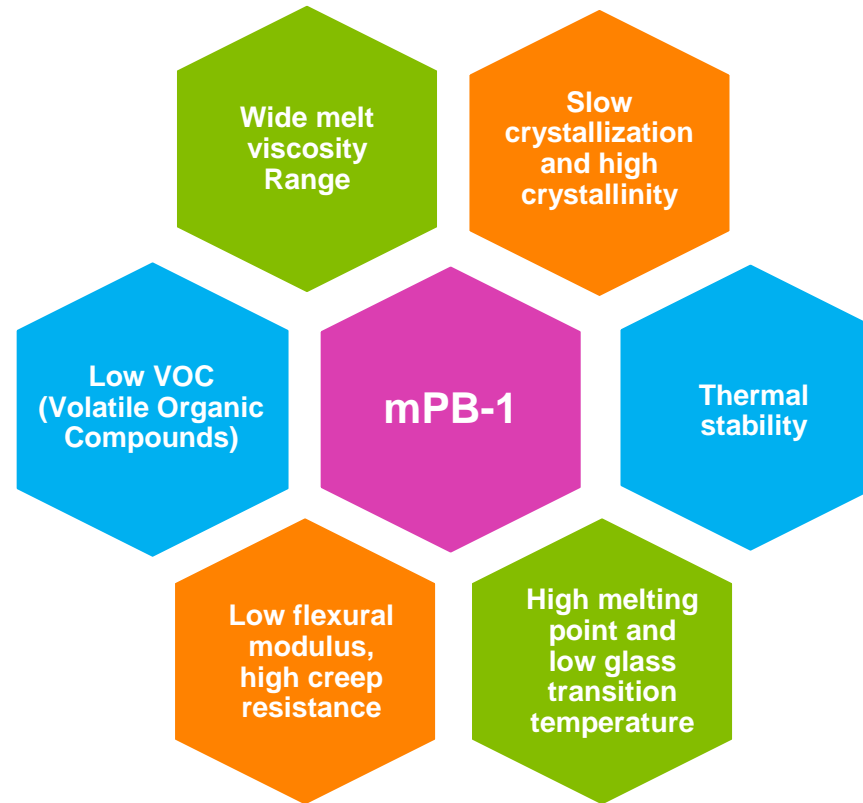
Assembly

Hygiene

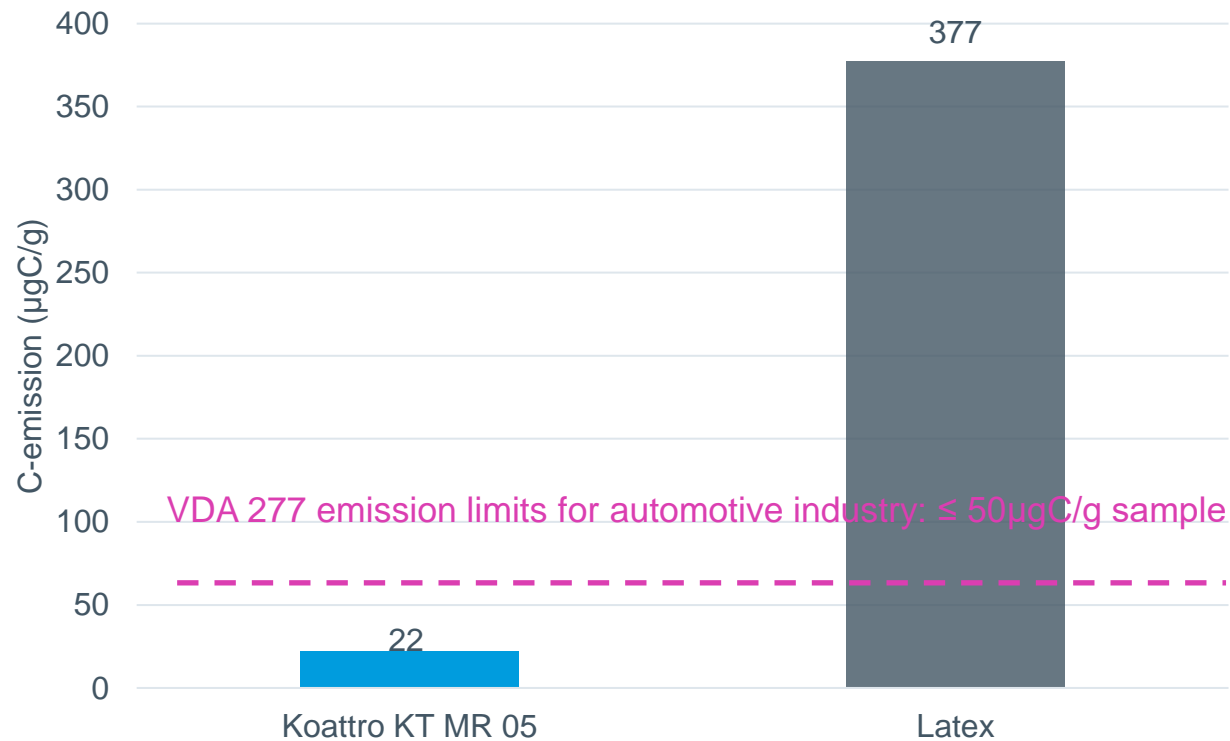


Woodworking

Packaging



SPE automotive nomination award 2021



PB-1 plastomer *Koattro* KT MR 05 enables full Polyolefin automotive car mats with reduced emissions replacing Latex

Note: VOC (C-emission) measured on carpet tiles based on Latex and *Koattro* KT MR 05 (replacing Latex)

Conclusions

- LyondellBasell's *Koattro* Polybutene-1 polymers act as a cohesive component in hotmelt adhesive formulations offering enhanced properties
- “State of the art” analytical techniques enabled characterization of *Koattro* PB-1 grades with respect to VOC and FOG emissions
- Low viscosity metallocene PB-1 grades show significantly lower organic emissions than the limits set by the automotive industry
- The volatile species detected for PB-1 grades mainly consist of aliphatic compounds such as linear and branched oligomers being free of toxic substances
- Low VOC characteristic of PB-1 contributes to low odor in hotmelts and a healthier indoor environment
- *Koattro* Polybutene-1 grades from LyondellBasell aptly address the growing VOC concerns in the market

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