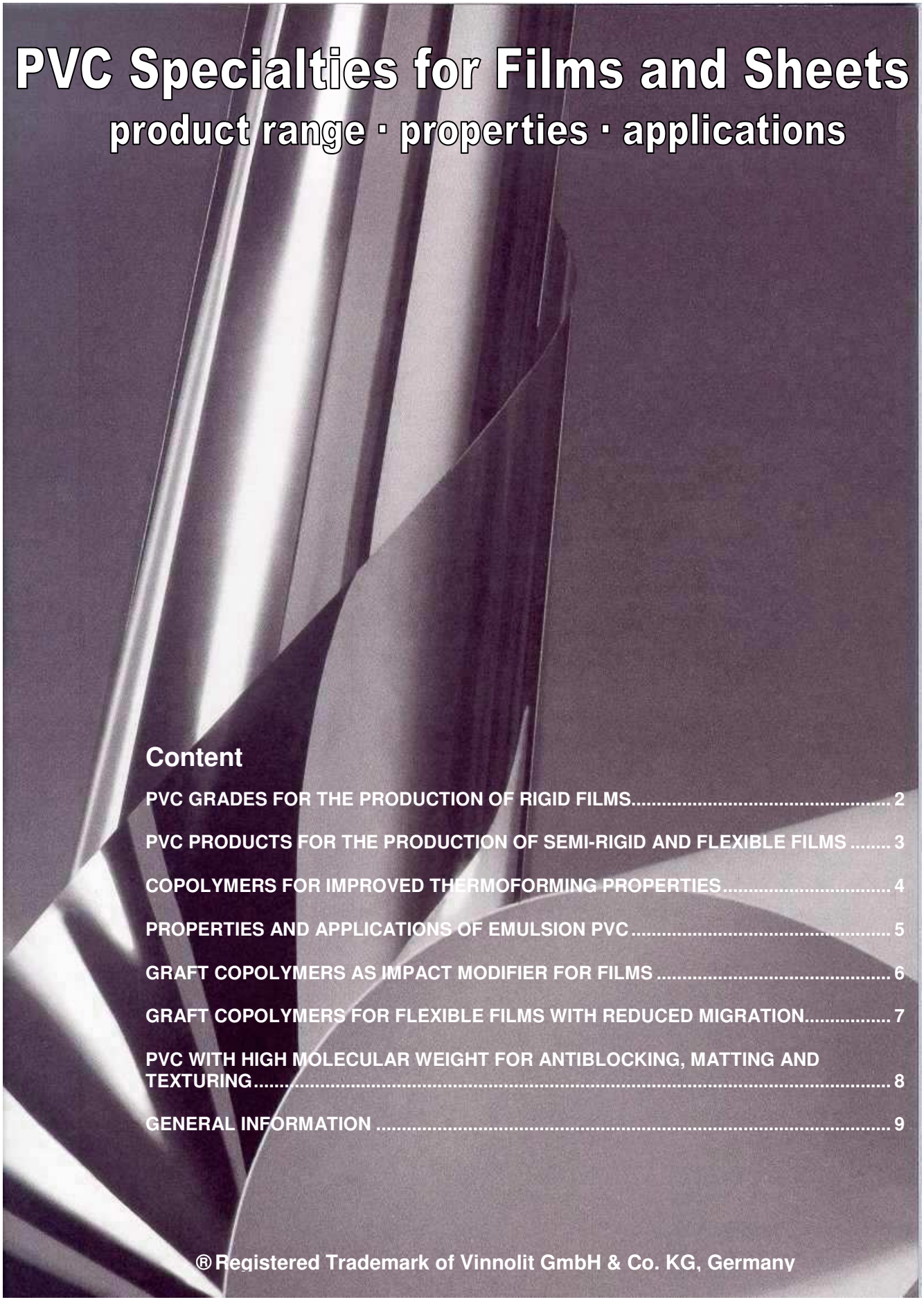
Vinnolit

Leadership in PVC

PVC Specialties for Films and Sheets

product range · properties · applications



Content

PVC Grades for the Production of Rigid Films

Examples for rigid films:
Packaging, credit cards, pharmablister, adhesive tapes etc.

