LANXESS
Energizing Chemistry

Levamelt®

A versatile and flexible material
for adhesives and films

Edition 2008-06

Contents

Levamelt® from Lanxess

With tomorrow's requirements in mind
As a worldwide leader in synthetic rubber production, LANXESS offers its customers a comprehensive range of synthetic rubbers.

Specialty rubbers such as Levamelt® play an important role here. When conventional polymers come up against their limits, Levamelt®, a polymer with very good heat and weathering resistance, is a suitable alternative. Levamelt® product range consists of co-polymers that can cope with the demanding requirements of the following sectors:

- Adhesives
- PVC
- Film & foil

The aim of this brochure is to give a first impression of Levamelt® by providing information on its many properties and advantages as well as by presenting both convertors and end users the possible applications and solutions.

Our Levamelt® experts will be happy to provide you with further technical information. Please find their contact data on page 14 of this brochure.
For immediate contact, further questions or urgent requests you can also use our e-mail address at: **info@levamelt.com**

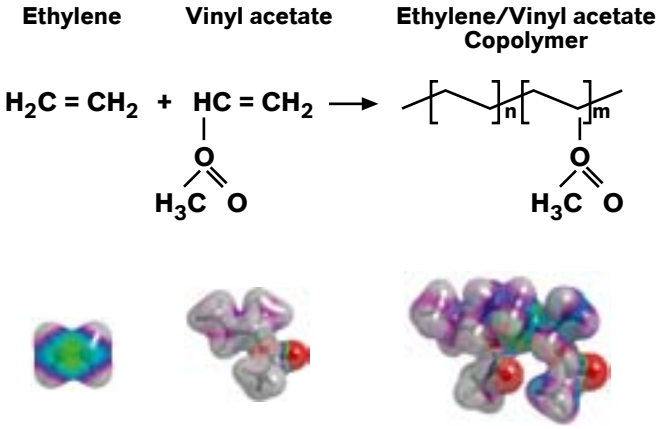
Pictures on this page show just a few examples of potential and current applications in both films and adhesives.

Polymer properties

Levamelt® is formed by copolymerizing ethylene and vinyl acetate. In principle Levamelt® consists of methylene units forming a saturated main chain with pendant acetate groups. These rubber-like polymers are designated as EVM[1] according to ISO 1629: 1995 (E). The presence of a fully saturated main chain is an indication that Levamelt® is a particularly stable polymer. Degradation generally only occurs at very high temperatures and even then very slowly.

These polymers are used as synthetic rubbers, as adhesive raw materials or as modifiers in thermoplastics, specifically PVC. The adhesive raw materials and plastic modifiers are marketed under the name Levamelt®, while powdered grades are distributed under the name Baymod® L

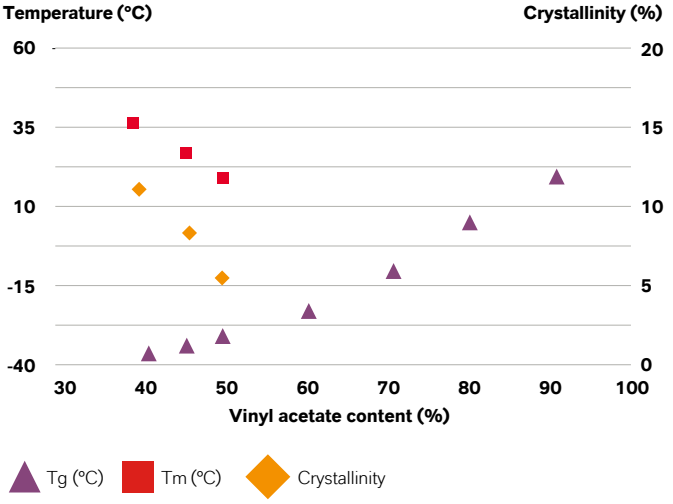
Radical polymerisation – chemical structure of Levamelt®



Influence of the VA- content on morphology

The higher the proportion of vinyl acetate in the copolymer, the more the regularity of the ethylene chain is disturbed. Crystallization is increasingly hampered and is entirely absent from a copolymer with a vinyl acetate content of approx. 55 %. Copolymers with a high vinyl acetate content are therefore amorphous.

Influence of the VA- content on morphology



[1] In accordance with ISO 1043-1: 1987, the abbreviation E/VAC is to be used for thermoplastics. The abbreviation EVA is also frequently used.

