LANXESS
Energizing Chemistry

Levamelt®

A versatile and flexible material
for adhesives and films

Edition 2010-10

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With tomorrow's requirements in mind
As a global leader in the synthetic rubber industry, LANXESS offers its customers a comprehensive range of synthetic rubber products, with specialties such as Levamelt® playing an important role.

Whereever conventional polymers come up against their limits, Levamelt®, a polymer with very good heat and weathering resistance, may present a suitable alternative. Levamelt® product range consists of co-polymers that can meet demanding requirements of industry applications such as:

- Adhesives
- PVC
- Films

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

Our Levamelt® experts will be glad to provide you with further technical information. Contact data can be found on page 14 of this brochure.

You may also use the e-mail address : **info@levamelt.com**

Opposite pictures provide you with just a few examples of possible Levamelt® applications in both films and adhesives.

Protection for the valuable surfaces of new cars

Close to each other - with Levamelt® film keeping the distance

Protects – while being gentle to the skin

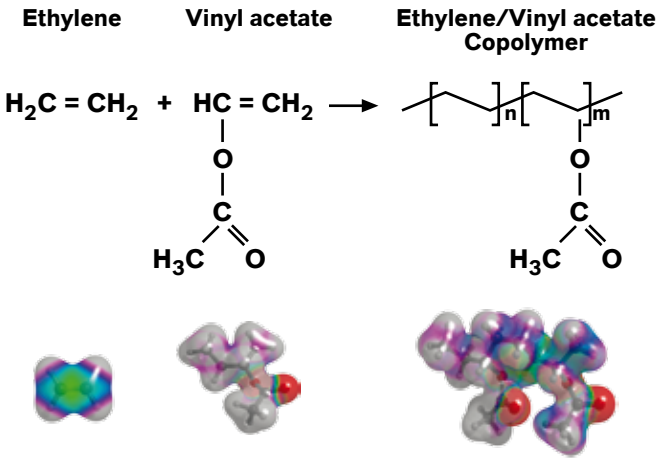
Convincing: public advertisements attached with Levamelt®

Polymer properties

Levamelt® is formed by copolymerization of ethylene and vinyl acetate. In principle Levamelt® consists of methylene units forming a saturated polymer backbone with pendant acetate groups. These rubber-like polymers are designated "EVM"[1] according to ISO 1629: 1995 (E) nomenclature. 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, particularly PVC. The adhesive raw materials and plastic modifiers are sold under the brand name Levamelt®, while powdered grades are distributed under the brand of Baymod® L

Radical polymerisation – chemical structure of Levamelt®

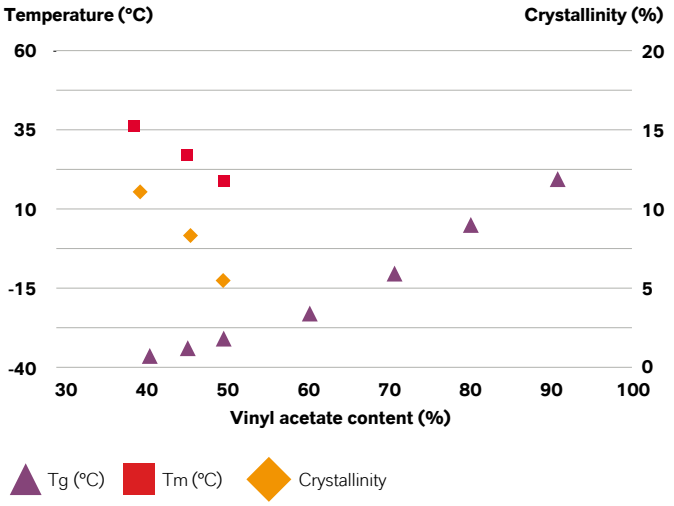


[1] In accordance with ISO 1043-1: 1987, the abbreviation E/VAC is to be used for thermoplastics. The abbreviation EVA is also frequently found.

Influence of the VA- content on morphology

The higher the proportion of vinyl acetate in the copolymer, the stronger the regularity of the ethylene chain is interrupted. Crystallization is increasingly hampered and becoming entirely absent at a vinyl acetate content of approx. 55 %. Hence copolymers with a high vinyl acetate content are amorphous.

