LyondellBasell

Hot melt adhesive solutions

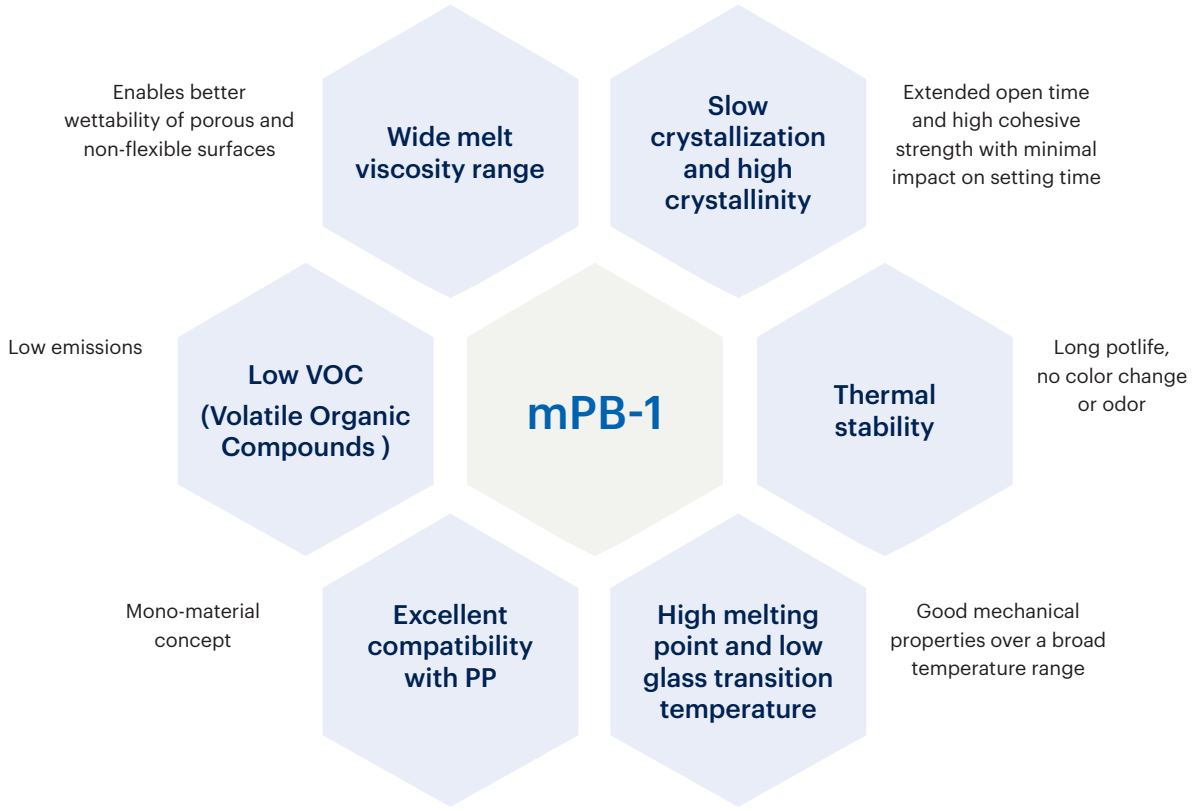
Koattro Metallocene PB-1 materials as the preferred polymer backbone.

Courtesy of SABA Dinxperlo B.V.

PB-1 for hot melt adhesives

In todays' production environments where safe, efficient and environmentally friendly assembly processes are required, solvent free adhesive systems are enjoying a growing acceptance. LyondellBasell has developed a dedicated metallocene Polybutene-1 (mPB-1) portfolio well suited as polymer backbone in hot melt adhesive (HMA) formulations.

This mPB-1 portfolio, comprising the *Koattro* grades, offers a wide melt viscosity range with excellent wetting capabilities. Key features include extended open time, a high cohesive strength with a good stiffness/impact balance, low VOC (volatile organic compounds) and very good thermal stability. Furthermore, mPB-1 materials are free of phthalates.