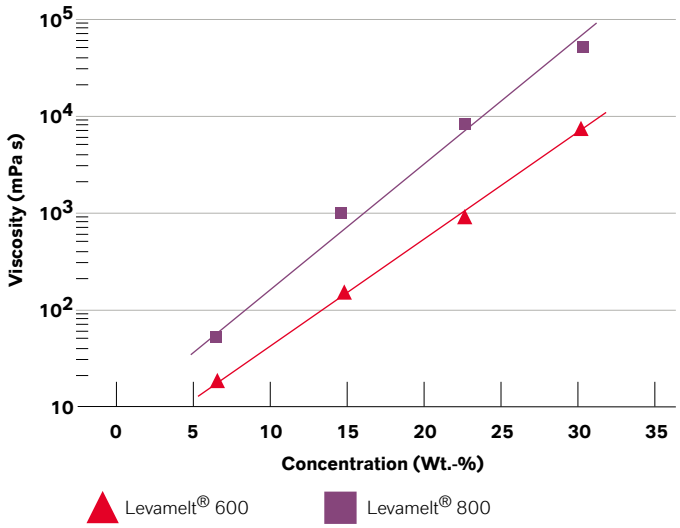
Levamelt® adhesive applications

Levamelt® in Solvent Borne Adhesives

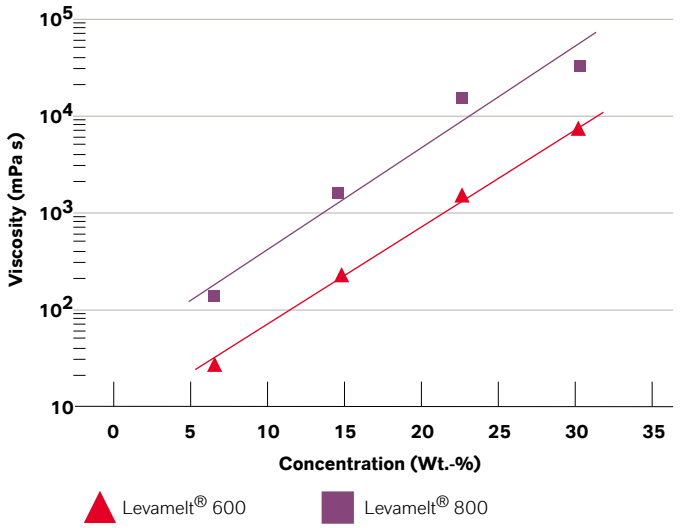
Levamelt® can be used in solvent borne adhesive applications. Solvents for the various Levamelt® ethylene-vinyl acetate copolymer grades are aromatic and chlorinated hydrocarbons, as well as cyclic ethers. Alcohols do not dissolve Levamelt® copolymers, while esters, ketones, and aliphatic hydrocarbons have a strong swelling effect. Storing solutions of Levamelt® copolymers at low temperatures will cause gelation which, however, is reversible upon mild heating and agitation without adverse effect.

The graphs show the viscosities of Levamelt® 600 and 800 solutions in MEK and toluene as function of the concentration.

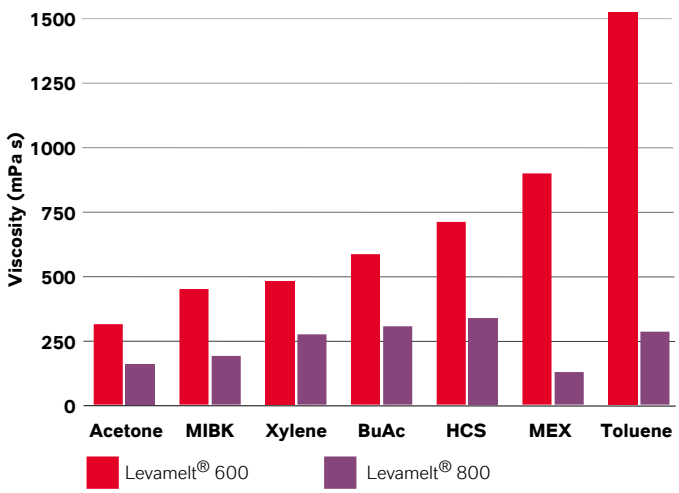
Levamelt® in MEK



Levamelt® in Toluene



Viscosity of 15 % Levamelt® solutions



Levamelt® for hot-melt applications

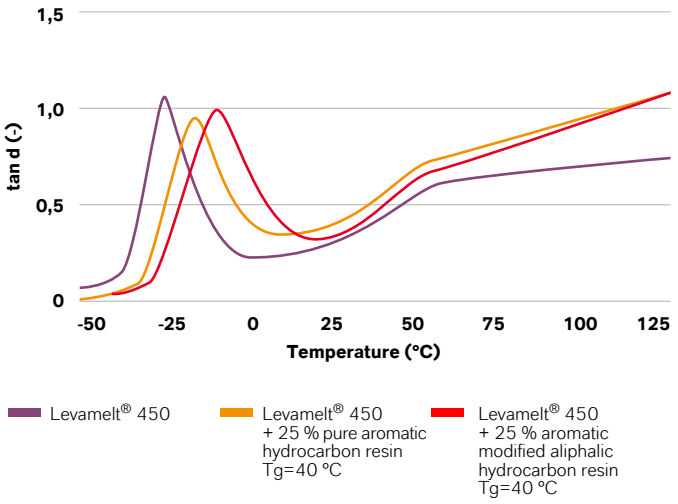
Levamelt® are suitable grades for hot-melt adhesives. Compared to EVA copolymers (of lower vinyl acetate content), Levamelt® grades offer improved adhesion characteristics, better low-temperature adhesion, and are particularly useful in the formulation of pressure sensitive hot-melt adhesives.

Levamelt® 456, having the highest melt index (lowest molecular weight), is the preferred polymer when low melt viscosities are required. Levamelt® 450 and 452 are utilized, either by themselves, or in a blend with Levamelt® 456 to enhance the heat strength.