Influence of the VA- content on morphology



Tg = Glass transition temp Tm = Melting temp

Levamelt® based films will protect your best friends...

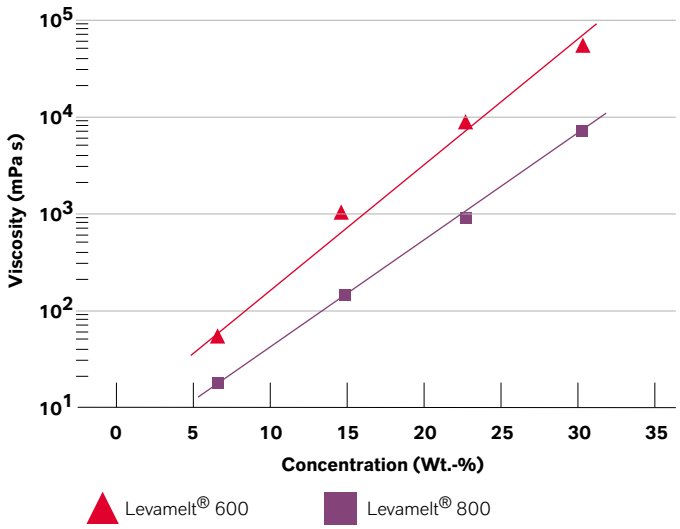
Levamelt® adhesive applications

Levamelt® in Solvent Borne Adhesives

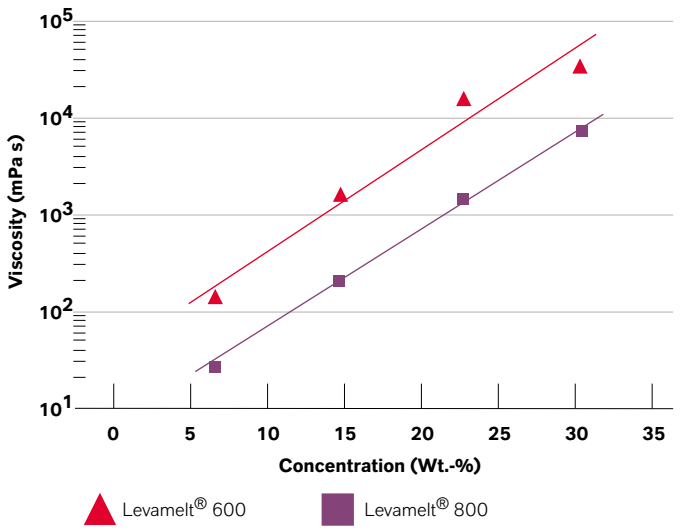
Levamelt® can be used in solvent borne adhesive applications. Solvents for various Levamelt® ethylene-vinyl acetate copolymer grades can be aromatic and chlorinated hydrocarbons, as well as cyclic ethers. Alcohols do not dissolve Levamelt® copolymers, while esters, ketones, and aliphatic hydrocarbons have a strong swelling effect.

Storing of Levamelt® copolymers at low temperatures will cause gelation which, however, is reversible upon mild heating and agitation without any adverse effect. The graphs show the viscosity development of Levamelt® 600 and 800 solutions in MEK and toluene as function of the weight % of the polymer.

