

Montan Waxes – High-Performance Additives for PVC

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Montan waxes are widely used in the plastics industry as multifunctional broadband additives, thanks to their special properties. They can simultaneously act as excellent and efficient viscosity reducers (flow enhancers), mould release agents and dispersion aids. Montan ester and acid waxes are used in polyvinylchloride (PVC), polyamide (PA), polycarbonate (PC), thermoplastic polyurethane (TPU) and styrene-maleic acid anhydride. The following overview summarises the advantages of montan waxes in PVC processing.

Introduction

Montan waxes are produced from a lignite extract by a multi-step process that includes bleaching. The principal component of montan waxes is montanic acid, a linear, saturated carboxylic acid with a main chain containing between mainly 26 and 34 carbon atoms.

The various possible chemical transformations of the starting wax make it possible to create products with different polarities, all with high thermal stability due to the structure of the backbone. Montan wax ester lubricants possess both internal and external lubrication properties, and the balance between the two can be shifted substantially depending on the polymer in which they are used. For example,

in non-polar plastics such as polyolefins, montan waxes have a much greater external lubricating effect (owing to their inherent polarity) than in polar plastics such as PVC.

Good Compatibility and Low Migration Tendency

Montan waxes have a similar chemical structure to fatty acid esters, although they have longer carbon chains¹. The advantages of montan waxes come to light in PVC especially when there are high demands made on the quality of the end product. The resulting higher melting points as well as their chemically good compatibility with PVC lead to a considerably lower migration tendency.

Excellent Release Effect and Flow Improvement

Among other properties, montan waxes function in PVC as release agents (“external lubrication”). They improve the surface quality and smoothness and provide the final product with a superior gloss. Montanic esters are used in materials processed by injection moulding and other processes that require a good melt flow, as they also reduce the melt viscosity (“internal lubrication”; Fig. 1). For example, they show their advantageous lubricating properties in high-speed cable extrusion, especially at the screw tips.

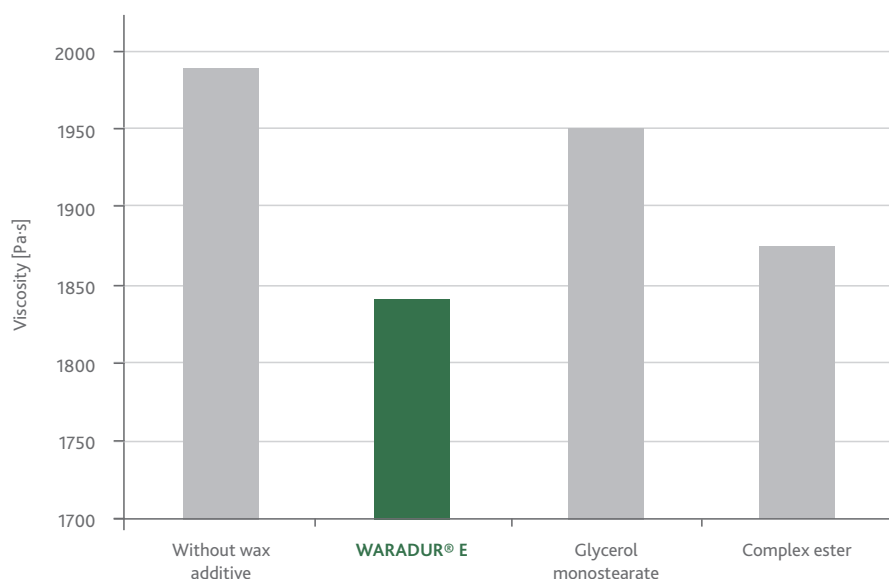


Fig. 1: Effect of various waxes on the viscosity of PVC melts

Voelpker offers a broad range of montan waxes branded WARADUR®. Among these, WARADUR® OP tends to have a somewhat lower external lubricating effect than WARADUR® E and WARADUR® GE. Both lower the melt viscosity somewhat more, enabling lower extrusion pressures (Tab. 1).