Since Levamelt® copolymers have very little inherent tack and relatively high melt viscosities, further compounding with resins is necessary in order to render them useful for adhesive applications. The type and level of resin varies widely with the properties required and the intended end-use. Typical resins include modified and unmodified wood rosins and wood rosin esters.

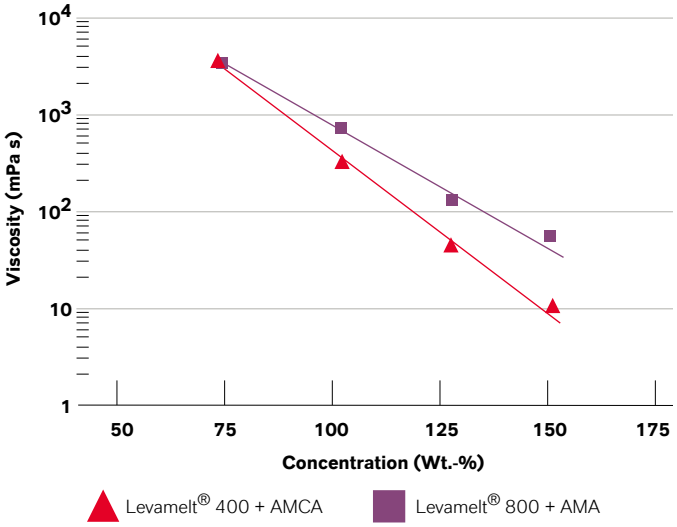
The compatibility of Levamelt® with different tackifier resins was checked by DMA. The enclosed graph shows a good compatibility of different tackifiers (hydrogenated and aromatic modified aliphatic hydrocarbon resin) in Levamelt® 450. Highly aromatic resins are not compatible with Levamelt® 450.

Compatibility of Levamelt® with tackifiers



The below graph demonstrates the viscosity of a hot-melt formulation based on Levamelt® as function of temperature and tackifier type, where AMCA is an aromatic modified cycloaliphatic hydrocarbon resin, AMA an aromatic modified aliphatic hydrocarbon resin.

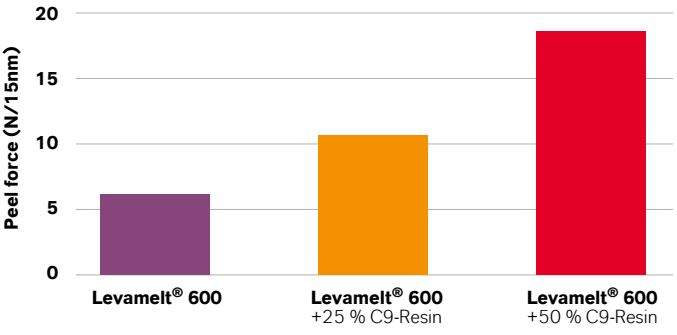
Viscosity of a hotmelt formulation depending on temperature (1 Hz shear rate)



Influence of tackifier on Levamelt®

Also the influence of the amount of tackifier (C9 hydrocarbon resin) was evaluated: Here the tackifier (C9 hydrocarbon resin) was increased from zero up to 50% in Levamelt® 600 and measured on steel

Influence of tackifier on Levamelt®



Adhesive films

Levamelt® in adhesive films

Levamelt® is particularly suitable for the production of adhesive films for a wide range of applications in various industries.

Depending on the grade that is used and the surface such films are applied to, properties from low up to semi-permanent adhesion can be achieved. Although Levamelt® is a sticky material, it is supplied in free-flowing pellets.

This fact enables the production of adhesive films within co-extrusion without adding other substances. Nevertheless the adhesion properties of Levamelt® can be adjusted by blending with polyethylene, resins or waxes. In this document, only the adhesive properties of pure Levamelt® and blends among themselves are discussed.