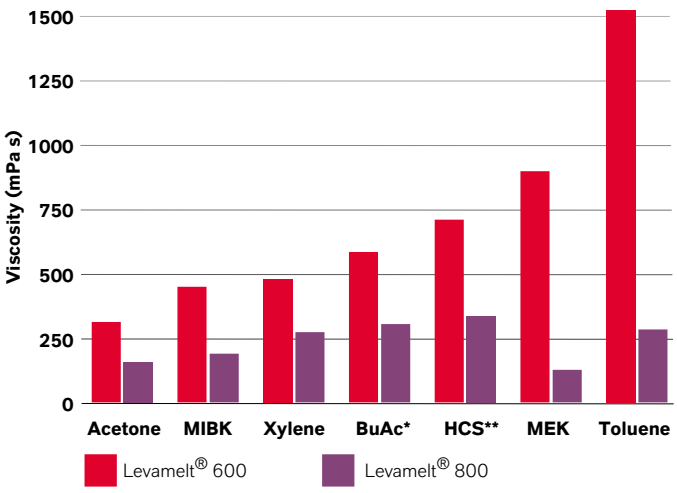
Levamelt® in MEK



Levamelt® in Toluene



Viscosity of 15 % Levamelt® solutions



* Butyl Acetat ** Solvesso 100

Levamelt® for hot-melt applications

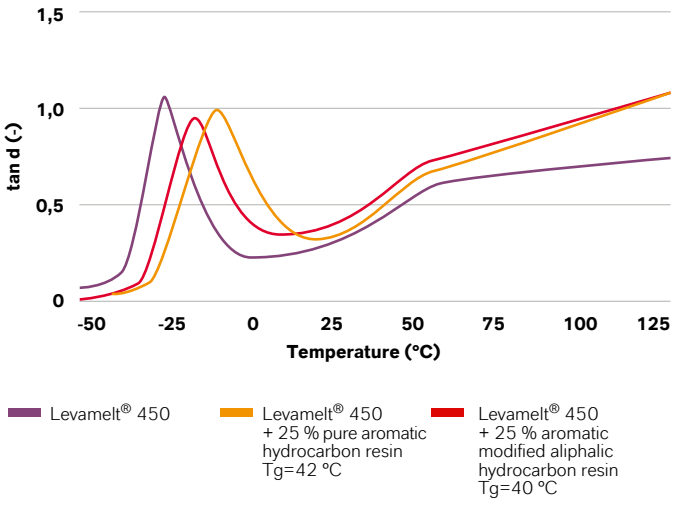
Levamelt® grades are suitable for hot-melt adhesives. Compared to EVA copolymers with lower vinyl acetate content, Levamelt® grades provide improved adhesion characteristics, better low-temperature adhesion, and are particularly useful in the formulation of pressure sensitive hot-melt adhesives.

Levamelt® 456, having the highest melt index / lowest molecular weight, is the preferred polymer in case low melt viscosities are required. Levamelt® 450 and 452 are utilized, either alone, or in a blend with Levamelt® 456 resulting in enhancee heat strength.

Since Levamelt® copolymers have very little inherent tack and comparatively high melt viscosities, further compounding with other 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 respectively.

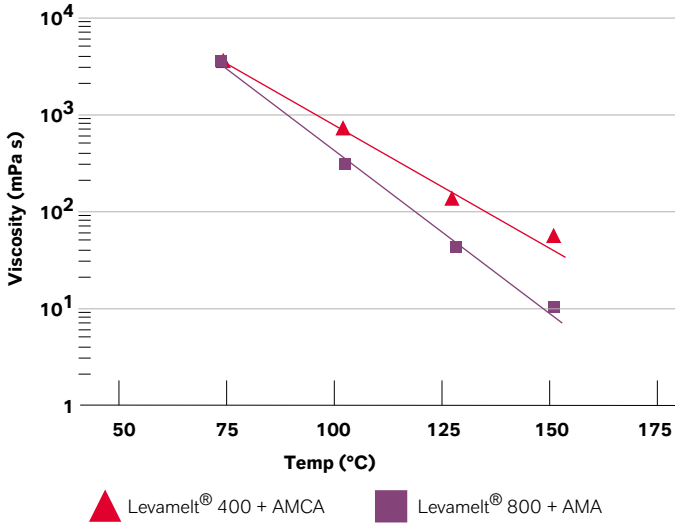
The compatibility of Levamelt® with different tackifier resins has been verified by DMA. The next graph shows a good compatibility of different tackifiers (hydrogenated and aromatic modified aliphatic hydrocarbon resin) with Levamelt® 450. Highly aromatic resins are however not compatible with Levamelt® 450.