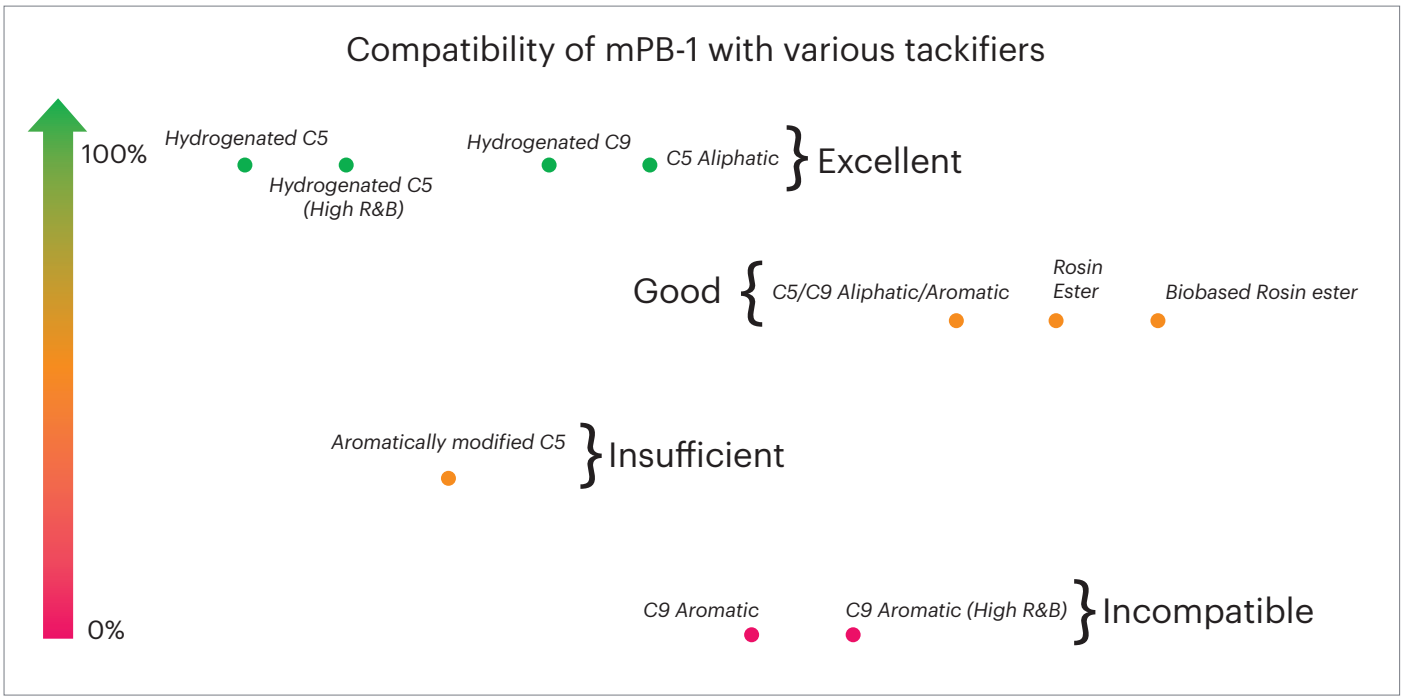


These key characteristics play a significant role in satisfying the needs of diverse HMA processes in assembly, woodworking, non-woven (hygiene) and packaging applications. Customers increasingly replace other thermoplastics by mPB-1 materials because of the exceptional property profiles and low environmental impact.

mPB-1 compatibility with tackifier resins

In hot melt formulations, metallocene PB-1 shows excellent compatibility with fully hydrogenated C5 tackifiers, C5 aliphatic resins as well as hydrogenated C9 resins. Due to the non-polar nature of PB-1, there is incompatibility with C9 aromatic resins. Rosin esters and C5/C9 Aliphatic/Aromatic resins tend to show good compatibility. As far as formulations with other polymers are concerned, metallocene PB-1 is compatible with metallocene Polyethylene (mPE) and Amorphous Polyalpha Olefins (APAO) but not with Ethyl Vinyl Acetate (EVA).

The use of *Koattro* mPB-1 in HMA formulations offers the right amorphous / crystalline composition balance and may allow for a reduction of the tackifier content.



Compatibility of mPB-1 with various tackifiers using cloud point method in a formulation comprising of 70% Polymer and 30% tackifier. 'Cloud Point' is the temperature at which the hot melt adhesive becomes cloudy upon cooling from melt and is a measure of compatibility of the formula components.

Products and applications

Customers select our metallocene PB-1 material as polymer backbone for innovative HMA formulations for the following reasons:

- the broad operational temperature range
- the medium to low viscosity profiles
- the extended open time, as well as
- the low odor and volatile organic compounds (VOC's).

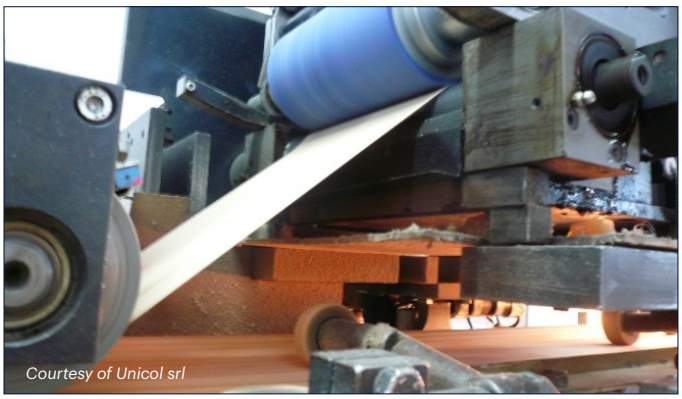
Woodworking applications

PB-1 is an increasingly popular raw material in the formulation of hot melt adhesives for the wood working sector like edge banding and profile wrapping, thanks to its distinctive properties that significantly improve its performance in the application phase.

One of the key features of the PB-1 is its wide operating temperature range, that allows easy processability while maintaining high adhesive performance in both cold and hot climates.