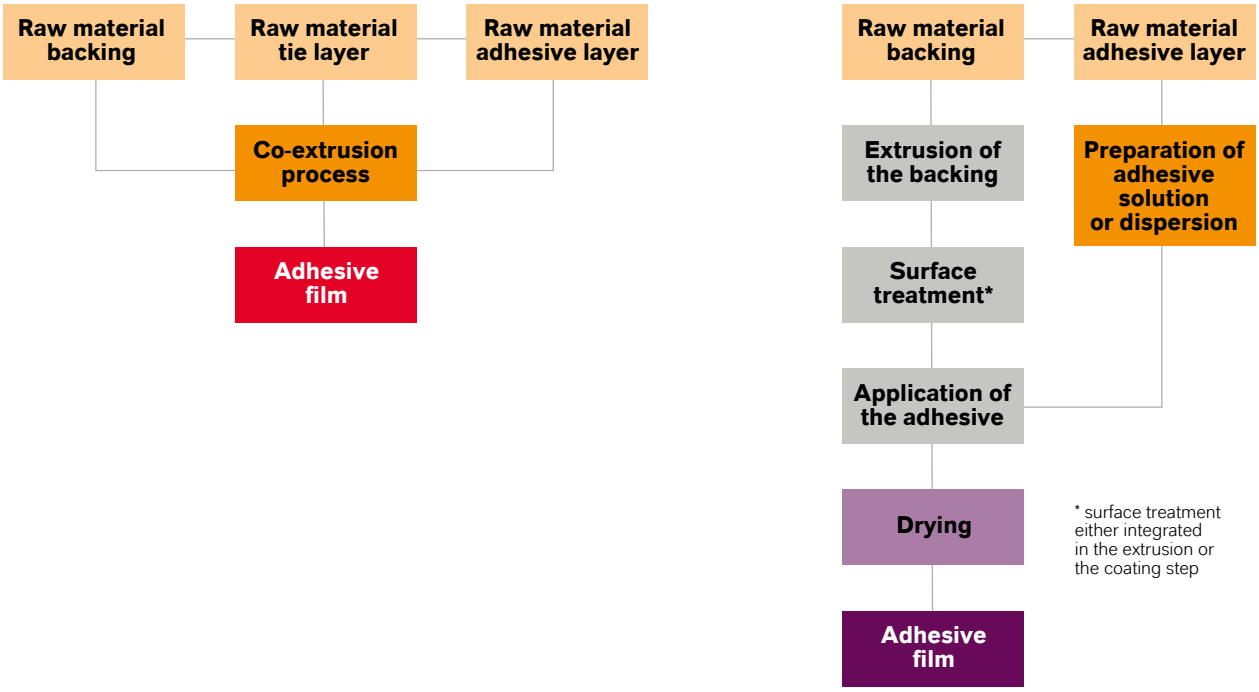
Production of adhesive films

A classical approach to manufacturing adhesive films is the coating of a backing film that is previously produced within a separate extrusion process with a solvent-borne or dispersion adhesive.

Before the application of the adhesive e.g. by means of roller coating, two additional steps are needed. On the one hand the adhesive solution or dispersion must be prepared in a laborious pre-process. On the other hand a conditioning of the film surface like corona pre-treatment is necessary to reach a sufficient bonding of the adhesive to the plastic. The last step is commonly integrated either within the extrusion or the coating stage. The use of solvent-borne or dispersion adhesives implies the extraction of the volatile matters contained. This downstream drying stage is a very energy-consuming sub-process.

As said above, Levamelt® is suitable for producing an adhesive film by means of co-extrusion. This practice allows a significant reduction of process steps. All necessary raw materials can be processed within one stage. A time and energy consuming pre- and post-processing is not required.

Co-extrusion with Levamelt® instead of time and energy consuming pre- and post-processing

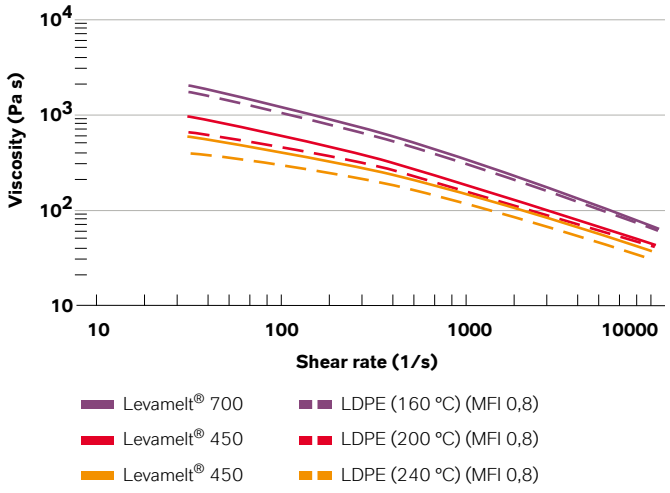


Coextrusion of Levamelt® with Polyolefines

Two materials are co-extrudable if they have a similar viscosity behaviour at process conditions. Commonly, polyolefines are used as backing material e.g. for protective or lamination films. The Melt Flow Index (MFI) of low density polyethylene (LDPE) is typically between 0.5 and 3 g/10min depending on blow or cast film grade, whereas the MFI of most of the Levamelt® grades lies in the range of 5 g/10min (see product range on page 13).

This brief consideration of the flow behaviour of the materials implies that co-extrusion with polyethylene is not possible. But the viscosity of a polymer depends on both the shear rate and the temperature. The MFI measurement is a single-point method and provides only information on one temperature and one shear rate that do not mandatorily lie within the processing range. Here, high pressure capillary viscosimetry is a better method.
The diagram shows that the curves of Levamelt® match those of LDPE very closely at low processing temperatures (~160 °C). This leads to the conclusion that both materials can be co-extruded, which has been proven by practical trials.

Viscosity of Levamelt® and low density polyethylene (LDPE)

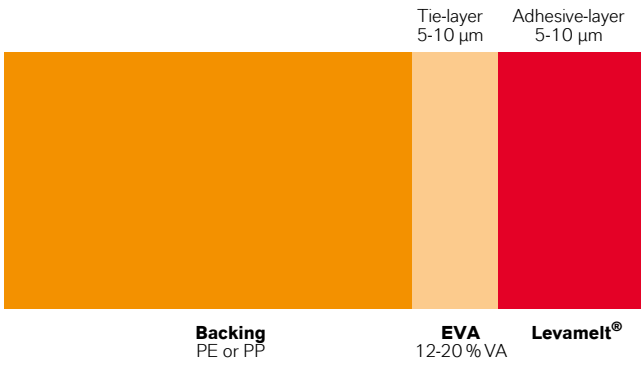


General consideration on layer construction

To ensure a good anchorage of the adhesive Levamelt® layer to the polyolefinic backing (such as LDPE or LLDPE) an EVA-based tie-layer should be used. This means that at least a three layer construction of the film is necessary (see figure below). The tie-layer material has a good adhesion to both the Levamelt® and the polyolefine and acts like a compatibilizer between the two materials due to the fact that it has an intermediate VA content. In doing so it can be reached that the interface adhesion is higher than the adhesion of the Levamelt® to typical surfaces such as metal, glass and different plastics or varnishes. Particularly for protective films this is important in order to ensure smooth removal without residues