Compatibility of Levamelt® with tackifiers



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

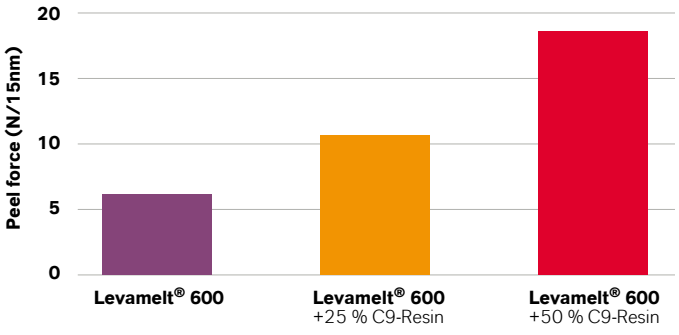
Viscosity of a hotmelt formulation depending on temperature (1 Hz shear rate)



Influence of tackifier on Levamelt®

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

Influence of tackifier on Levamelt®



Adhesive films
Levamelt® – Low Tack is High Tech

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, low up to semi-permanent adhesion can be achieved. Despite Levamelt® being an inherent sticky material, its supply form are yet free-flowing pellets, facilitationg the production of adhesive films via co-extrusion without the need of process additives.

The adhesion properties of Levamelt® can be adjusted by blending with polyethylene, resins or waxes. This document concentrates on the adhesive properties of pure Levamelt® grades or blends thereof.

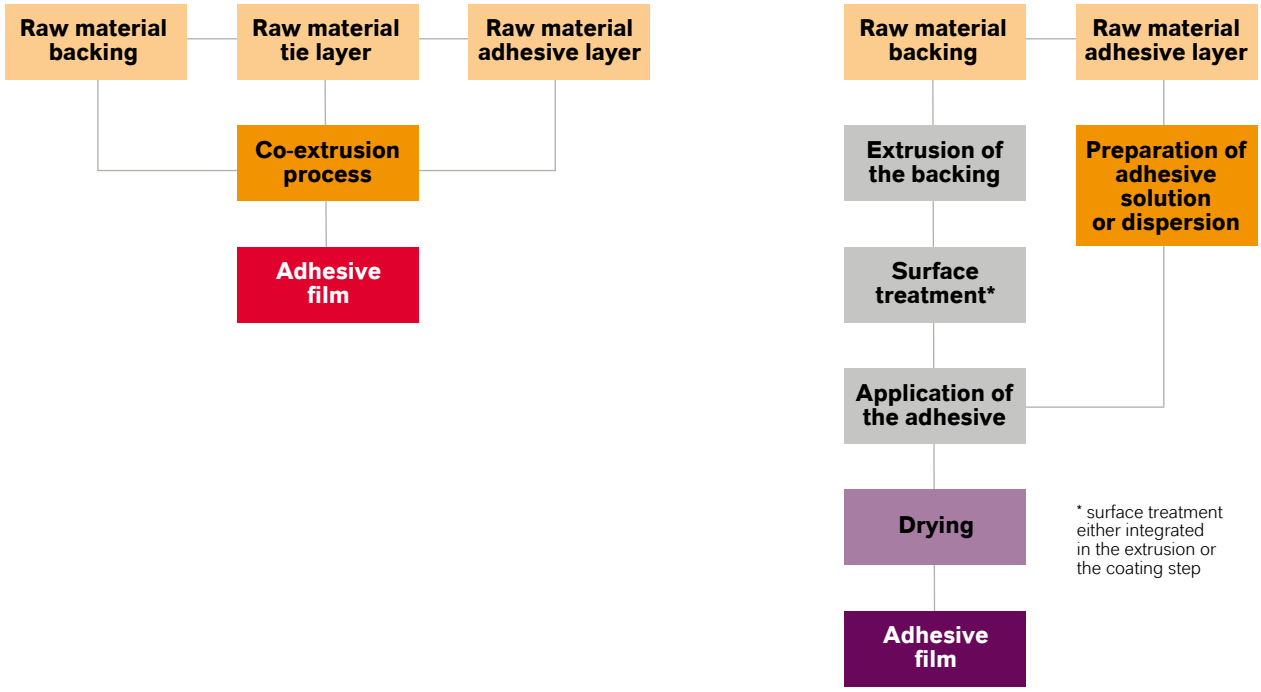
Production of adhesive films

A classical approach to manufacturing adhesive films is the lamination of a film that has been produced in a separate extrusion process with a solvent-borne or dispersion adhesive.

