



Cariflex[®]

Polyisoprene Products

Transparent Rubber Compound for Footwear Applications

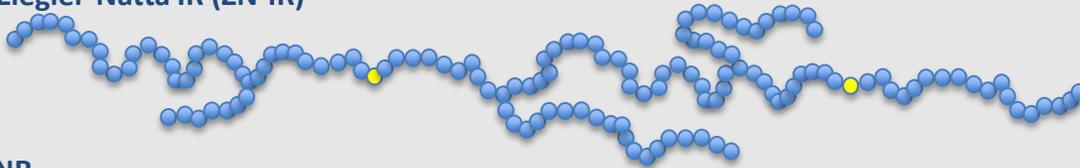
December 2015

Cariflex[®] Polyisoprene (IR) – Pure – Strong - Soft

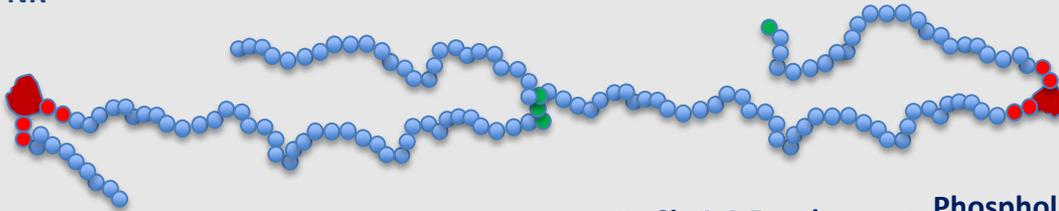
Cariflex IR



Ziegler-Natta IR (ZN-IR)

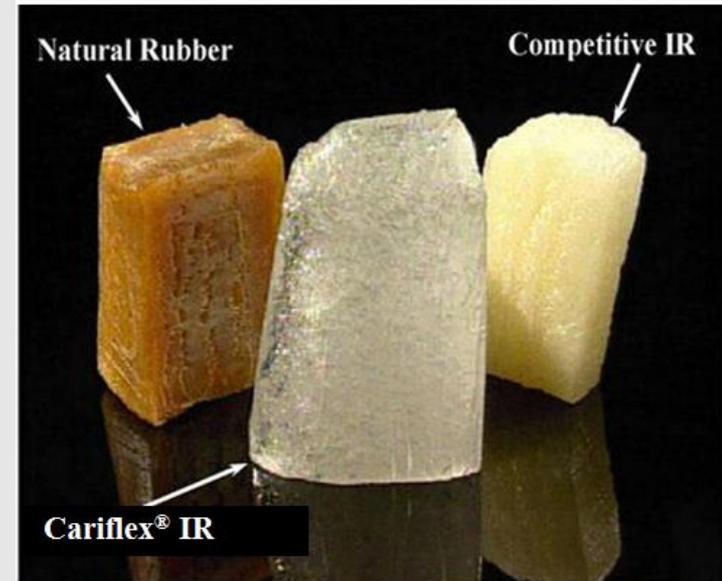


NR



Polyisoprene microstructure models.

- Cis 1,4-Bonds
- Trans 1,4-Bonds
- 3,4-Bonds
- Phospholipid / Fatty acid
- Proteins



Cariflex Isoprene Rubber features

- Anionic polymerization
- No protein
- Low residual metals
- Low gel content (~0 %)
- No odour
- Excellent transparency due to high purity

Kraton customers have used Cariflex® IR and IRL in the following applications



Medical stoppers and other medical rubber pieces



Stoppers for IV bags



Needle shields

Dental Dams



IR Latex material



Condoms



Catheters (heart, urinary)



Cold seal adhesives for food & medical packaging

- IR solid material
- Pure
- Transparent
- Elastic
- Soft
- Strong



Cariflex IR



Transparent shoe soles

- Electronic coatings
- Printing inks
- Glues



Marine coatings

Cariflex[®] Transparent Rubber Compounds

Kraton Polymers has developed Cariflex[®] Transparent Rubber Compounds, using Cariflex[®] IR307 as an ingredient

Cariflex[®] TRC

- can provide “crystal-clear” transparency over a wide range of hardness with good purity and mechanical strength, including abrasion resistance and soft touch. To our knowledge, no other rubber can provide the same balance of properties.
- can offer excellent clarity and sharp coloring
- can be processed with most conventional rubber compounding technology.
- can be sterilized with most sterilization methods without, or with limited performance deterioration.

