B.P. CHEMICALS

RUBBER HOUSE

TECHNICAL DATA SHEET

EVONIK

VESTENAMER® 8012

Rubber with unique properties

VESTENAMER 8012 is a rubber based on trans-polyoctenamer which has proved itself as a valuable processing aid.
Due to its properties, it is a versatile polymer that can be used to solve a wide variety of problems dealing with rubber compounding and processing.

The monomer feedstock of VESTENAMER is cyclooctene, which is synthesized from 1,3-butadiene via 1,5-cyclooctadiene. Cyclo-octene is polymerized to polyoctenamer (TOR) in a metathesis reaction.

VESTENAMER 8012 can be used in the following applications:

- calendering
- tire production
- batch technology
- modifications of thermoplastics
- rubber recycling

VESTENAMER 8012 is supplied as cylindrical pellets in polyethylen packaging.

Property		Test method international	national	Unit	VESTENAMER 8012
Density	23°C	ISO 1183	DIN EN ISO 1183	g/cm³	0.91
Tensile test		ISO 527-1	DIN EN ISO 527-1		
Stress at yield		ISO 527-2	DIN EN ISO 527-2	MPa	7.5
Strain at yield				%	25
Strain at break				%	> 50
CHARPY impact strength		ISO 179/1eU	DIN EN ISO 179/1eU		
	23°C			kJ/m²	N[1)]
	-20°C			kJ/m²	N[1)]
IZOD notched impact strength		ISO 180/1A	DIN EN ISO 180/1A		
	23°C			kJ/m²	N[1)]
	0°C			kJ/m²	22
	-23°C			kJ/m²	19
Tensile impact strength		ISO 8256	DIN EN ISO 8256		
	23°C			kJ/m²	165
	0°C			kJ/m²	190
	-20°C			kJ/m²	240
Melting range		ISO 11357			
DSC	2nd heating			°C	54
Crystallinity		ISO 11357			
	23°C			%	approx.30
Glass transition temperature		ISO 11357			
	Tg			°C	– 65
Thermal decomposition	TGA	ISO 11357		°C	275
Melt volume-flow rate (MVR)		ISO 1133	DIN EN ISO 1133		
	190°C/ 2.16kg			cm³/10 min	18
	190°C/ 5kg			cm³/10 min	50
	230°C/ 2.16kg			cm³/10 min	28
	230°C/ 5kg			cm³/10 min	78
Mooney viscosity ML		DIN 53523	ASTM D 1646		
(1+4) 100°C					< 10
Molecular weight M_W	GPC	following DIN 55672-1			90,000
Cis/trans ratio of double bonds	IR	SOP 0188		%	20/80
Apparent density	23°C	ISO 60	DIN EN ISO 60	g/l	560

1) N = No break

EVONIK INDUSTRIES

VESTENAMER® has been well established for years, and has proved itself as a valuable processing aid. Due to its properties, it is a versatile polymer that can be used to solve a wide variety of problems dealing with rubber compounding and processing.

The unique and exceptional properties of VESTENAMER• are characterized by four structural features:

- **Crystallinity**
- **Low viscosity above the melting point**
- **High proportion of macrocycles**
- **Double bond content**

Synthesis and structure of VESTENAMER•

The monomer feedstock of VESTENAMER• Is cyclooctene, which is synthesized from 1,3-butadiene via 1,5-cyclooctadiene. Cyclooctene is polymerized to polyoctenamer (TOR) that produces both linear and cyclic macromolecules. The cis/trans ratio, which determines the degree of crystallinity of TOR, is controlled by the polymerization conditions.

Crystallinity

As mentioned above, the cis/trans ratio of the double bonds in polyoctenamer determines the degree of crystallinity. In general, if trans-content is increased, a higher crystallinity is produced and thus a higher melting point can be obtained.

The crystallinity is thermally reversible, and the crystallization rate is exceptionally high. This effect can be used to reduce the cold low of, e.g., soft compounds, to improve collapse resistance in profile extrusion, increase the hardness of vulcanizates, and reduce the shrinkage and its anisotropy in calendering.

Low viscosity above the melting point

The high content of macrocycles permits a considerable reduction of the molecular weight, since macrocycles, in contrast to linear macromolecules, can form a completely three-dimensional network on cross-linking, even at a low molecular weight.