	®Vinnolit grade	K-value DIN 53726	Viscosity no. (cm^3/g) DIN 53726	Co/Graft component	Bulk density(g/l) DIN 53466	Typical applications
S-PVC (Suspension PVC)	S 3160	60	89	-	570	Standard grade for rigid films
E-PVC (Emulsion PVC)	E 2059	59	86	-	500	Blending component for rigid films promotes faster fusion and supports antistatic properties
	E 2178	78	159	-	460	Special grade for Luvitherm process
	K 301 NF	*	*	-	550	Antistatic agent for transparent, rigid films
Copolymer	S 3157/11	57	80	11 % VAC	650	Main or blending component for highly transparent rigid films to improve thermoforming performance, melt and lamination
Graft Copolymers	K 707 E	*	*	50 % ACR	550	Impact modifier for opaque or pigmented rigid films suitable for outdoor use
	VK 710	*	*	50 % ACR	650	Impact modifier as described above with additional release effect
Grades for antiblocking, matting and texturing	K 240 C 100 V	* *	* *	- -	600 630	Antiblocking or matting agent
	K 221	*	*	-	590	Texturing agent, gives a sand-blasted or frosted effect

* Not applicable ® Registered Trademark of Vinnolit GmbH & Co. KG, Germany

VAC Vinylacetate
ACR Polyacrylic rubber

PVC Products for the Production of Semi-Rigid and Flexible Films

Examples for semi-rigid and flexible films:
Roofing sheets, label films, insulating tapes, tarpaulins, artificial leather etc.

	®Vinnolit grade	K-value DIN 53726	Viscosity no. (cm^3/g) DIN 53726	Graft component	Bulk density(g/l) DIN 53466	Typical applications
S-PVC (Suspension PVC)	S 4170	70	124	-	480	Standard grade for flexible films
	S 4080	80	168	-	450	Grade for flexible films with improved mechanical properties and for thick calendered films
	S 100	99	300	-	450	Special grade for flexible films with improved mechanical properties especially at high temperatures, allows high plasticizer concentration
E-PVC (Emulsion PVC)	E 2169	69	120	-	410	Additive for semi-rigid and flexible films for faster fusion, supports also antistatic properties
Grafted Copolymers	VK 710 K 707 E	* *	* *	50 % ACR 50 % ACR	650 550	Grades for flexible films with low or no migration. VK 710 is the standard type, K 707 E shows enhanced resistance to chemicals
Grades for antiblocking, matting and texturing	C 100 V	*	*	-	630	Antiblocking or matting agent
	K 221	*	*	-	590	Texturing agent, gives a sand-blasted or frosted effect

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VAC Vinylacetate
ACR Polyacrylic rubber

Copolymer for Improved Thermoforming Properties

®Vinnolit S 3157/11

Calendered or extruded rigid films are usually produced with S-PVC having K-values between 57 and 61.

If improved performance for subsequent thermoforming, welding, glueing or printing is required, copolymers containing vinyl acetate can be used. Our product is a random copolymer of vinyl chloride and vinyl acetate and is produced by means of the suspension process. It has generally a vinyl acetate content of 11 % and a K-value of 57.