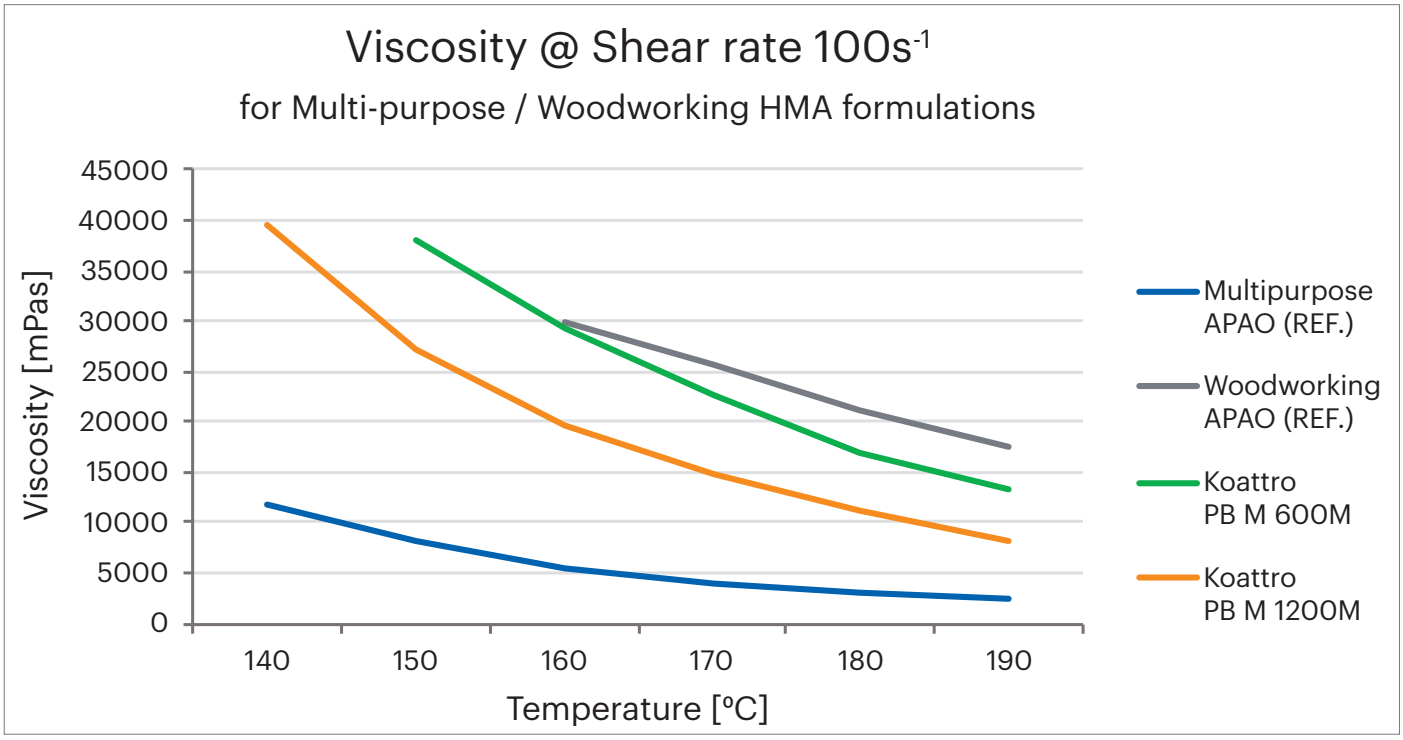
The polymer PB-1 also enables the formulation of medium to low viscosity adhesives, facilitating processing and improving application window for industrial processes. This also implies reduced wear and tear on equipment.

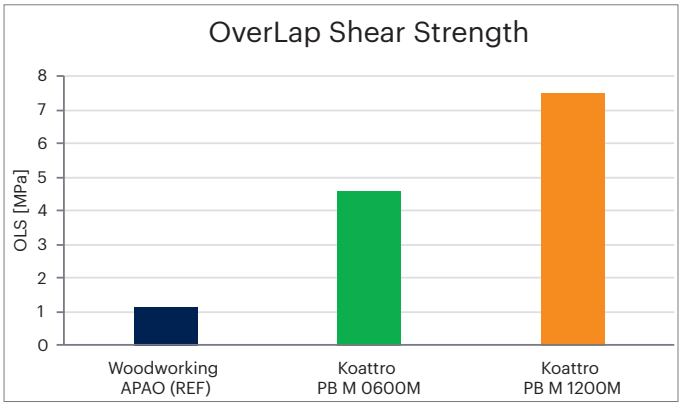
Another key advantage is the extended open time, which offers a longer time frame for the placement and assembly of the timber components. This is especially useful in complex or large-scale machining, where flexibility in handling times is crucial. Finally, the use of PB-1 contributes to improving the working environment thanks to its low odor and reduced content of volatile organic compounds (VOCs).