This low molecular weight, in combination with a broad molecular weight distribution, also accounts for the exceptionally low viscosity at elevated temperatures.

At temperatures above the melting point, both VESTENAMER• grades are low viscous melts with Mooney values (100 °C) below 10. Thus the plasticizing effect of VESTENAMER• improves the processing of rubber compounds in many ways.

High proportion of macrocycies

VESTENAMER® contains at least 25 weight-% of macrocycles with a molecular weight of up to 100,000. These macrocycles presuably account for the high collapse resistance of VESTENAMER® containing rubber compounds at temperatures well above its melting point.

This is certainly the result of entanglements between the linear molecules of the basic rubber and the macrocycles of VESTENAMER®. These cyclic macromolecules have a further influence on the physical properties of the vulcanizates, e.g., by increasing the rebound resilience. On the other hand, the lack of end groups in the macrocycles and the remaining, completely unbranched linear molecules significantly reduce the tack of uncured rubber compounds. Depending on the application, this can be a negative effect, e.g., in natural rubber compounds, or a positive effect as in the case of polychloroprene compounds.

Double bond content

On metathesis polymerization, the double bond of cyclooctene is preserved so that the resulting trans-polyoctenamer contains a double bond at every eighth carbon atom.

Due to the degree of unsaturation, the cure rate is somewhat lower than for SBR. VESTENAMER® vulcanizes with all cross-linking agents commonly used in rubber curing, e.g., sulfur, sulfur donors, peroxides or curing resins.

Polymer compatibility and mixing technique

VESTENAMER® is compatible with almost all rubbers, irrespective of their chemical structure or polarity. It can even compatibilize polymers that are otherwise incompatible, such as EPDM and NBR or emulsion- and solution-rubbers.

In general, VESTENAMER® is applied in a blend by substituting 5 to 15 parts of the base polymer. In special cases, the dosage may be higher. With few exceptions, VESTENAMER® is fed into an internal mixer or an open mill together with the base polymer.

It facilitates and accelerates filler incorporation, improves filler dispersion and reduces energy consumption as well as dump temperature and compound viscosity.

Influence of VESTENAMER• on wicanizate properties

The physical properties of VESTENAMER® containing compounds are determined by the TOR content. In general, hardness and modulus are increased, whereas tensile strength, strain at break and tear resistance are slightly decreased.

The dynamic properties are improved as demonstrated by the reduced heat built-up in fatigue tests. Thermal and UV stability is better than for SBR. The ozone resistance of EPDM is not impaired. Swelling is similar to EPDM or SBR, and abrasion resistance nearly matches polybutadiene.

Extrusion

Flowability is improved by VESTENAMER®, resulting in a higher output of precise extrudates and improved surface finish. With TOR it is possible to process very hard compounds (e.g., without plasticizer) that otherwise cannot be processed at all or only with great difficulty. The better collapse resistance afforded by TOR also improves the dimensional stability of profiles.

The increasing hardness you obtain with decreasing temperature can be a benefit in hose production, where the lining often has to be cooled for braiding. Hence cooling time can be reduced to obtain the required hardness.

Injection molding

The application of VESTENAMER® improves the molding of large and voluminous parts as well as high precision parts. Moreover, it allows very hard compounds with originally poor flow properties to be injection-molded. Due to the enhanced flowability, cycle times can be reduced.

Calendering

VESTENAMER® reduces shrinkage and anisotropy of calendered sheets and improves surface finish and fabric penetration. The sheeting of dry shoe sole compounds is facilitated. The increased green strength makes roll covering easier, whereas the good flowability improves layer welding and prevents flow marks.

Tire production

Tire production represents an important and diverse range of applications for VESTENAMER®. To build a tire, ten to fifteen different compounds are necessary. Many of these compounds have special requirements for which TOR can be useful to solve processing or handling problems.

For very thin tire parts, such as sidewall or rim strips, TOR prevents deformation or over-stretching, thanks to its high green strength. On the other hand, it improves - by its plasticizing effect - the processing of very hard compounds with high carbon black loadings, such as bead and apex compounds. Here the application of reinforcing resins is limited because of their negative influence on the dynamic properties. VESTENAMER®, however, combines improved mixing and processing while enhancing dynamic properties.