Prior to the application of the adhesive e.g. by means of roller coating, two additional steps are needed. First the adhesive solution or dispersion must be prepared in an intricate process. Secondly the conditioning of the film surface e.g. via a corona pretreatment is needed to reach a sufficient bonding of the adhesive layer 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 requires the extraction of volatile matters contained. This downstream drying stage represents a very energy-consuming sub-process.

In contrast, Levamelt® provides the option to produce an adhesive film by means of co-extrusion, thus reducing overall process steps. In short: all raw materials needed can be processed within the same stage, with no requirement for time and energy consuming pre- and post-processing.

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

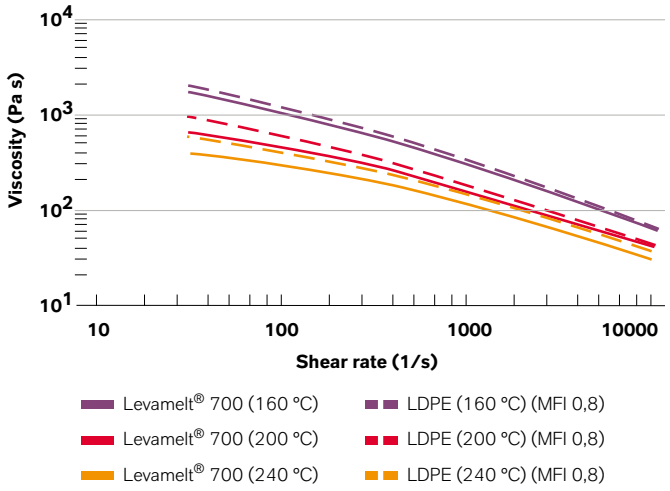


Coextrusion of Levamelt® with Polyolefines

Two materials are co-extrudable if they display a similar viscosity 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) ranges 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 details on page 13).

This – at first sight - suggests, that co-extrusion with polyethylene is not possible. However the viscosity of a polymer varies with shear rate and temperature. The MFI measurement is a single-point method and provides only information on a given temperature and a given shear rate that are not necessarily representative for real-life-processing conditions. Thus, high pressure capillary viscosimetry represents a more suitable method for the coextrusion process.
The diagram shows that the curves of Levamelt® match those of LDPE very closely particularly at low processing temperatures (~160 °C) and increasing shear rates. Hence -as proven in practical trials - both materials can in fact be co-extruded.

Viscosity of Levamelt® and low density polyethylene (LDPE)

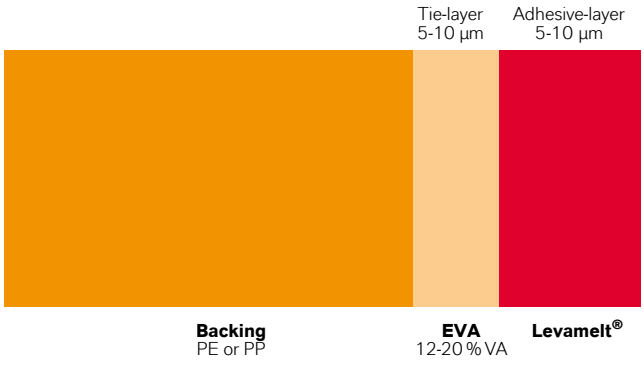


General consideration on layer construction

To ensure a good bonding 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 picture below). The tie-layer material has a good adhesion to both the Levamelt® and the polyolefine. It acts as compatibilizer between the two materials given its intermediate VA content. In fact the adhesion of the tie-layer interface is even higher than the adhesion of the Levamelt® to typical surfaces such as metal, glass, different plastics or varnishes and lacquer. This is important particularly for protective films 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 even better 15 % - and maximum VA content of about 18 % to 20 %. This kind of layer construction has the advantage of a very low backing adhesion, 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 and required flexibility.
The addition of processing agents such as anti-block packages (i.e. silica) provides an uncritical micro-rough surface, thus preventing the inner layer of the folded film from sticking. 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 e.g. for removable labels.