The higher the VA content of the Levamelt® is, the higher the VA content of the tie layer material should be. The EVA should have a minimum VA content of 12 % or better 15 % and maximum VA content of about 18 % to 20 %. This kind of layer construction has the advantage that the backing adhesion is very low, thus the film roll can be uncoiled easily.

Layer Construction wih Levamelt®



The choice of the backing material is mainly based on the required mechanical properties of the film such as stretch properties, puncture resistance, flexibility.
The addition of processing agents such as anti-block packages (i.e. silica) to prevent the inner layer of the folded film from sticking by creating a micro rough surface is uncritical. In contrast to this the use of erucamide slipping agent might cause a slight reduction of the interface adhesion. Furthermore the bulk layer can comprise various layers to allow further design options, e.g. using an outer layer with additives to allow printability. Such a film construction can be used for removable labels.

Extrusion of Levamelt®

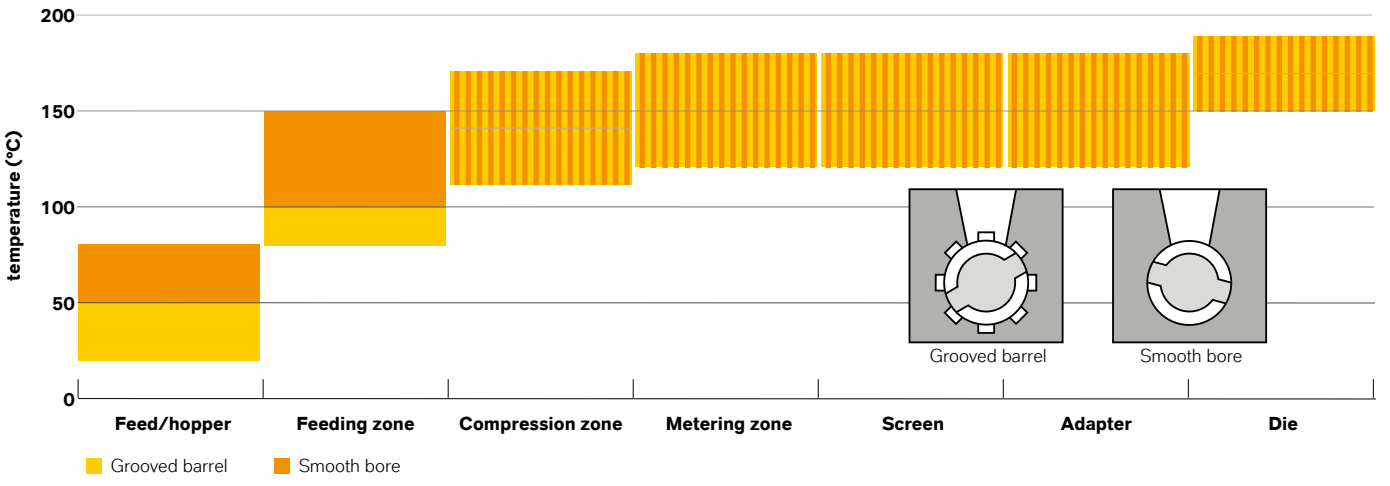
Considering rheological aspects, both blow film and cast film extrusion are suitable processing technologies for Levamelt®. As shown in the table below Levamelt® can be processed undiluted or blended to adjust the stickiness of the adhesive layer. Blending of different Levamelt® grades also with polyethylene is suitable. For this purpose a low viscose LDPE grade without any slipping agent should be applied. Test with an LDPE containing erucamide showed that the adhesion decrease to an extremely high degree even using only some weight-percent. Considering the temperature setting of the extruder only the feeding zone might be critical. Levamelt® is a material that shows a very high cold flow. Thus cooling down the feed is essential to avoid clogging, especially if a grooved barrel extruder is used. Here a temperature of 80 °C should not be exceeded. Apart from that a constant increase along the flow path of the melt up to die temperature is suitable (see next figure). Melt temperatures above 180 °C should be avoided.

Product	Cast film	Blow film
	Extrusion	
Levamelt® 400	pure/blended	pure/blended
Levamelt® 450	pure/blended	pure/blended
Levamelt® 452	pure/blended	blended
Levamelt® 456	pure/blended	blended
Levamelt® 500	pure/blended	pure/blended
Levamelt® 600	pure/blended	pure/blended
Levamelt® 650 VP*	pure/blended	pure/blended
Levamelt® 700	pure/blended	pure/blended
Levamelt® 800	pure/blended	pure/blended
Levamelt® 900 VP*	pure/blended	pure/blended

* trial product (VP = Versuchsprodukt)

For extrusion of Levamelt®, similar material considerations have to be made as with thermoplastic EVA grades. Degradation of the polymer melt can occur due to excessive temperature stress. Therefore components that are in contact with the melt such as extruder, adaptor and die components should be constructed from corrosion resistant alloys or surfaced with durable chrome plating. Nevertheless, Levamelt® is a relatively temperature-resistant material. Concerning the screw design no special recommendation can be given. Tests have shown that screws designed for the processing of polyolefinic materials are suitable.