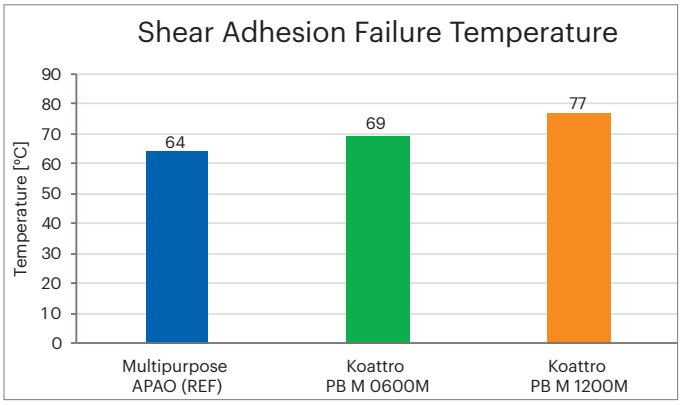

Courtesy of Unicol srl

This makes PB-1-based hot melt adhesives safer and more sustainable, both for operators and the environment. In summary, the integration of PB-1 into hot melt adhesives for woodworking represents an advantageous technical choice, combining efficiency, application quality and sustainability.

For instance, in woodworking adhesive formulations *Koattro* PB M 0600M combines low viscosity, good flexibility and high thermal resistance (high shear adhesion failure temperature - SAFT) contributing to the durability and environmental friendliness of furniture items.







OverLap shear strength of *Koattro* resins versus APAO-reference for woodworking

Mattress assembly applications

In the context of mattress assembly, choosing the right adhesive is crucial to ensure production efficiency, finished product quality, and environmental safety. Polybutene-1 (PB-1) has a proven track record as a base for hot melt adhesives, thanks to a combination of properties that perfectly meet the needs of the industry.

One of the distinguishing features of the PB-1 is its wide operating temperature range, which ensures reliable and consistent application in a variety of production environments.

PB-1 also enables the formulation of medium to low viscosity adhesives, improving processability, facilitating application even on complex surfaces such as foams and fabrics, and contributing to uniform product distribution.

The extended open time offered by PB-1 is a significant advantage in assembly processes where longer handling times are required, without compromising initial adhesion or bond quality.

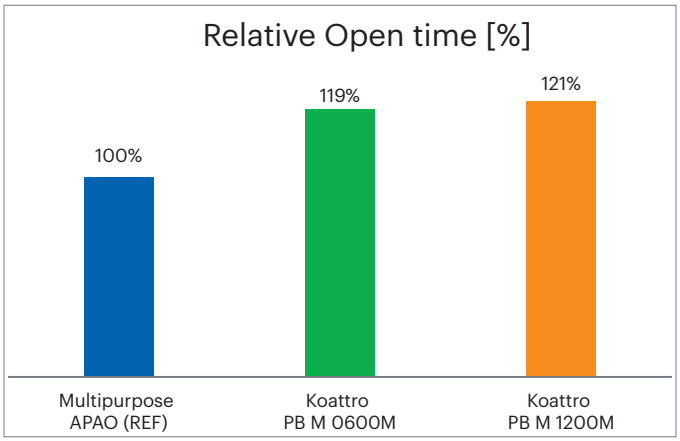
The material also stands out for its low odor and reduced volatile organic compound (VOC) content, contributing to a healthier working and end use environment.

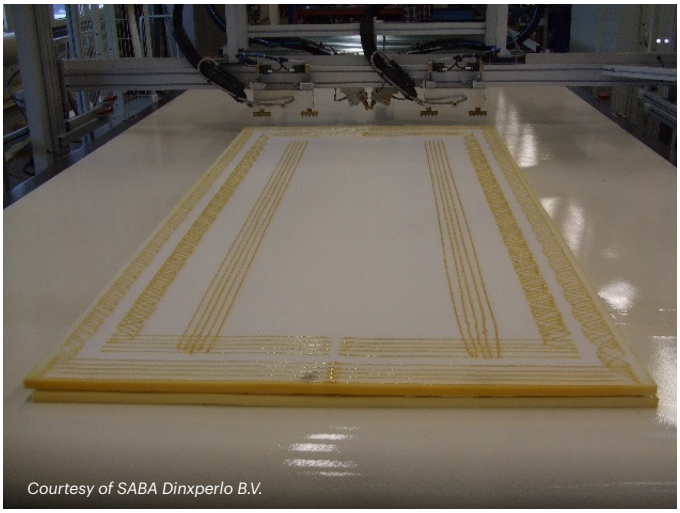
Mattress assembly

The assembly of spring-loaded mattresses requires an excellent green strength*) combined with a long open time to allow a manual or automated assembly process.

Koattro PB M 1200M is used by customers as a key component in adhesive formulations for sandwich mattress assembly, providing the flexibility and durability that a mattress should provide for a good night's sleep.

**) hot tack*




Courtesy of SABA Dinxperlo B.V.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Packaging applications

In the packaging industry, choosing the right adhesive is crucial to ensure reliable, fast bonding suitable for a wide range of surfaces. PB-1 is emerging as a promising component in the formulation of high-performance hot melt adhesives, thanks to its functional properties and application versatility. Formulation studies were conducted for the different end-market applications including the use of different types of waxes. mPB-1 shows good compatibility with various types of waxes like Fischer Tropsch wax, Paraffin, Microcrystalline, PE and PP wax. These case studies are available upon request to give HMA formulators a head start when developing HMA's using PB-1.

One of the main features of PB-1 is its ability to provide effective wettability on both porous surfaces, such as corrugated cardboard, and non-porous surfaces, such as coated paper and board. This implies consistent and long-lasting adhesion, even under high-speed production conditions or on difficult-to-bond materials.