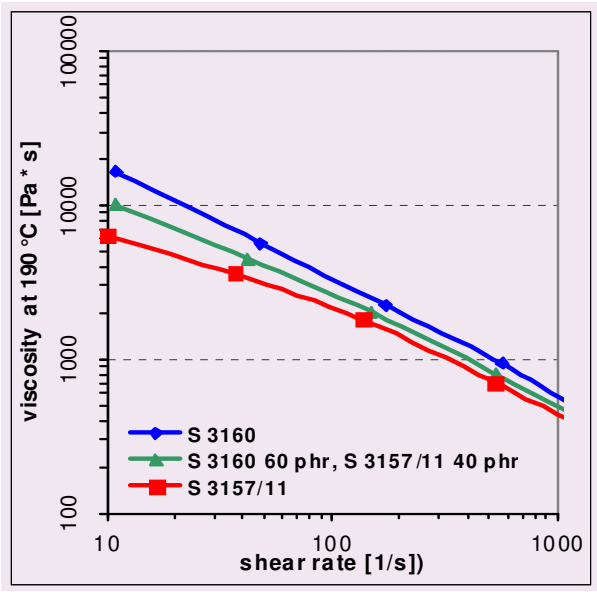


Fig. 1: Melt viscosity of S-PVC, Copolymer and a blend of both products (log. scale)

Compared with homopolymeric PVC, the copolymerized product shows two superior properties, i.e. low melt viscosity (Fig. 1) and high melt elongation, especially at low processing temperatures (Fig. 2). A low melt viscosity improves the welding and laminating properties, and for good thermoforming properties a high melt elongation is also important.

The copolymer is therefore suitable as blending component to improve the following properties:

- Large vacuum formed articles can be produced at relatively low temperatures, resulting in a shorter cycle time. Thus copolymers enhance the performance during subsequent processing to e.g. blister packaging
- Films containing copolymer are easier to laminate and weld. The copolymer also allows the production of highly transparent films with excellent printability. Therefore the copolymer is essential for the manufacture of credit cards, identity cards etc.

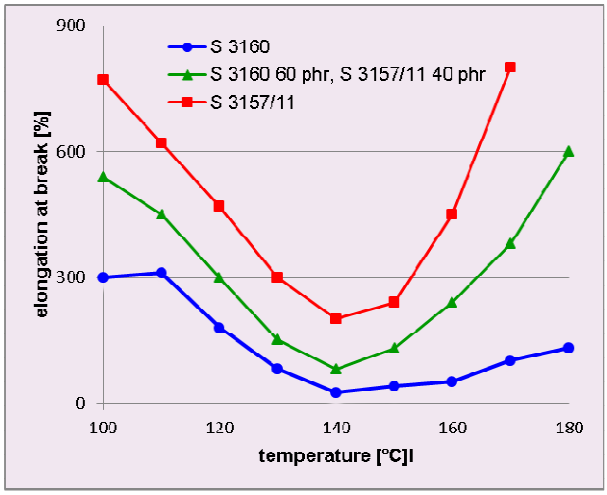


Fig. 2: Elongation at break measured on 0,2 mm films (thermoelastic temperature range). The test films were based on S-PVC (blue line), a blend of S-PVC and S 3157/11 (60:40, green line), and S 3157/11 (red line).

Properties and Applications of Emulsion PVC

®Vinnolit E 2059 ®Vinnolit E 2169 ®Vinnolit E 2178 ®Vinnolit K 301 NF

E-PVC for thermoplastic processing has several morphological characteristics which influence the processing behaviour as well as the finished article. As a consequence of the emulsion polymerisation process, E-PVC consists essentially of primary particles (size usually 0.2-1.5 µm see Fig. 3.) surrounded by a thin emulsifier layer. These primary particles are sintered during the drying process (drum or spray drying) into larger, free flowing agglomerates, which constitute the actual powder particles. These E-PVC grains are readily broken down into their constituent primary particles during thermoplastic processing. Formulations containing E-PVC fuse rapidly and are soon dispersed into a homogenous blend. For this reason also, E-PVC, aided by the emulsifier, facilitates the production of optically faultless films with few flow lines and a low fish-eye count.