Recommended temperature setting of the extruder



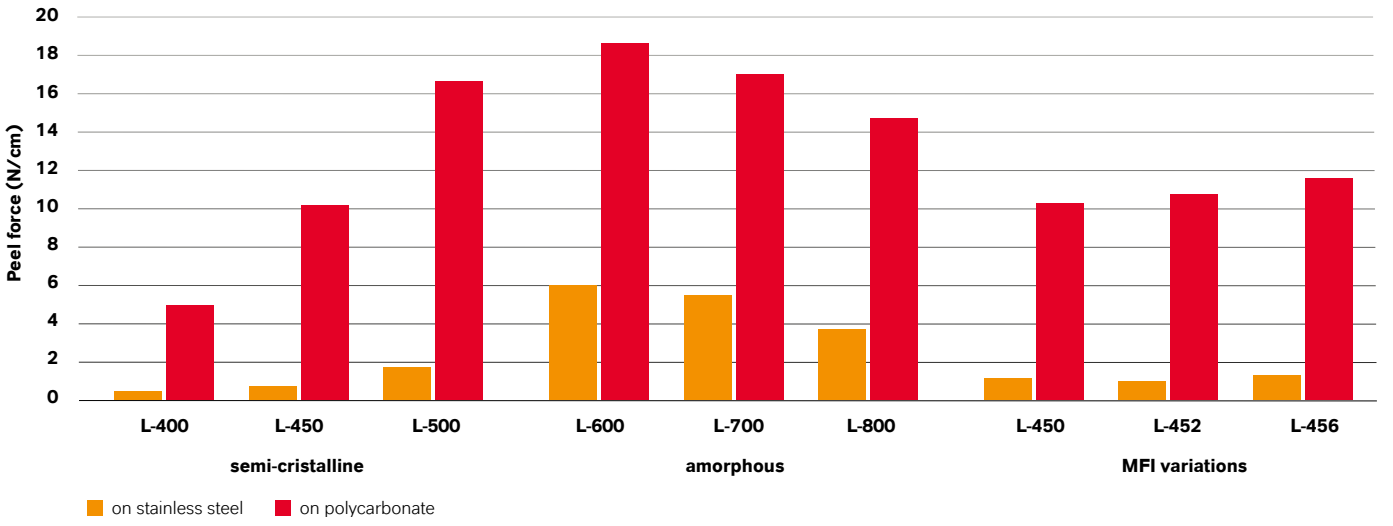
Levamelt®'s adhesive film properties

In order to determine the adhesive properties of Levamelt® on different surface, a 30µm thick Levamelt® layer was applied to a 100µm thick plastic backing film by extrusion coating processes. Later from these films samples were punched and laminated to various substrates at room temperature. After storage over night the peel forces were determined within a 180 °C peeling test using standard tensile test equipment. The next figure shows the peel forces of the different pure Levamelt® grades on stainless steel and polycarbonate representing metal and polymeric surfaces.

Within the semi-crystalline Levamelt® grades the adhesion to both stainless steel and polycarbonate rises with increasing VA content. This effect can be traced back to the growing polarity of the material. For the amorphous grades a counteracting effect dominates. As shown at the beginning of this brochure the glass transition temperature depending on the VA content increases progressively. This implies that the difference between application and glass transition temperature becomes significantly smaller and the mechanical anchorage to the surface decreases. This effect was not observed at higher application temperatures.

With decreasing viscosity a better wetting of the surface and thus increasing peel forces can be expected. In case of the polycarbonate, this effect can be observed. For the polished surface of the stainless steel substrate the viscosity does not influence the adhesion.