Lubricant	Average molecular weight [g/mol]	Drop point range [°C]	Effect on fusion time	Effect on extrusion torque	Effect on extrusion pressure
WARADUR® E Fatty acids, montan wax, ethylene esters	approx. 900	82 – 88	→ →	↓↓	↓↓
WARADUR® GE Fatty acids, montan wax, glycerol esters	approx. 900	80 – 88	→ →	↓↓	↓↓
WARADUR® OP Fatty acids, montan wax, 1-methyl-1,3-propanediyl esters	approx. 900	99 – 105	→	↓↓	↓

Tab. 1: Chemical, physical and rheological data of some typical lubricants on addition of lubricant; →: means fusion is delayed; ←: fusion is promoted; ↑: torque or pressure increases; ↓: torque or pressure decreases; (the more symbols, the more pronounced the effect at the same dosage)

Superior Surfaces

Montan waxes are often used as specialty high-quality release agents. Apart from the release action, in contrast to other waxes, they tend not to “plate out”, even at higher dosage. This ensures good removal of finished parts from the mould and also a high-quality glossy surface (Fig. 2). Additionally, downstream processing steps such as metalizing, printing and bonding are not significantly influenced.

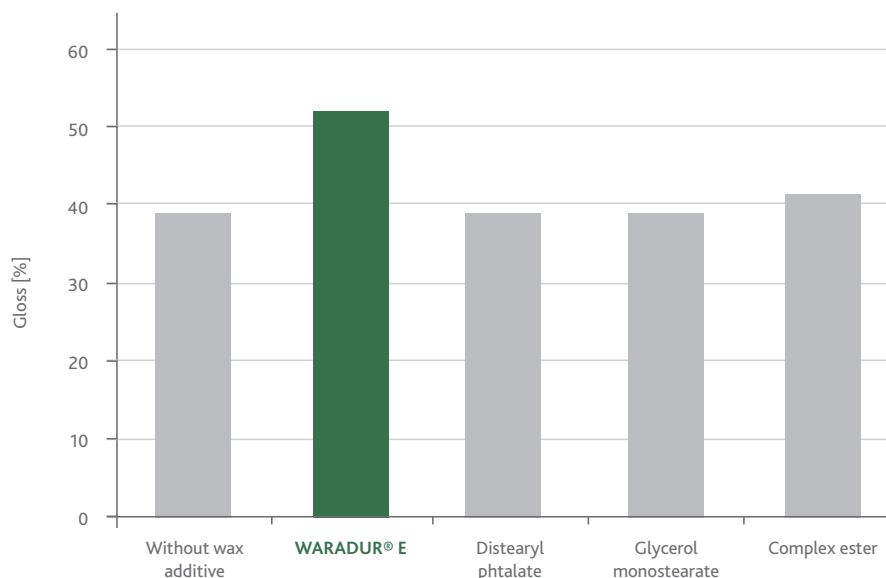


Fig. 2: Effect of various waxes on gloss of extruded PVC window profiles

Highly Effective at Low Dosage

The use of montan waxes is especially advantageous in PVC because – compared for example to glycerol monostearate (GMS) and complex esters used in the same amounts – they are much more effective in reducing melt viscosity (Fig. 1). This effect is especially interesting in PVC applications in which high shear forces occur, e.g. in the injection moulding or in the co-extrusion of window profiles.

Chattering/Juddering

During extrusion of PVC window profiles, montan waxes can also solve the problem involving what is known in English as “chattering” (also known as “juddering”), if they are used to partially replace primarily external lubricants such as Fischer-Tropsch paraffins or PE waxes. This phenomenon manifests itself in vibrations along the whole extrusion line and may be caused by various factors:

1. “Stick-slip” behaviour in the vacuum calibration section;
2. Excessively high melt viscosity;
3. Sticking and sliding of the melt in the hot tool;
4. Too large an expansion of strands as they exit the nozzle.

Factors 1 to 3 can all be solved by the addition of montan waxes.

Influence on VICAT Softening Temperature

A further advantage of montan waxes lies in their relatively high melting points, which means that they have a reduced effect on the VICAT softening temperature of, for example, PVC injection moulding grades. Figure 3 shows an example in an injection moulding application. In principle, this can

also be applied to compounds containing various stabilisation systems such as calcium, zinc and calcium-organic. A very similar trend can be also found in tin-stabilised injection moulding grades. However, their VICAT softening point is already much lower, even before lubricants are added.