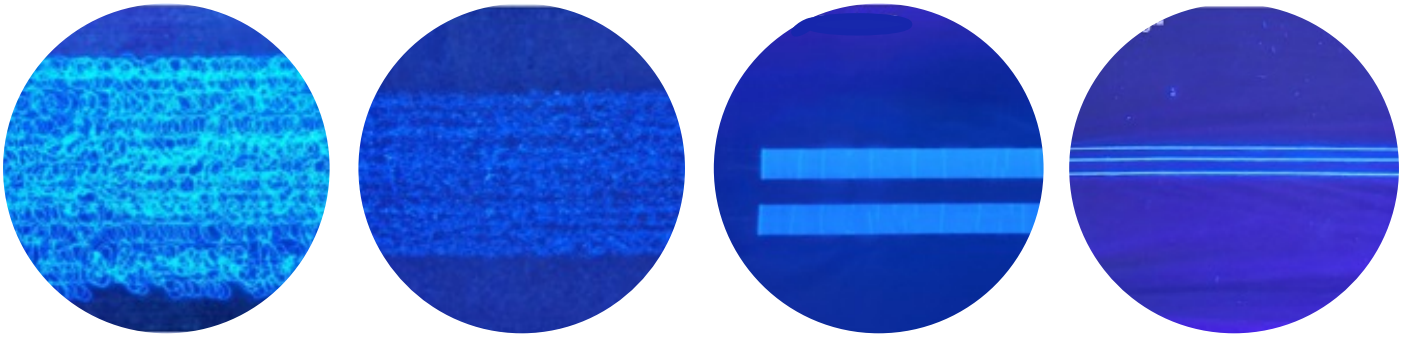
PB-1 also offers excellent thermal stability that allows the adhesive properties to be maintained even after long periods of melting in the tanks of the applicator machines, reducing the formation of residues or gels and improving the maintenance of the systems. Its low viscosity allows easy application even at lower temperatures than traditional hot melts, with advantages in terms of energy efficiency and less thermal stress on substrates and equipment. In addition, PB-1 based hot melt formulations are characterized by fast setting times, which are essential for high-speed packaging lines, where it is vital to ensure immediate and stable bonding. The effective wetting of porous (cardboard) and non-porous surfaces (coated paper / cardboard) is of key importance in packaging assembly processes. Thermal stability, low viscosity and fast setting times do complete the property profile for HMA formulations to allow high production speeds used for cardboard boxes, trays and paper bags.

In summary, the integration of PB-1 into hot melt adhesives for packaging offers an optimal combination of universal adhesion, thermal stability, controlled fluidity and fast fixing, making it the ideal choice for demanding industrialized packaging lines.

Hygiene applications

In the area of non-woven hygiene applications, where performance demands are particularly high, the use of *Koattro* PB M 1500M, a more flexible variant of PB-1 offers an ideal solution. This PB-1 grade offers an unmatched balance of flow and elasticity, perfectly meeting the specific needs of a very demanding application segment. Furthermore non-woven hygiene applications typically require odorless and light-coloured adhesive solutions that preferably can be applied at low temperatures.

The *Koattro* PB M 1500M is designed to provide excellent performance in hot melt adhesive applications, particularly in the hygiene field, such as diapers, sanitary napkins and disposable hygiene products. Its superior elasticity allows for long-lasting bonding, which maintains performance even under mechanical stress. Extraordinarily high production speeds require HMA formulations that are accurately sprayable, offer excellent thermal stability and have high tackiness to allow a flawless assembly process. *Koattro* PB M 1500M offers excellent spraying behaviour that is crucial for applications where a meticulous high speed application of the adhesive on non-woven materials is required, while ensuring good adhesion without compromising the softness or flexibility of the finished product. The balance between flow and elasticity that *Koattro* PB M 1500M offers is essential to meet the requirements of production efficiency, durability and comfort in non-woven applications for hygienic products. Its formulation ensures that the finished product can withstand multiple bending and compression, while maintaining the adhesion integrity. In summary, *Koattro* PB M 1500M is the ideal choice for hot melt adhesives in non-woven hygiene applications, where a perfect combination of optimized flow, long-lasting elasticity, and superior spray performance is required.



Courtsey: Savare

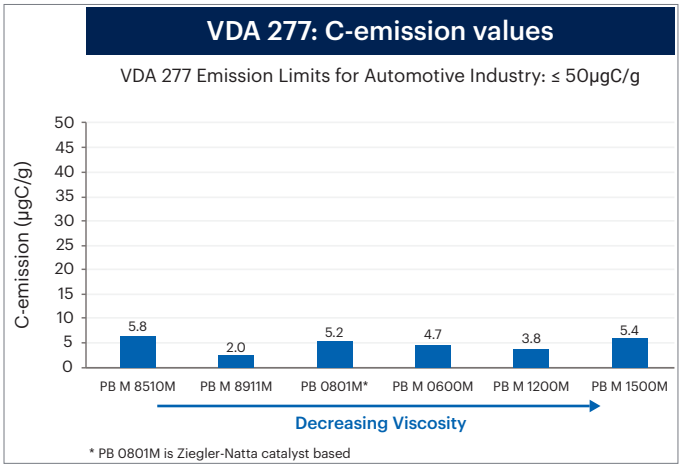
Above spray patterns show a very precise glue path offered by the *Koattro* PB M 1500M ensuring superior production efficiency.