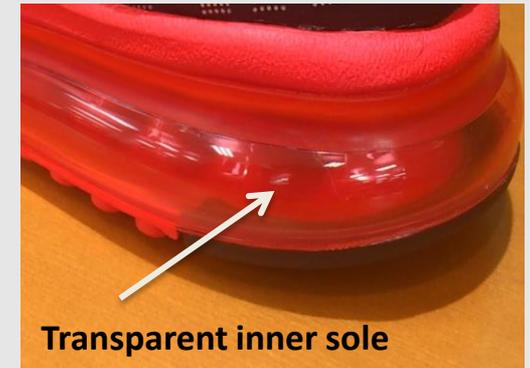


We have identified potential applications for Cariflex[®] TRC in Footwear, both for the outer sole and the inner sole.

Key features for this material are:

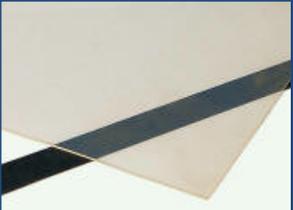
- Fits the fashion trend of transparent shoes
- Excellent clarity and sharp coloring possible
- Better abrasion resistance than TPE soles
- Good UV stability

Optimization of the technology is still ongoing

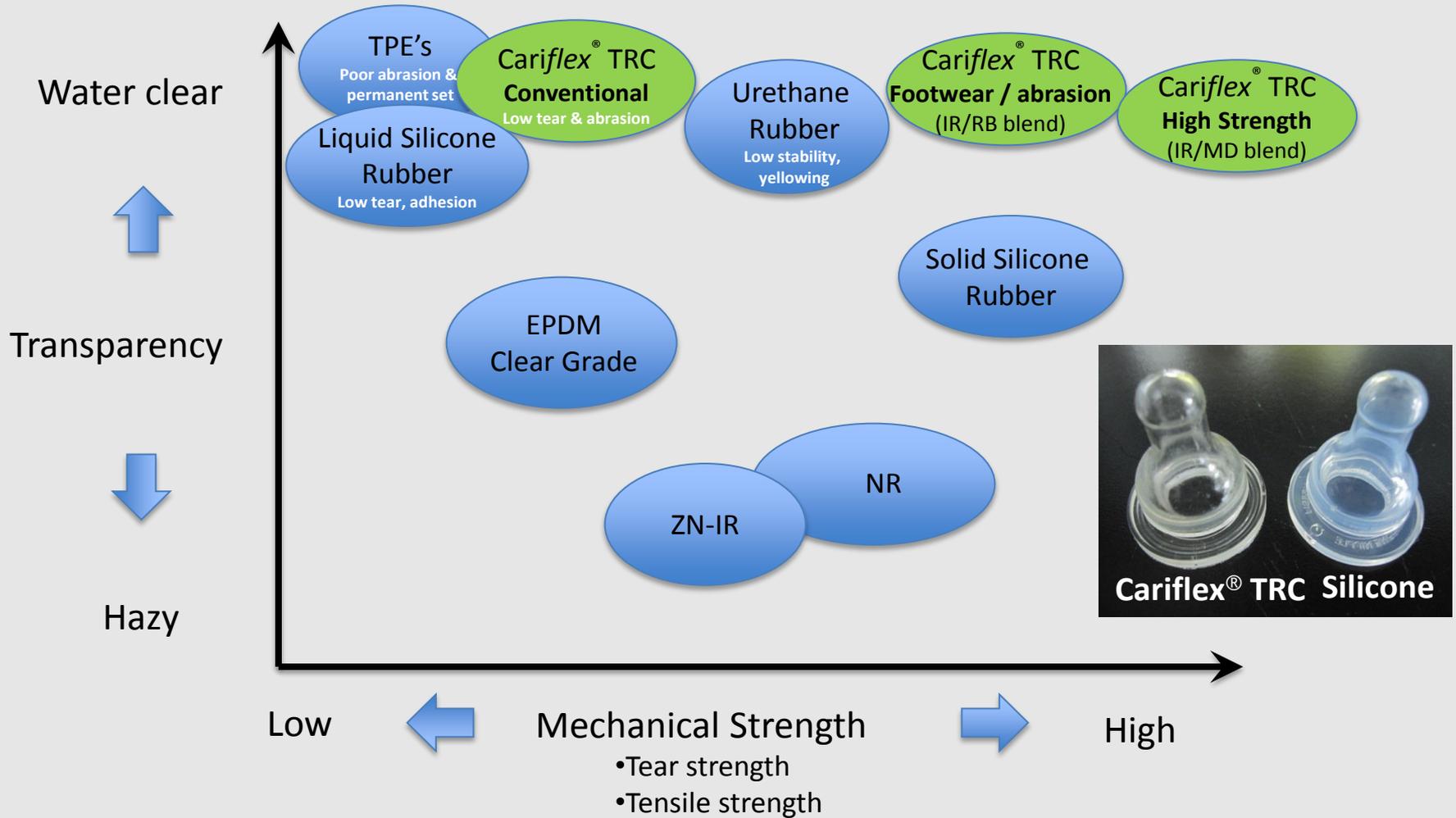


Please note, that Kraton has filed patent applications on the Cariflex[®] TRC technology and related applications described in this presentation.