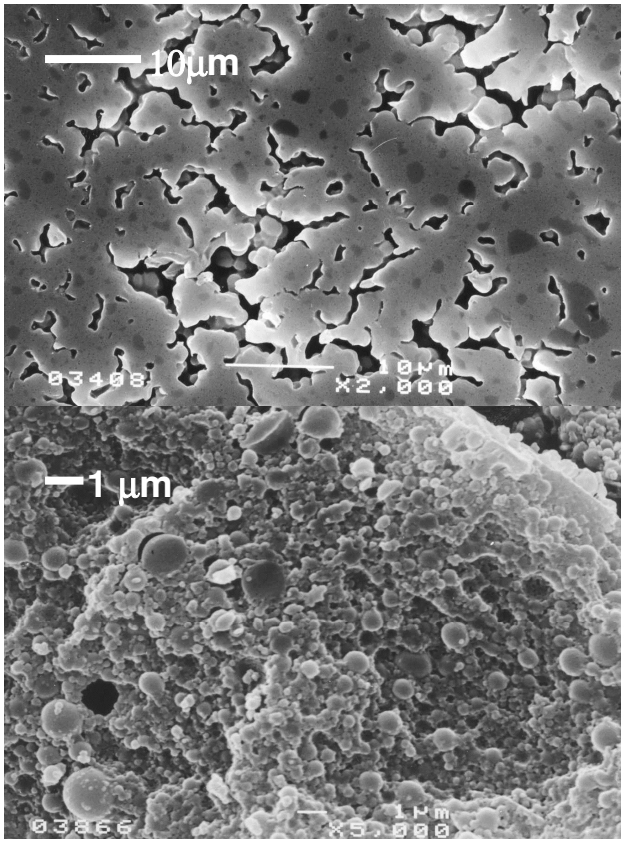


Fig. 3: REM microphotographs of cross sections of standard S-PVC (upper picture) and E-PVC (below). The loosely agglomerated primary particles differ from the solid structure of S-PVC and will disperse more easily

The processing ease also permits S/E blending with E-PVC of a higher K-value, a simple variant for raising the mechanical properties of the film.

Additional advantage: Additives, which are difficult to disperse, such as pigments and fillers, can be incorporated and homogenised much more easily in formulations containing E-PVC.

The emulsifiers contained in the E-PVC are hygroscopic. In addition to the effect as a processing aid, this characteristic enables E-PVC to be used for films with improved antistatic properties.

E-PVC for thermoplastic processing is mainly used as a blending component with S-PVC. Typical proportions range between 5 and 40 %. In the case of antistatic films, a minimum quantity of E-PVC from 20 – 25 % is recommended; when used as a processing aid 5 – 10 % is often sufficient.

®Vinnolit offers a range of products which differ in K-value and emulsifier content, thus making it possible to select the ideal product for any application:

E 2059 is the standard processing aid in rigid films.

On account of the higher K-value, **E 2169** is the preferred blending component in semi-rigid or flexible film formulations.

K 301 NF is a special E-PVC grade containing additional antistatic agent. With **K 301 NF** enhanced antistatic properties can be achieved in rigid films with very little effect on transparency.

The Luvitherm process is a special procedure for the processing of E-PVC. In this process, E-PVC with a high K-value is processed to thin, usually stretched, high quality rigid films for adhesive tapes. **E 2178** has proved itself to be excellent for this purpose.

Grafted Copolymers as Impact Modifiers for Films

®Vinnolit VK 710 ®Vinnolit K 707 E

Modifiers are frequently used to increase impact strength. An impact modifier is almost always used in rigid films. This is especially the case for semi-rigid and flexible films if embrittlement at low temperatures is to be avoided or if a combination of impact resistance with simultaneous reduction in migration is required. ®Vinnolit offers 3 impact strength modifiers for the film producing industry. **VK 710** and **K 707 E**, all graft polymers consisting of 50 % acrylic ester rubber (ACR) and 50 % PVC. These products offer the following advantages:

- The rubber particles are easily distributed and form discrete structures in the PVC matrix. This structure permits the production of impact-resistant films over a wide processing range.
- The rubber particles are grafted with PVC. This ensures an ideal adhesion to the PVC matrix.
- The modifiers are based on ACR - rubber. This allows applications with excellent resistance to UV, weathering and ageing.
- **K 707 E** is the standard grade for impact modification. Its advantages are fast fusion and high surface quality of the finished article.
- In addition to improving the impact strength, **VK 710** also functions as a release agent.
- All products are free-flowing powders which can be supplied in bag, big bag or silo.