VOC emissions of mPB-1

Volatile organic compounds (VOC's) are low molecular weight organic chemicals that have a high vapor pressure at room temperature due to their low boiling points.
The VOC emissions of mPB-1 have been characterized using the VDA method (Verband der Automobilindustrie or the German Association of the Automotive Industry) consisting of VDA 277 and VDA 278 protocols. 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. The VDA 277 protocol detects species with low boiling point volatiles whereas the VDA 278 protocol provides information on VOC's including higher boiling substances (SVOC's or Semi Volatile Organic Compounds) also known as FOG emissions.

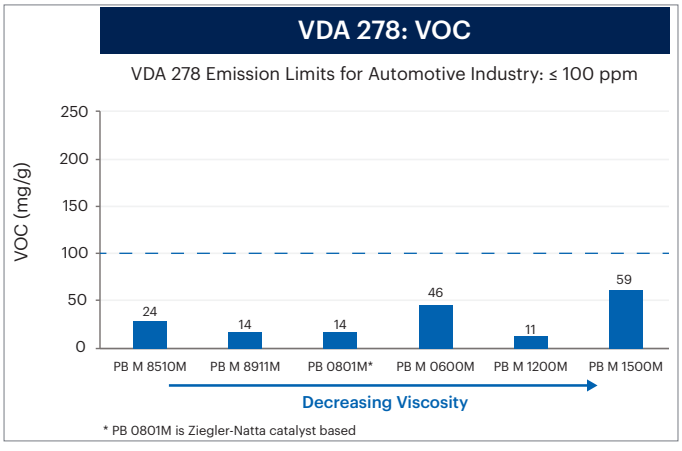
mPB-1 carbon emissions based on the VDA277 protocol:

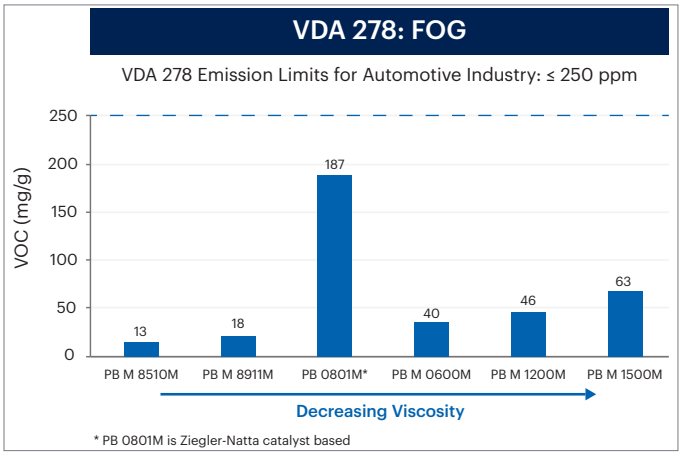
According to the analytical characterization following the VDA 277 protocol, mPB-1 grades show very low organic emissions. The C-emission values are much below the VDA 277 emission limits for the automotive industry (≤ 50µgC/g). Another observation is that the measured C-emission values show no correlation with the viscosity or the molecular weight of the polymer.



mPB-1 carbon emissions based on the VDA278 protocol:

Using the VDA 278 protocol, the emissions can be characterized into VOC (volatile organic compounds) and FOG (fogging compounds).