Extrusion of Levamelt®

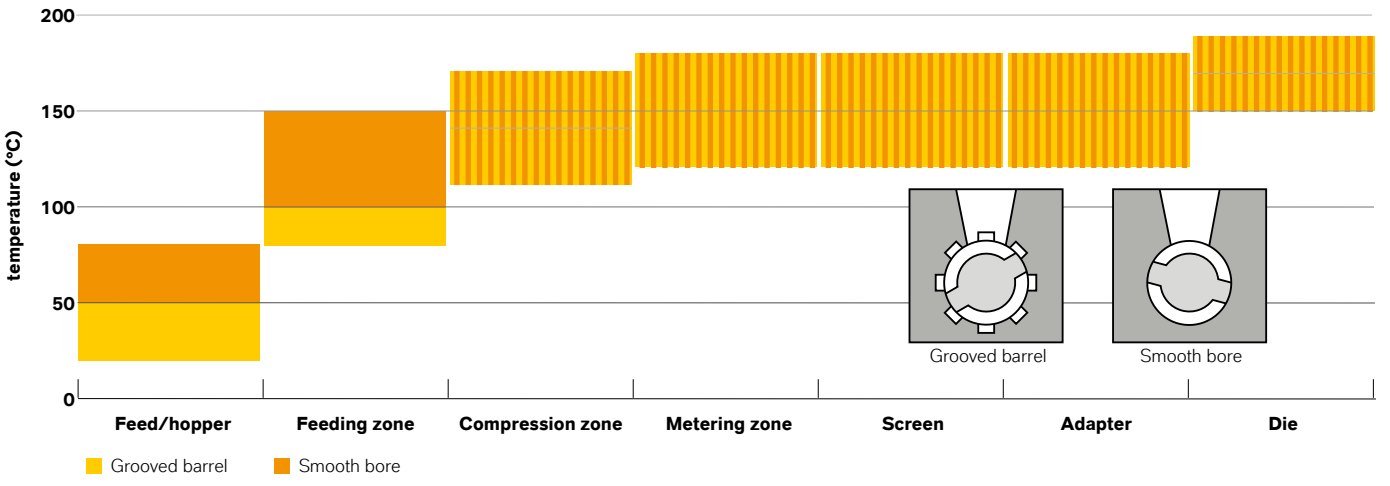
Considering rheological aspects, both blow film and cast film extrusion represent suitable processing technologies for Levamelt®. As shown in the table below Levamelt® can be processed undiluted or blended to adjust the stickiness of the adhesive layer. Blending of different Levamelt® grades also with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

For the extrusion of Levamelt®, material considerations similar to those given for thermoplastic EVA grades need to be obeyed. 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.

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® 686	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)