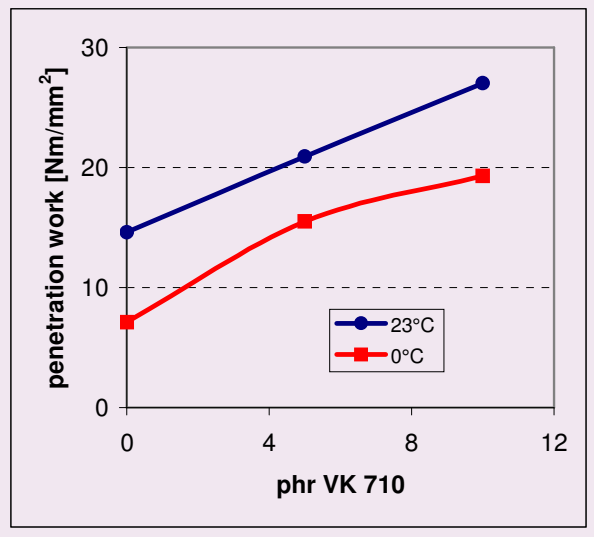


Fig. 4: Results of a dart test measured on rigid films based on S 3160 containing VK 710.

Depending upon the type and quantity of the plasticizer, impact strength modifiers are commonly used in plasticized films in order to reduce the cold crack temperature. Table 1 for example, shows the characteristic physical properties of two semi-rigid films having the same shore hardness with and without **K 707 E.** When using **K 707 E** or **VK 710**, plasticizer migration can also be reduced at the same time.

Table 1:

Formulation	®Vinnolit S 4170	100	95
	®Vinnolit K 707 E	-	10
	DINP	20	19
	Ca/Zn- stabilizer	3,5	3,5
Property	*Test method/units*		
Shore D	DIN 53505 / -	68	68
Cold crack	DIN 53373 / °C	-5	-19

Grafted Copolymers for Flexible Films with reduced Migration

®Vinnolit VK 710 ®Vinnolit K 707 E

Classical flexible PVC, i.e. PVC with monomeric plasticizers, is common because of its good processing properties. Depending upon the plasticizer type, quantity and application, the phenomenon of plasticizer migration can play an important role in some applications. Typical migration problems are em-brittlement during long-term stress, pigment blooming, sticky and dirty surfaces, low resistance to extraction or the softening of label adhesives. This problem can be reduced with plasticizers of a higher molecular weight (e.g. polyester plasticizers). Migration-resistant materials can be achieved by alloying PVC with flexible polymers (EVA, PEC, NBR etc.). However, this requires a more complex processing technique to achieve an adequate melt homogeneity.

Vinnolit graft copolymers do not have the above mentioned disadvantages. Being a polymeric substance, the flexible component (acrylic rubber) does not migrate and, by grafting with PVC, an ideal homogeneity is achieved. Although the proportion of rubber is 50 %, nevertheless they are free-flowing powders and silo storage is possible.

The individual products: **VK 710** (50 % ACR, 50 % PVC) is the standard grade of this product group. **K 707 E** (50 % ACR, 50 % PVC) is preferred where a high resistance to chemicals is required.

The Shore hardness is an important criterion in formulations for flexible sheets. The two products have an inherent hardness of approx. Shore A 90. Higher Shore A values are achieved by blending with PVC, but also with other polymers such as SAN, PMMA or ABS. Softer products are achieved by combination with, for example, EVA, Et-VAC-CO terpolymer, PEC, NBR or TPU. The variety of alloy partners permits the production of custom-made materials for special requirements, e.g. Shore hardness, resistance to weathering or ageing, as well as resistance to abrasion, chemicals or heat.