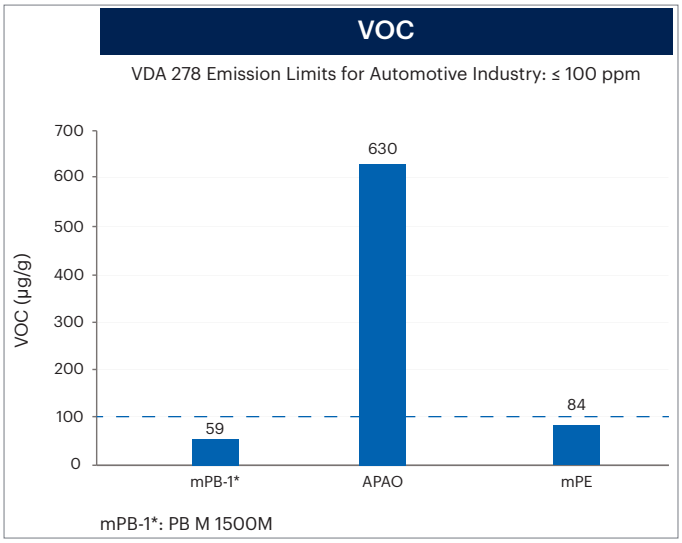


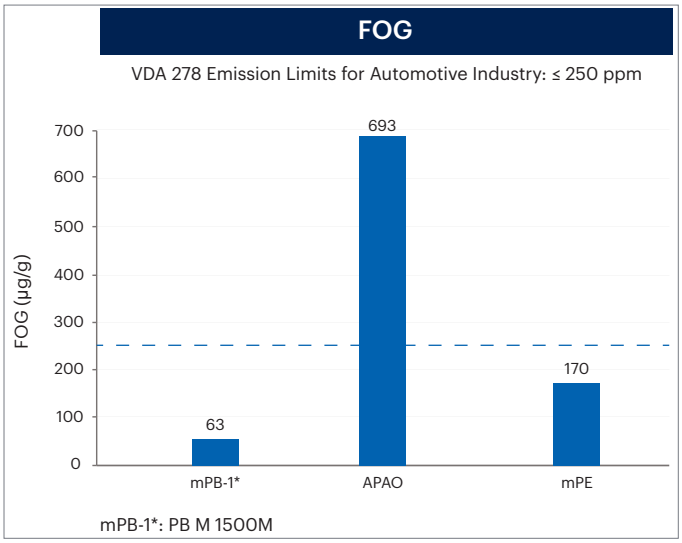


The low emission profile for mPB-1 is a direct result from the solution polymerization technology used for the production of PB-1 where Butene-1 is not only the monomer but also acts as the solvent. Hence, the process is rather clean as it avoids the use of any external high molecular weight solvent. The combination of metallocene technology providing a precise control over the polymer structure and the efficient finishing section in the production ensures adequate residual monomer.

The volatile species detected for PB-1 grades mainly consist of aliphatic compounds such as linear and branched oligomers being free of toxic substances. The grade *Koattro* PB 0801M shows slightly higher FOG emissions as it is produced using the Ziegler-Natta catalyst, though the emissions are still below the stringent automotive limits.

In comparison to the incumbent polymers like mPE and APAO that are used in hotmelt adhesives, mPB-1 exhibits even lower emissions.





Sustainability

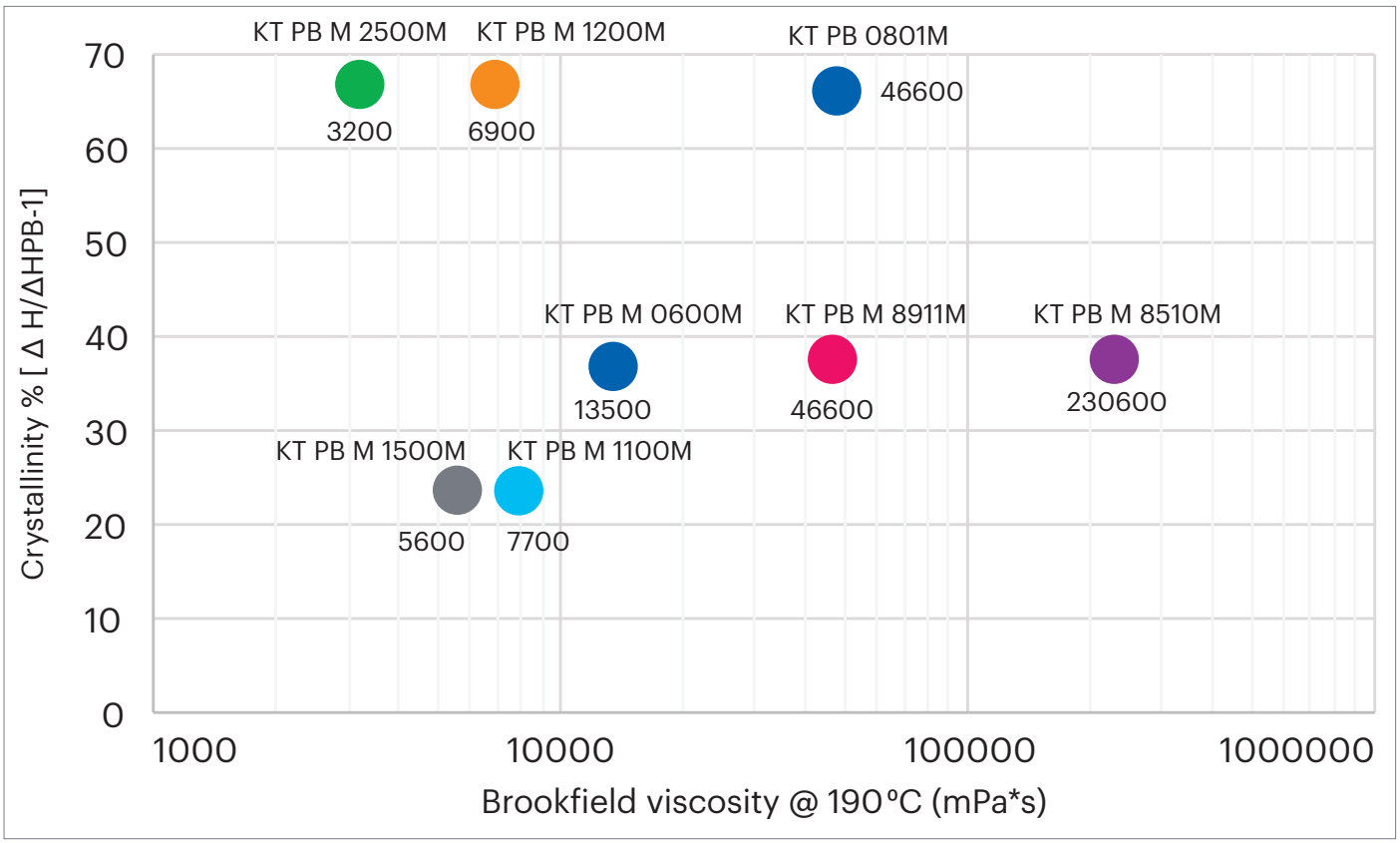
ISCC PLUS is a certification system for companies that provide recycled or renewable-based product content using a mass balance approach that follows a set of predefined and transparent rules. ISCC PLUS is a standard well-recognised by all stakeholders for advanced recycled and renewable materials. It is now available for our German crackers and for the European polymer sites, including the PB-1 asset. For the *Circulen* grades a certain amount of feedstock made from advanced recycled plastic waste or renewable-based feedstock is used in the cracker. Certificates are available to allocate this feedstock to product on a mass balance basis.