Peel forces of different Levamelt® grades



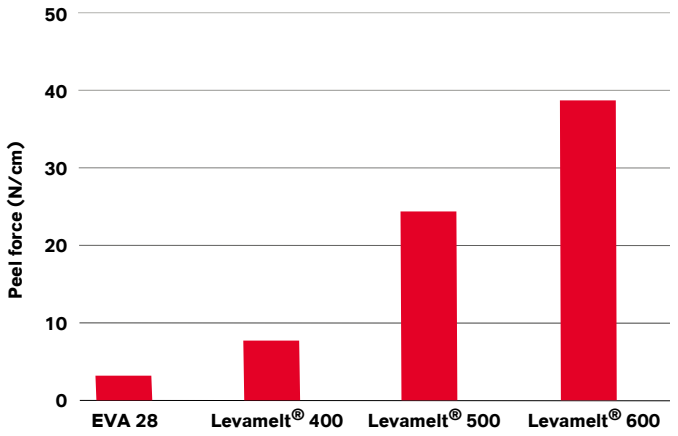
Adhesive film properties

Levamelt®'s adhesive film properties

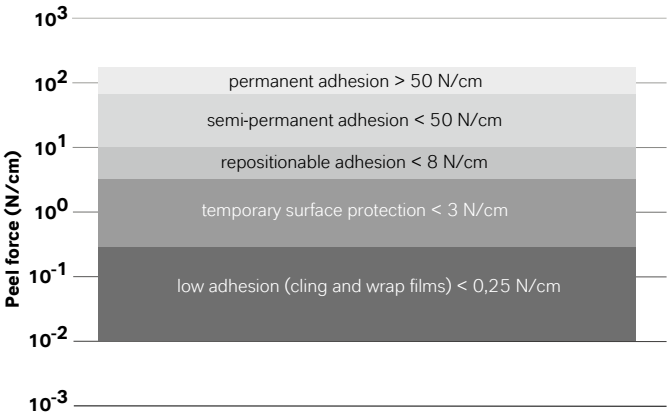
The upper figure gives an overview on the customary peel forces that are required for different applications. Depending on the Levamelt® grade used and the surface the adhesive film is applied to, Levamelt® covers the applications of temporary surface protection, repositionable adhesive tapes and is even useful for semi-permanent adhesion (see also the two figures below).
In both diagrams another possibility of Levamelt® is shown. By blending two or more grades the peel forces can be matched to the requirements of different applications. Beyond the presented values it is possible to achieve lower peel forces even on high adhesion substrates by diluting Levamelt® with different kinds of polyethylene such as m-PE or LDPE.

Beside the adhesion of cold laminated films, hot application is interesting, in particular in the area of food packaging. To enhance the sealing properties, PVC trays often are laminated with a polyolefine film. As lamination layer thermoplastic EVAs are commonly used. Nevertheless, these are sometimes limited concerning the achievable peel forces. The next figure shows a comparison of an EVA with app. 30 % VA content versus various Levamelt® grades. Both the EVA and the Levamelt® samples were laminated on PVC at 80 °C. The following peel test resulted in up to eight times higher adhesion values for Levamelt® compared to the thermoplastic EVA.

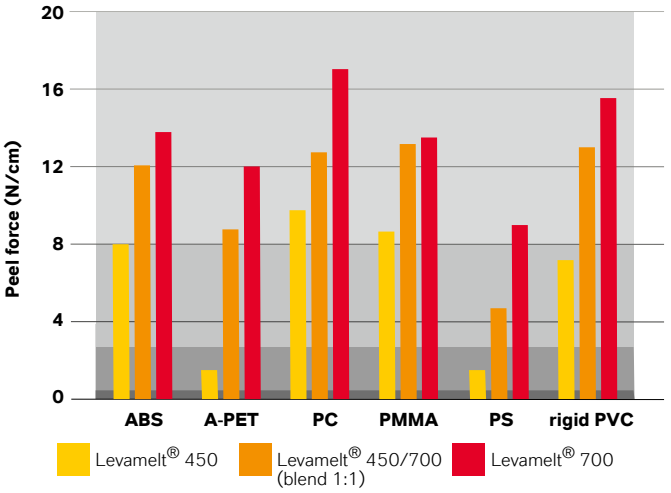
Comparison of EVA to various Levamelt® grades



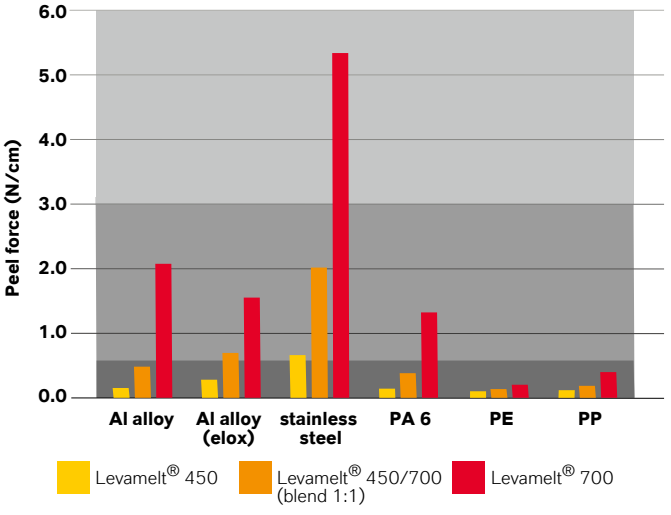
Customary peel forces for different applications



Semi-permanent adhesion to temporary surface protection



Repositionable adhesion to low adhesion



Levamelt® and Baymod®L range and supply form

Product	VA content (weight %)	MFI (g/10 min) (190° C/21.1N)
Levamelt® 400	40	1-5
Levamelt® 450	45	1-5
Levamelt® 452	45	5-15
Levamelt® 456	45	15-35
Levamelt® 500	50	1-4
Levamelt® 600	60	1-4
Levamelt® 650 VP*	65	1-4
Levamelt® 686	68	15-35
Levamelt® 700	70	2-6
Levamelt® VP KA 8865*	70	3-4
Levamelt® 800	80	2-6
Levamelt® 900 VP*	90	1-7
Baymod® L 2450	45	> 6

* Trial Products (VP=Versuchsprodukt)