Cariflex® TRC - Comparison with other materials

Cariflex® TRC		<ul style="list-style-type: none"> Cariflex® TRC has excellent transparency and mechanical performance compared with other types of rubber
ZN-IR		<ul style="list-style-type: none"> Competitive ZN-IR is hazy
Urethane		<ul style="list-style-type: none"> Urethane has good transparency, but suffers from poor heat, hydrolytic and UV stability (discoloration)
Silicone		<ul style="list-style-type: none"> Silicone can come close in transparency, but is costly (LSR), or weak in tear strength and adherence issues in laminate structures
EPDM		<ul style="list-style-type: none"> EPDM is somewhat hazy, and much less elastic

Transparent Rubber Compounds – The Landscape



Cariflex® TRC – Formulation

Generic formulation for a Cariflex® Transparent Rubber Compound

Ingredients	
Polymers	Polyisoprene - Cariflex® IR307
	Syndiotactic-1,2-polybutadiene, JSR RB820
Curing agent	Peroxide (2,5-Dimethyl-2,5-di(tert-butylperoxy)hexane) (like: Trigonox®101, Luperox® 101, Perhexa® 25B)
Curing co-agent	Ethylene glycol dimethacrylate (EGDMA)
Anti-oxidant	Irganox®1726 (4,6-bis(dodecylthiomethyl)-o-cresol)

The amount of each ingredient can be tailored to suit the mechanical properties and transparency requirements of the application.

For footwear we typically recommend 50 phr of polyisoprene and 50 phr of JSR RB820 to achieve an abrasion resistance of < 100 mm³

Trigonox®101 is a trademark of AkzoNobel

Luperox®101 is a trademark of Arkema

Perhexa®25B is a trademark of Nippon Oils & Fats Co Ltd.

Irganox®1726 is a trademark of BASF

Process	Steps	Details	Processing Parameters	Storage Conditions
Compounding (in 2-Roll Mill OR Internal Mixer)	Step 1	Mix masterbatch using Cariflex® IR307, JSR RB820 and Anti-oxidant (AO)	Temperature: Blend RB820 and AO into IR at 120 C (max 130 C)	<ul style="list-style-type: none"> • Limit exposure to oxygen and UV light • Shelf-life = 3 weeks at max. T of 60°C
	Step 2	Mix green compound using masterbatch of Step 1, peroxide and co-agent	Temperature: about 75 C	<ul style="list-style-type: none"> • Limit exposure to oxygen and UV light • Shelf life = 3 weeks at max. T of 25°C
Molding		Compression Molding	Temperature: 160 C Time: 6 – 7 minutes	
		Injection molding also possible		

Properties	CF -TRC	CF - TRC – aged *
Abrasion (mm ³) – 6mm	51 - 100	90 - 110
Transparency (%) – 6mm	87	87 - 89
Haze (%) – 6 mm	9.4 – 14.5	~ 15
Yellowness Index – 6 mm	< 5	< 5
Tensile (MPa)	10.7 – 11.6	TBD
Modulus 100% (MPa)	3.8 – 5.8	TBD
Elongation@Break (%)	147 - 201	TBD
Tear (kN/m)	24 - 27	TBD
Shore A 0 sec	71 - 72	69
Shore A 30 sec	67 - 68	66
Stickiness	None	None

* Properties of cured sheets that had been aged for 1 month at 40 °C

No yellowing of cured sheets is observed after 1.5 hr at 120 °C

Further aging tests still underway

Cariflex® TRC – Further Developments Ongoing

High-Abrasion Resistant Transparent Rubber Compounds

- Recently adapted a Cariflex® TRC formulation targeting even lower abrasion resistance
- Achieved by addition of 1- 4 phr of a trans-polyoctenamer - Vestenamer® 8012
- As amount of Vestenamer increases, the abrasion resistance improves (to below 50 mm³), but slightly at the expense of transparency

High-Strength Transparent Rubber Compounds

- By blending Cariflex® IR307 with a unique Kraton developmental polymer grade, we can tailor the formulations to have improved mechanical properties, specifically tensile and tear strength. This goes at the expense of abrasion resistance
- This technology will be valuable for softer Transparent Rubber Compounds with requirements of improved strength for which abrasion resistance is not critical