Customers can use these certificates to verify compliance with sustainability and traceability requirements along the supply chain. LyondellBasell has also conducted the Life Cycle Analysis (LCA) study of PB-1. This study quantifies the impact (CO2 equivalent emissions included) of PB-1 produced at the LyondellBasell EU site (Moerdijk, The Netherlands) comparing a mass-balanced biomass feedstock versus the current fossil based feedstock. The LCA study uses a Cradle-to-Gate approach i.e. from raw material extraction up to the product at the LyondellBasell factory gate. The PB-1 LCA data is available upon request.

Koattro portfolio for hot melt adhesives

LyondellBasell has industrialized new *Koattro* metallocene Polybutene-1 grades (mPB-1) manufactured in the plant located in Moerdijk, The Netherlands. These grades provide an outstanding combination of properties to HMA formulators such as:

- Melt viscosity range of 230.000 - 3.000 mPa*s @ 190°C ensuring good wettability
- Broad crystallinity range offering good balance of cohesion/adhesion or flexibility
- Blends are possible to tailor the melt viscosity and the physical property profile



Test methods

Melt Flow rate (ISO 1133-1), Brookfield Viscosity (ASTM D3236), Tg (LYB internal test method) Density (ISO 1183-1), Tm1 (Melt Temperature ISO 11357-3), Flexural Modulus (ISO 178) - measured on specimens conditioned for 10 days at 23°C (1) ZN Grade

**Note: Typical properties not to be construed as specifications*

Product	MFR (190°C/2.16kg)	Brookfied Viscosity @ 190°C	Density	Tg	Tm1	Flexural Modulus
	g/10min	mPa's	g/cm³	°C	°C	MPa
Koattro PB M 0600M	600	13500	0.89	-26	100	100
Koattro PB M 1100M	1100	7700	0.89	-30	100	< 100
Koattro PB M 1200M	1200	6900	0.91	-13	105	340
Koattro PB M 1500M	1500	5600	0.89	-30	100	< 100
Koattro PB M 2500M	2500	3200	0.91	-13	105	350
Koattro PB M 8510M	45	230600	0.89	-22	93	120
Koattro PB M 8911M	200	46600	0.89	-22	93	100
Koattro PB 0801M(1)	200	46600	0.91	-8	125	410

Koattro KT MR 05 resin – a new high performance plastomer for polymer modification and hotmelt pressure sensitive adhesives

LyondellBasell has developed and industrialized a high performance plastomer based on Butene-1, called *Koattro* KT MR 05. *Koattro* plastomer is produced using metallocene catalyst technology and is fully compatible with PP. This innovative plastomer is non-phthalate based and is free of plasticizers. It is available in the form of free flowing pellets. This product is characterized by several unique properties in combination with PP such as improved transparency, softness, flexibility (without use of plasticizers) and elasticity (without any cross-linking). Besides, polymer modification, *Koattro* KT MR 05 may be considered in hot melt pressure sensitive applications owing to its almost amorphous nature that naturally promotes tackiness and adhesion. It may also help to improve hot tack properties. From regulatory point of view, the *Koattro* KT MR 05 is EU Food Contact compliant as well as FDA compliant.

Product	MFR (190°C/2.16kg)	Charpy notched impact strength (23°C)	Density	Shore Hardness (Shore A)	Compression Set (23°C, 22h)	Flexural Modulus
	Unit g/10min	Unit kJ/m2	Unit g/cm3		%	Unit MPa
Koattro KT MR 05						
Method	ISO 1133-1	ISO 179	ISO 1183-1	ISO 868	ISO 185	ISO 178
Value	1.3	No Break	0.870	60	35	< 10

Please contact us to learn more about these innovative products. Our Application Development engineers are available to support in driving your solutions for tomorrow's hotmelts.

About us

We are LyondellBasell (LYB) – a leader in the global chemical industry creating solutions for everyday sustainable living. Through advanced technology and focused investments, we are enabling a circular and low carbon economy. Across all we do, we aim to unlock value for our customers, investors and society. As one of the world's largest producers of polymers and a leader in polyolefin technologies, we develop, manufacture and market high-quality and innovative products for applications ranging from sustainable transportation and food safety to clean water and quality healthcare. For more information, please visit www.lyb.com or follow @LyondellBasell on LinkedIn.

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