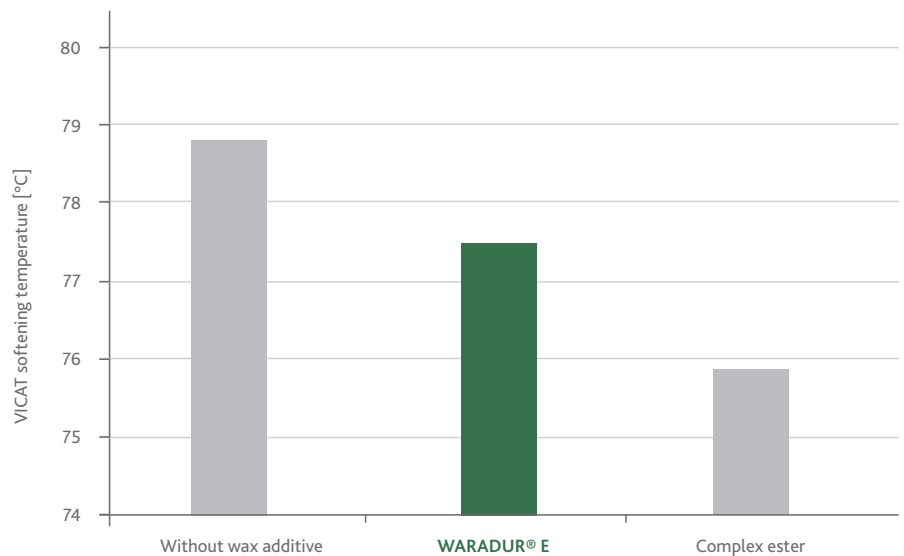


Fig. 3: Effect of various waxes on the VICAT softening point of PVC (100 phr PVC, 1.5 phr octyl tin stabiliser, 1 phr processing aid, 1 phr lubricant)²



Influence on Melt Elasticity

Apart from the internal lubricant effect, the influence on thickening behaviour and the release effect, montan wax derivatives have one more beneficial effect: some products can also considerably improve melt elasticity in PVC. Thus, for example, the extensibility and also the elastic modulus of PVC melts are improved. One process benefitting from high melt elasticity is calendering, since it enables the foil to be drawn from the takedown roller without any problems^{3,4} (Fig. 4). Apart from lubricants, high-molecular weight processing aids based on polymethacrylate have a considerable effect on the elasticity of the melts.