Mixtures based on Vinnolit graft copolymers can generally be processed on typical equipment suitable for the production of PVC films, and the formulation know-how can also be transferred to this group of materials. In contrast to conventional flexible PVC, these materials fuse rapidly and have a higher melt viscosity. The high viscosity allows production of thicker films, such as roofing sheets, of up to 1,5 mm in one calender operation. Typical calendering temperatures range from 175 to 180 °C.

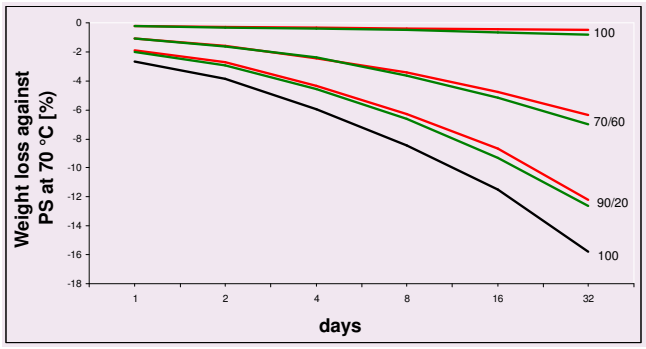
Migration-resistant, flexible sheets or laminated fabrics are required, for example, for roofing sheets, special tarpaulins, automotive films, conveyor belts, protective clothing, container linings etc. As an example, the property characteristics of a non-reinforced roofing sheet based on **K 707 E** without monomeric plasticizer, which was calendered with a thickness of 1.2 mm in one operation, is shown in Table 2.

Table 2

Shore A		77
Tensile strength (DIN 53455)	[N/mm^2]	18
Elongation at break (DIN 53455)	[%]	300
Tear strength (DIN 53515)	[N/mm^2]	25
Cold crack temp. (DIN 53372)	[°C]	<-60
Water vapour permeability	[g/d m^2]	2,1

Vinnolit graft copolymers are also used as an additive in conventional flexible PVC formulations when only the migration is to be reduced (Fig. 5). Typical applications are e.g. self-adhesive films, labels, insulating tapes etc. The action is based on the effect, that ACR has a stronger capability for retaining plasticizer than PVC.

In addition, the cold crack temperatures are improved (see Table 1 on page 6).



	—	—	—	—	—	—	—
S 4170	100	90	90	70	70		
VK 707 E	-	20		60		100	
VK 710	-		20		60		100
DIDP	80	75	75	70	67	25	15
Ca/Zn Stabi	3,5	3,5	3,5	3,5	3,5	3,5	3,5

Fig. 5: Migration of flexible PVC (Shore A 71, black), and with VK 710 (green) and K 707 E (red) in different concentrations (S-PVC 90/graft copo 20, 70/60). Pure graft copolymers have no relevant migration.

PVC with High Molecular Weight for Antiblocking, Matting and Texturing

®Vinnolit K 240 ®Vinnolit C 100 V ®Vinnolit K 221

Definitions:

Blocking refers to the tendency for contacting layers of plastic materials to stick together. The effect is enhanced by smooth surfaces. As a result high forces must be overcome when reels of films are being unwound, and it is more difficult to remove individually cut sheets from a stack.

Matting can be equated with a reduction of the surface gloss. To the eye the sheet remains smooth.

Texturing is a special surface effect that can also be achieved by means of embossing with sand-blasted rollers. The surface appears uniformly rough, and the irregularities can be observed with the naked eye.

Antiblocking, matting and texturing properties are achieved by the selective introduction of irregularities into the sheet or film. These irregularities take the form of particles, which, although they are firmly embedded in the product, cause small elevations at the surface (see Fig. 6). Even relatively small amounts of **Vinnolit K 240**, **C 100 V** or **K 221** produce the desired effect. Whether the surface will be non-blocking, matt or textured depends on the size and amount of added particles.