Recommended temperature setting of the extruder



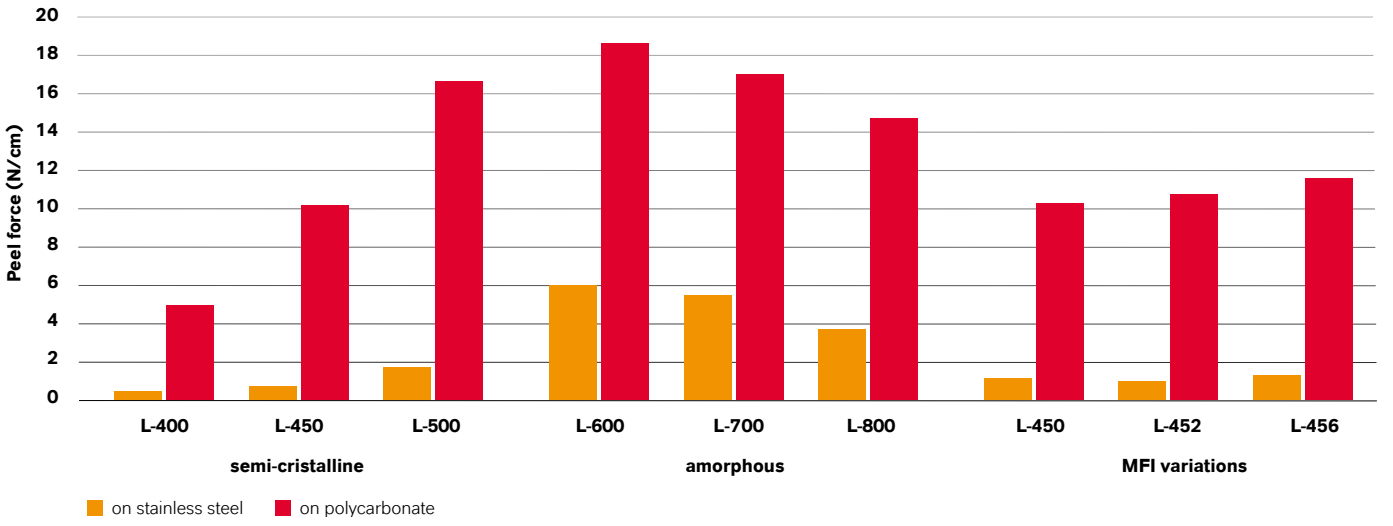
Levamelt® adhesive film properties

In order to determine the adhesive properties of Levamelt® on different surfaces, a 30µm Levamelt® layer was applied to a 100µm plastic backing film by extrusion coating processes. Subsequently film samples were punched and laminated to various substrates at room temperature. Following over night storage the peel force was determined in a 180° angle peeling test using standard tensile test equipment. The chart below shows the peel force of different 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 counteracting effects dominate. As already discussed at the beginning of this brochure the glass transition temperature increases progressively depending on the VA content. This implies that the difference between application and glass transition temperature becomes significantly smaller and the mechanical bondig to the surface decreases. This effect is not observed at higher application temperatures.

With decreasing viscosity a better wetting of the surface and thus increasing peel forces can be expected, which can be observed in the case of polycarbonate. As to the polished surface of the stainless steel substrate the viscosity does not influence the adhesion.

Peel forces of different Levamelt® grades



Adhesive film properties

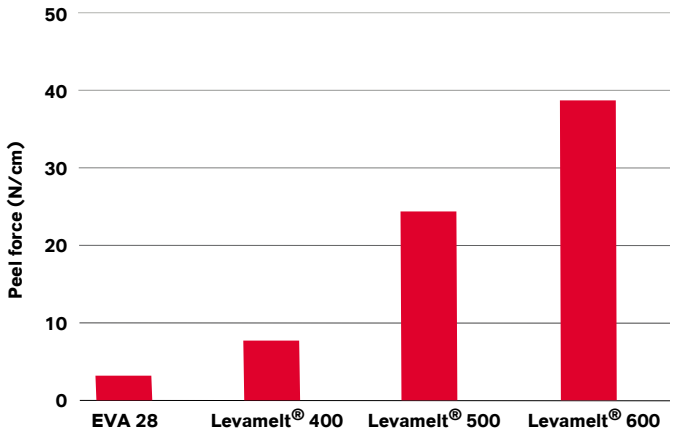
Levamelt® adhesive film properties

The figures to the right give an overview about the customary peel force that is 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 (as can be seen in respective charts).

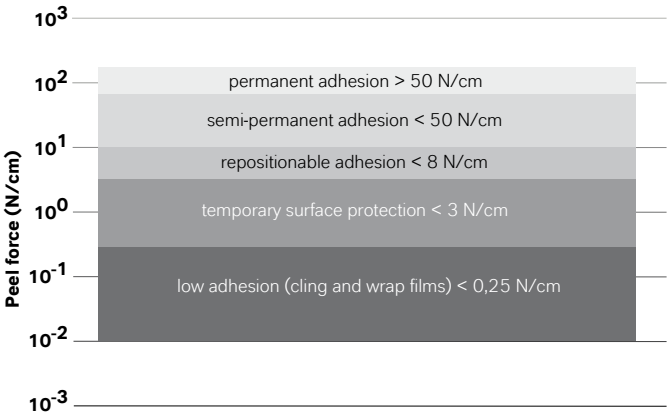
In both diagrams another option of Levamelt® is shown: Individual peel forces to the requirements of different applications can be matched by blending two or more grades. Beyond the presented values it is possible to achieve lower peel forces even on high adhesion substrates by diluting Levamelt® with 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 - however with limitations with reagards to achievable peel forces. The next chart shows a comparison of an EVA with app. 28 % VA content versus various Levamelt® grades. EVA and the Levamelt® samples were laminated on PVC at 80 °C. The subsequent peel test resulted in up to eight times higher adhesion values for Levamelt® compared to the thermoplastic EVA.