Rubber recycling

VESTENAMER® can easily be dissolved in mineral oils at elevated temperatures. Ground rubber waste can be reprocessed by simply coating the crumbs in inexpensive equipment with an oil-VESTENAMER® solution and additional curatives. These "activated" rubber crumbs can either be molded into rubber goods directly or can be added to fresh rubber compounds as a reactive filler. Compared to uncoated crumb, the physical properties of the finished parts are improved by VESTENAMER®

Asphalt

Based on our experience with rubber recycling, we found a new application for VESTENAMER® in connection with ground tire rubber in asphalt concrete production. High quality pavements can be prepared by mixing VESTENAMER® with ground tire rubber and bitumen and hot mix asphalt concrete. Small amounts of VESTENAMER® disperse fillers efficiently, promoting compatibility and crosslinking in rubberized asphalt mixtures. In addition, it reduces the high tackiness of these rubberized mixtures. This allows for an earlier compacting of the asphalt concrete with steel and rubber rollers at higher temperatures, which saves time and money. This ability of VESTENAMER® to cross-link the ground tire rubber to the asphalt creates a rubberized matrix in the asphalt paving that prevents premature cracking, rutting and shoving. For more details please see our brochure "VESTENAMER® Essential for Polymer-Modified Asphalt".

Batch technology

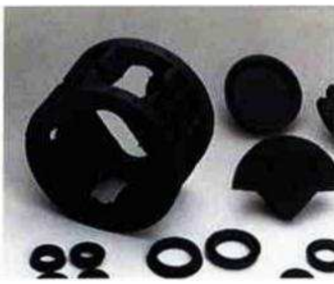
Due to its distinct thermoplasticity and low melting range, VESTENAMER® can be used for the production of polymer-bound masterbatches of chemicals, both for plastics and rubber compounds. This is especially true for the preparation of masterbatches containing thermally sensitive chemicals, such as peroxides, accelerators and blowing agents. VESTENAMER®, e.g., in combination with EP(D)M or EVA, serves as a carrier because of its good filler incorporation.

Due to the high crystallization rate and level, the batches can easily be granulated for handling, and undesired tack is suppressed. On the other hand, the low viscosity above its melting point allows fast and easy dispersion of the chemicals.

Modification of thermoplastics

Because of its unique characteristics, VESTENAMER® can also be used as an impact modifier in thermoplastics. In the production of thermoplastic rubbers based on polyolefines, TOR can compatibilize the different raw materials and activates the dynamic cross-linking through peroxides.



Characteristic properties of VESTENAMER® 8012

Property		Test method	Unit	Value
Molecular weight M_w	GPC	acc. DIN 55672-1		90,000
Glass transition temperature	Tg	ISO 11357	°C	– 65
Crystallinity	23°C	ISO 11357	%	~ 30
Melting range	DSC 2nd heating	ISO 11357	°C	54
Thermal decomposition	TGA	ISO 11357	°C	275
cis/trans ratio of double bonds	IR	SOP 0188	%	20/80
Mooney viscosity ML	(1+4) 100°C	DIN 53 523, ASTM D 1646		<10
Viscosity number	J/23°C	ISO 1628-1	ml/g	120
Ash content		DIN 53 568, part 1	%	max 0.1
Volatile matters	1h/105°C	ISO 248	%	max 0.5
Density	23°C	ISO 1183	g/cm³	0.91
Apparent density	23°C	ISO 60	g/l	560
Appearance				light, opaque pellets
Melt volume-flow rate (MVR)	190 °C/2.16 kg 190 °C/ 5 kg 230 °C/2.16 kg 230 °C/ 5 kg	ISO 1133	cm³/10 min cm³/10 min cm³/10 min cm³/10 min	18 50 28 78
Tensile test Stress at yield Strain at yield Strain at break		ISO 527-1/ -2	 MPa % %	 7.5 25 400
CHARPY impact strength	23°C -20°C	ISO 179/1eU	kJ/m² kJ/m²	N* N*
Tensile impact strength	23°C 0°C -20°C	ISO 8256	kJ/m² kJ/m² kJ/m²	165 190 240
IZOD notched impact strength	23°C 0°C -20°C	ISO 180/1 A	kJ/m² kJ/m² kJ/m²	N* 22 19

* N = No break

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