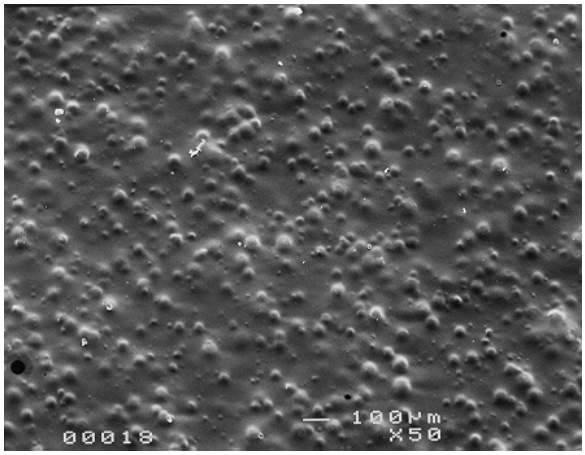


Fig. 6: Surface elevations on a film surface caused by K 221

Vinnolit K 240, **C 100 V** or **K 221** are used in the formulations as an additive. The number and size of particles present in the sheet are decisive for non-blocking, matt or textured sheet.

Even very small additions will prevent the blocking of sheet. Thus, only 0.3 – 1 phr **K 240** or **C 100 V** result in a sufficient number of bumps so that individual layers are no longer in intimate contact with each other (see Fig. 7). These “spacers” cannot be recognised visually.

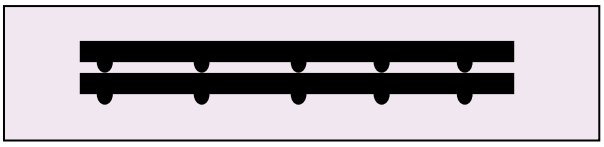


Fig. 7: Two film layers with "spacers“ caused by K 240

The same applies to matt films if the quantity of **K 240** or **C 100 V** is increased to 3 – 10 phr. The incident light is scattered by the uneven surface, which then appears to be matt or even “dull” (Fig. 8).

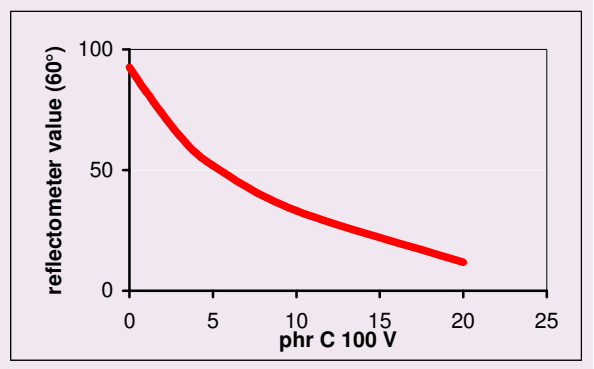


Fig. 8: Matting effect of C 100 V in rigid film. The reflectometer value shows the decreasing gloss.

The individual particles of **K 221** are exceptionally stable. During the usual conditions of thermoplastic processing, these particles are neither sheared nor swollen by plasticizers and keep their initial size of approximately 35 – 40 µ. Correspondingly high elevations appear on the sheet surface. These are seen not as matt but rather as a “sand-blasted”, textured surface. 5 – 10 phr **K 221** produce a “frosted" effect in transparent film, which nevertheless retains a high contact transparency (underlying pictures or handwriting).

Vinnolit K 240, **C 100 V** and **K 221** result in “formulation matt” surfaces. In contrast to mechanical embossing e.g. with sand-blasted rollers, the desired surface structure is retained during subsequent deformations such as vacuum forming.

General Information

Further information and recommendations for processing can be obtained from our technical support staff and representatives.

The data and recommendations contained in this brochure represent the current state of our knowledge and serve as a guide only to our products and their potential applications. Therefore, no warranty of specific properties of the products mentioned herein nor of their suitability or fitness for a particular purpose is implied.

The information given in this brochure should be checked by preliminary trials because of conditions during processing over which we have no control, especially where other companies' raw materials are also being used.

Patent or other proprietary rights of third parties must be observed. The quality of our products is warranted under the terms of our General Conditions of Sale.

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