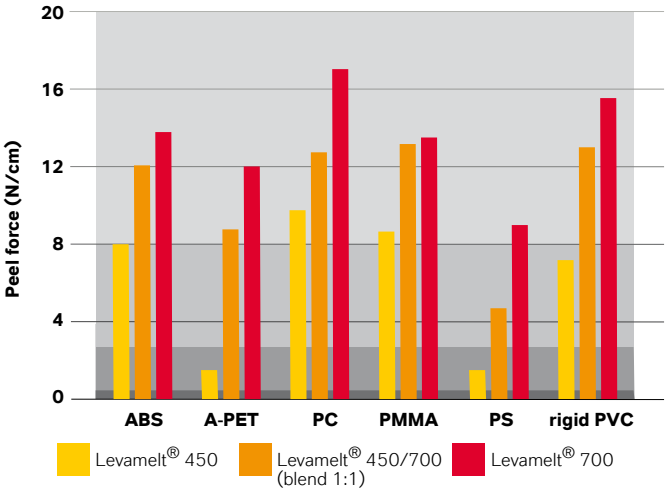
Comparison of EVA to various Levamelt® grades



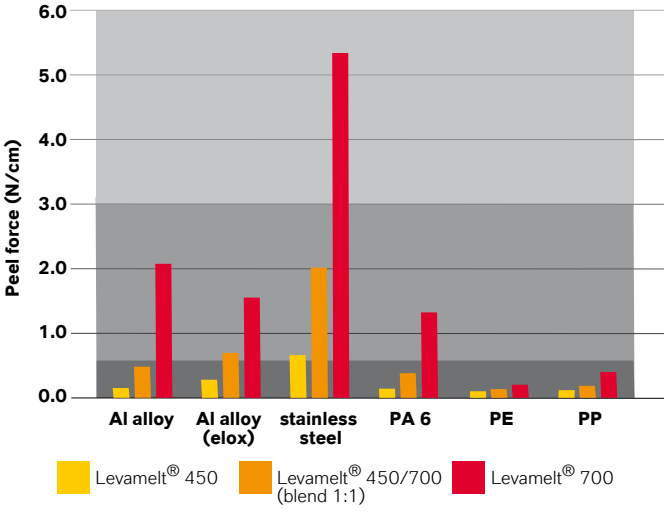
Customary peel forces for different applications



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® 800	80	2-6
Levamelt® 900 VP*	90	1-7
Baymod® L 2450	45	≤ 6 (1)

(1) determined on base polymer Levapren® 450
* Trial Products (VP=Versuchsprodukt)

Product	Pallet, 40 bags 25 kg PE bag in a box	Pallet, 40 bags 25 kg PE bag
Levamelt® 400		■
Levamelt® 450		■
Levamelt® 452	■	
Levamelt® 456	■	
Levamelt® 500	■	
Levamelt® 600	■	
Levamelt® 650 VP*	■	
Levamelt® 686	■	
Levamelt® 700	■	
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 of the Levamelt® grades indicate the % vinyl acetate content.

Levamelt® and Baymod® L are dispatched in 25 kg bags on pallets or in big bags. The bags 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 and the powder to agglomerate, so that free-flowing properties cannot be guaranteed.

The perfect sticker:
good material, positive message.

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.

Gossamer film, efficient protection

** The information contained herein is merely preliminary data. Testing as to properties and applications is not final. Further information, including data which could change or add hazards with use, may be developed. Such information may be needed to properly evaluate or use this product. Use is undertaken at the sole risk of the user.
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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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www.lanxess.com

Order no.: LXS-KA 027e
Edition: 2010-10
Printed in Germany

Note: The information contained in this publication is current as of October 2010. Please contact your LANXESS representative to determine if this publication has been revised.