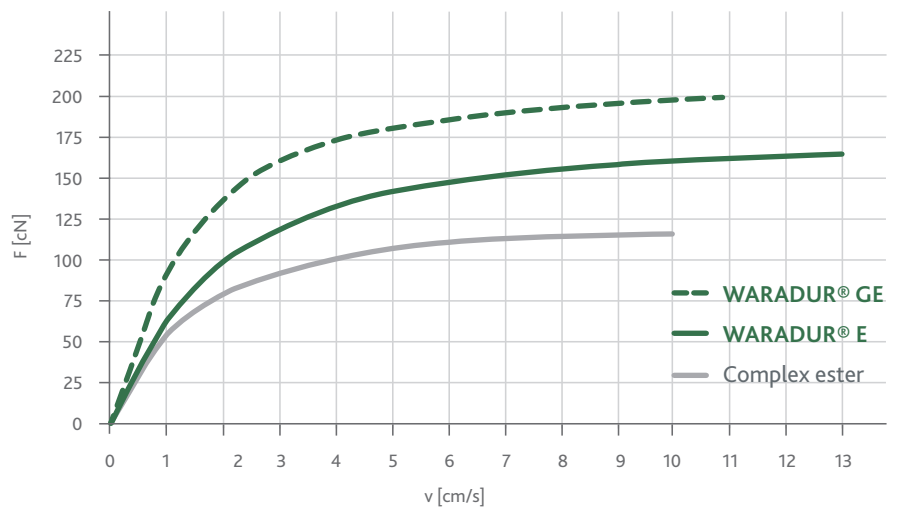


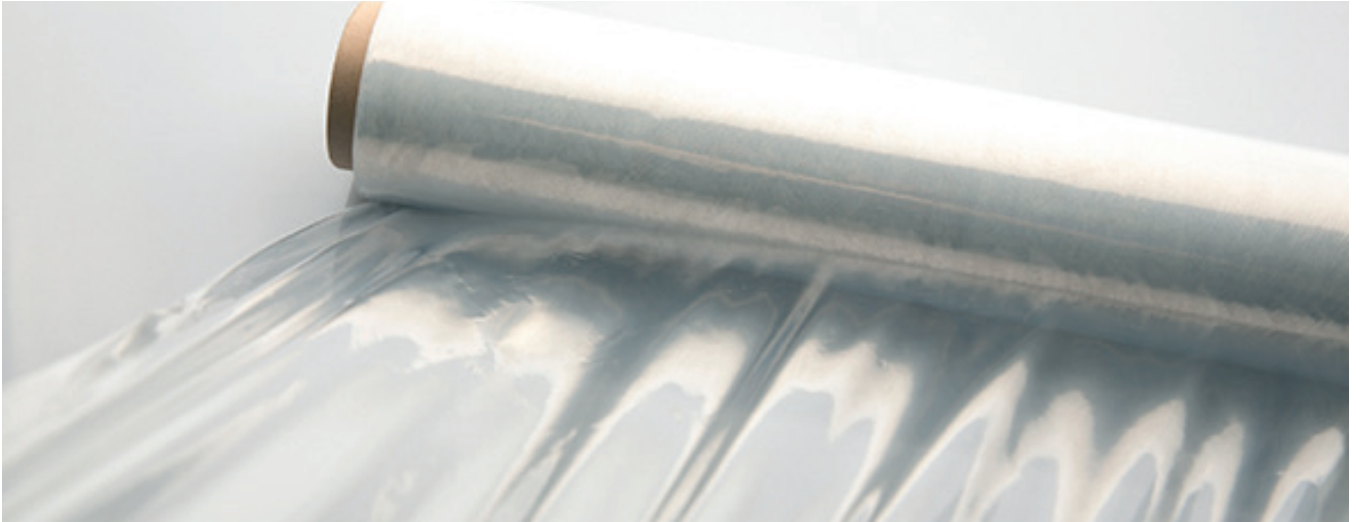
Fig. 4: Effect of lubricants on the melt elasticity of PVC (100 phr PVC k=60, 0.3 phr calcium soap, 0.1 phr zinc stearate, 3.0 phr ESBO, 0.3 phr β -diketone, 0.5 phr lubricant)⁴

	Calendered films		Thermo-forming	Credit card		Shrink film	
	Furniture	Pharmaceutical		Overlay	Core	Calendered	Blown
PVC	100	100	100	100	100	100	100
VC-AC copolymer	-	10 – 20	20 – 50	40	-	-	-
Plasticiser	-	-	-	-	-	10	10
Impact modifier	5	8	5	10	10	-	6
Acrylic processing aid	1	1	1	1	1	1	1
Montan wax / complex ester	0.5	0.5	0.4	0.5	0.5	0.2	0.3
Fatty acid / ester waxes	0.4 – 1.0	0.4 – 1.0	0.4 – 1.0	0.6	0.6	-	-
Amide wax	-	-	0.2	0.2	-	-	-
Tin stabiliser	1.0 – 1.5	1.0 – 1.5	1.0 – 1.5	1.0 – 1.5	1.0 – 1.5	2.0 – 3.0	2.0 – 3.0

Tab. 2: Recommended lubricant-containing formulations for various PVC dry blend products (phr)⁵

Summary

Montan waxes such as WARADUR® S, WARADUR® GE, WARADUR® E and WARADUR® OP are highly efficient lubricants for PVC. They provide excellent processing behaviour during extrusion, calendaring and injection moulding and superior properties to the final product, which are difficult to obtain with other waxes.



Literature

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- [5] H. Zweifel, R.D. Maier, M. Schiller (eds); *Plastics Additives Handbook*, 6th ed., C. Hanser Publisher, Munich/Germany (2009), p. 572.

About VOELPKER

Voelpker – a family-owned company with innovative strength.

With more than 117 years of production history, Voelpker is among the most long-standing wax producers in Europe and is renowned worldwide as a reliable manufacturer and supplier of

montan waxes and special wax blends. Due to their unique properties, montan waxes produced by Voelpker are widely used as high-performance additives in the engineering plastics industry. True to the motto 'to make ideas work', we do everything to improve and optimise the products and processes of our industry partners. We design special wax additives

that are precisely tailored to their requirements. We have served our customers as a reliable partner and have developed individual solutions for many branches over the last few decades.

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