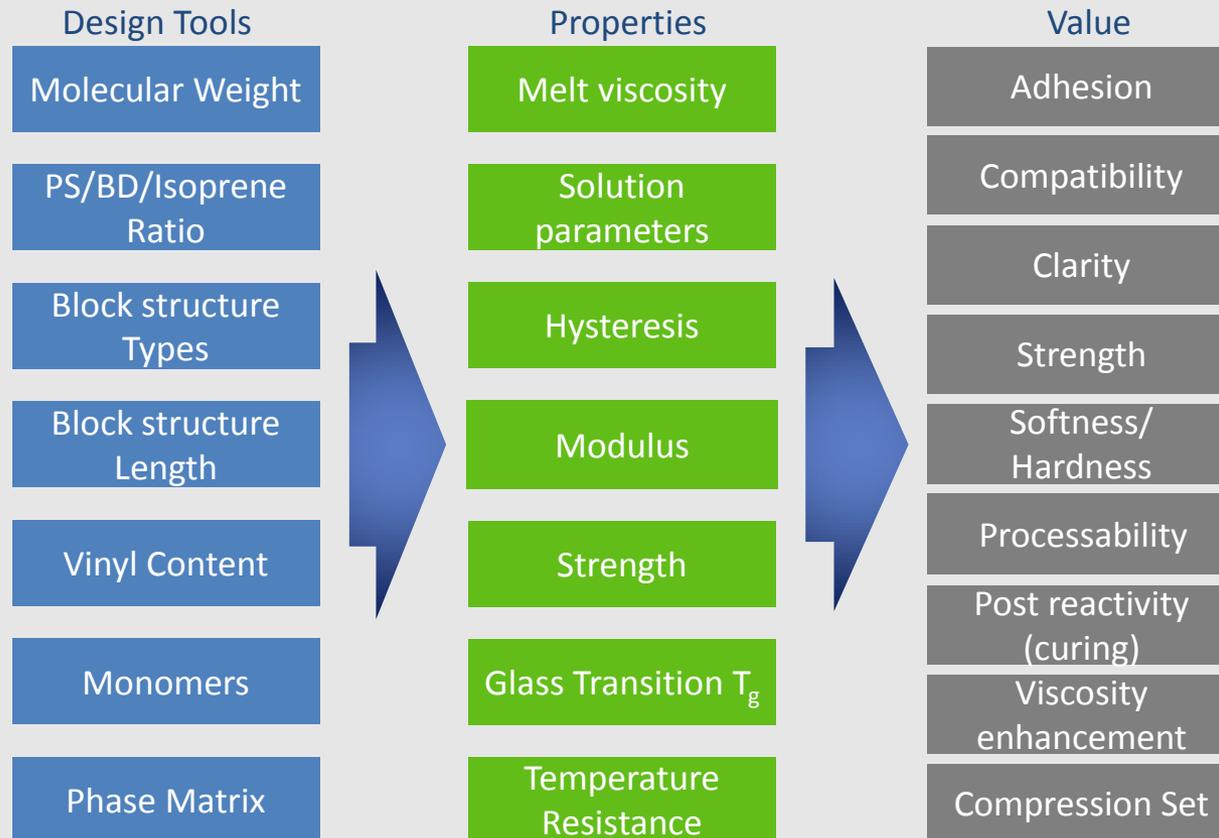
Vestenamer® is a trademark of Evonik Degussa GmbH

Cariflex® TRC - Summary

- Cariflex® IR is a unique polyisoprene rubber with proven track record in applications requiring PURE - STRONG – SOFT properties.
- Cariflex® TRC, using Cariflex® IR as ingredient,
 - can provide “crystal-clear” transparency over a wide range of hardness with good purity and mechanical strength, incl. abrasion and soft touch. No other rubber can provide the same balance of properties.
 - can be processed with most conventional rubber compounding technology.
 - can be sterilized with most sterilization methods without, or with limited performance deterioration.
 - can meet requirements of medical and food applications requiring high level of purity (subject to adequate regulatory assessment, compound recipe, and processing conditions).
- JP provisional patent was published on Aug 28, 2014
- Potential applications are footwear/shoe soles, baby nipples, stoppers for transfusion bottles, vial stoppers, medical tubes such as joint drain tubes, high voltage insulation material incl. silicone rubber replacement, photo-curable rubbers, nice looking consumer goods

Other potential developments

Kraton Polymers has unique Polymer Development Capabilities. Anionic polymerization allows for precise control over polymer molecular structure. For Cariflex[®] Polymers we could envision developing alternative rubber structures with specific property attributes.



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