Product	Pallet, 40 sacks 25 kg PE sack in a box	Pallet, 40 sacks 25 kg PE sack
Levamelt® 400		■
Levamelt® 450		■
Levamelt® 452	■	
Levamelt® 456	■	
Levamelt® 500	■	
Levamelt® 600	■	
Levamelt® 650 VP*	■	
Levamelt® 686	■	
Levamelt® 700	■	
Levamelt® VP KA 8865*	■	
Levamelt® 800	■	
Levamelt® 900 VP*	■	
Baymod® L 2450	■	

* Trial Products (VP=Versuchsprodukt)

The numbers of the Levamelt® and Baymod® L nomenclature are used to differentiate the grades. The first two digits relate to the vinyl acetate content, while the high-viscosity grades are designated HV. With regard to trial products (identified by VP = Versuchsprodukt in German), the KA number has no real significance other than to identify the product. Some products are pre-crosslinked in a controlled manner in an additional process stage.

Levamelt® and Baymod® L are dispatched in 25 kg sacks on pallets or in big bags. The sacks are made from transparent PE and should always be removed if the compounding temperature does not significantly exceed their softening point.

Under suitable conditions (dry, max. temp. of 5 °C), Levamelt® and Baymod® L can be stored for 36 months from the date of manufacture. Higher temperatures or pressure may cause the granules to agglomerate, with the result that free-flowing properties cannot be guaranteed.

Levamelt® and Baymod®L service and contact data

For further information please contact your regional expert.

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Quality & Environmental Management
Levamelt® and Baymod®L are produced under strict control regarding safety, environmental protection and quality. The whole supply chain, from production to customer service, is covered by ISO 9001 and ISO 14001 certification.

Product safety
Relevant safety data and references as well as the necessary hazard warning labels can be found in the Material Safety Data Sheet.

Food contact
Information concerning FDA and BfR compliance can be obtained on request from the Health, Safety, Environment and Quality Department (HSEQ) of Lanxess.

Tesa AG, the owner of various intellectual property rights relating to self-adhesive protective films, has provided LANXESS a worldwide license to make, use, and sell adhesive material products encompassing the Tesa Technology, as well as the right to pass along these rights to our customers. (A listing of the Tesa Technology is provided below.) Importantly, however, the licensing arrangement does NOT include any rights under the Tesa Technology to make, use or swell adhesive material products within the Automotive Sector. The Automotive Sector is understood to mean the field of self-adhesive films for the protection of surfaces in the interior and exterior areas of motor vehicles or their individual components. The Tesa Technology includes the following German Patents and Patent Applications and all equivalent foreign patents and patent applications arising from the German Patents and Patent Applications: DE 195 32 220; DE 196 35 704; DE 197 42 805; DE 199 23 780; DE 199 54 700; DE 199 54 701; DE 100 07 060; DE 100 15 708; DE 100 50 499; and DE 101 23 985.

Product safety: Relevant safety data and references as well as the possibly necessary warning labels are to be found in the corresponding safety data sheets.

Health and Safety Information:
Appropriate literature has been assembled which provides information concerning the health and safety precautions that must be observed when handling the LANXESS prod-ucts mentioned in this publication. For materials mentioned which are not LANXESS prod-ucts, appropriate industrial hygiene and other safety precautions recommended by their manufacturers should be followed. Before working with any of these products, you must read and become familiar with the available information on their hazards, proper use and handling. This cannot be overemphasized. Information is available in several forms, e.g., material safety data sheets and product labels. Consult your LANXESS representative in Germany or contact the Health, Safety, Environment and Quality Department (HSEQ) of LANXESS Germany or - for business in the USA - the LANXESS Product Safety and Regulatory Affairs Department in Pittsburgh, PA.

Regulatory Compliance Information: Some of the end uses of the products described in this publication must comply with applicable regulations, such as the FDA, BfR, NSF, USDA, and CPSC. If you have any questions on the regulatory status of these products, contact your LANXESS Corporation representative, the LANXESS Regulatory Affairs Manager in Pittsburgh, PA or the Health, Safety, Environment and Quality Department (HSEQ) of LANXESS Germany.

The manner in which you use and the purpose to which you put and utilize our products, technical assistance and information (whether verbal, written or by way of production evaluations), including any suggested formulations and recommendations, are beyond our control. Therefore, it is imperative that you test our products, technical assistance and information to determine to your own satisfaction whether they are suitable for your intended uses and applications. This application-specific analysis must at least include testing to determine suitability from a technical as well as health, safety, and environmental standpoint. Such testing has not necessarily been done by us. Unless we otherwise agree in writing, all products are sold strictly pursuant to the terms of our standard conditions of sale. All information and technical assistance is given without warranty or guarantee and is subject to change without notice. It is expressly understood and agreed that you assume and hereby expressly release us from all liability, in tort, contract or otherwise, incurred in connection with the use of our products, technical assistance, and information.
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This product information contains forward-looking statements based on current assumptions and forecasts made by the LANXESS AG management. Various known and unknown risks, uncertainties and other factors could lead to material differences between the actual future consolidated results, financial situation, development or performance of the company, and the estimates given here. The company assumes no liability to update such forward-looking statements or to adapt to future events or development.

LANXESS
Energizing Chemistry

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