New Hydrogenated Styrenic Block Copolymers for PP Modification

Bing Yang, Aparajita Bhattacharya, Richard Ma, Yonghua Zhou

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Agenda

- Introduction of styrenic block copolymers
- A new developmental product MD1646VO
- Polypropylene random copolymer impact modification
- Medical tubing application
- Summary

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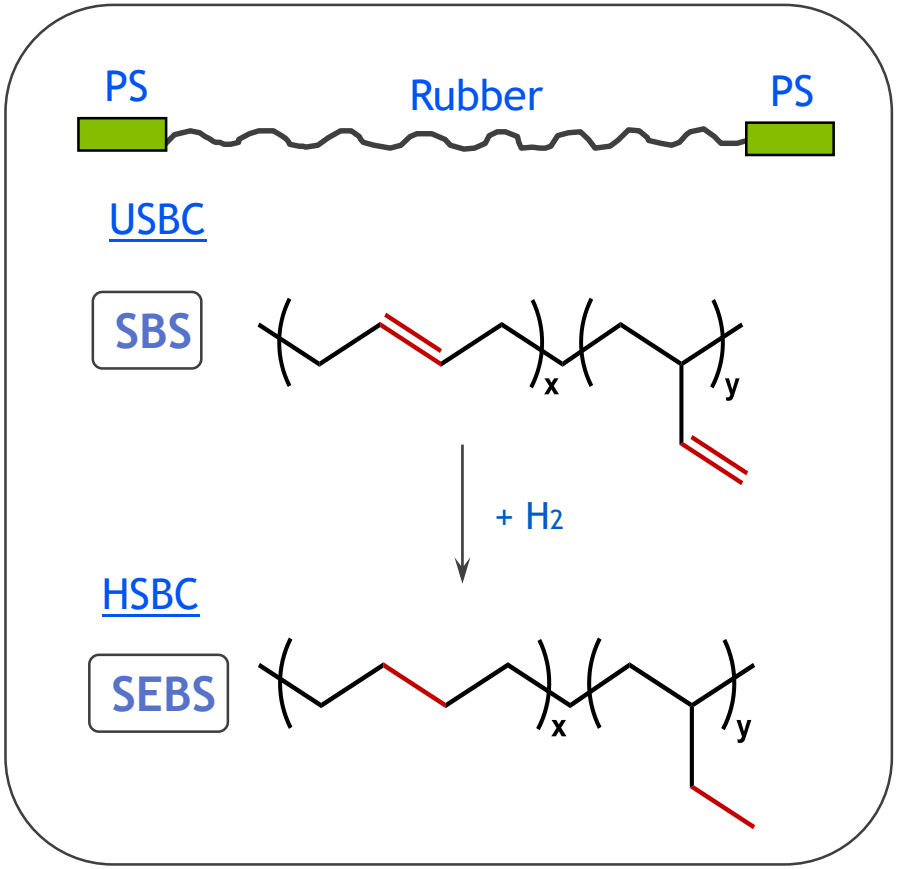
Introduction of Styrenic Block Copolymers

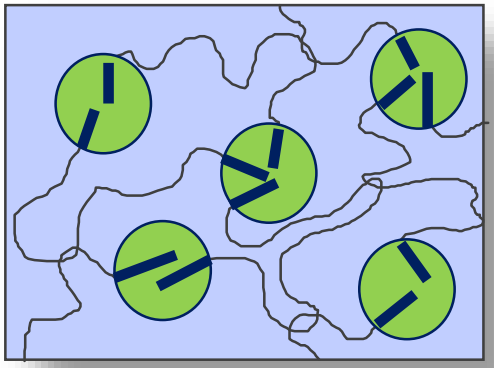
What are Styrenic Block Copolymers?

Styrenic Block Copolymer (SBC) is a thermoplastic elastomer.

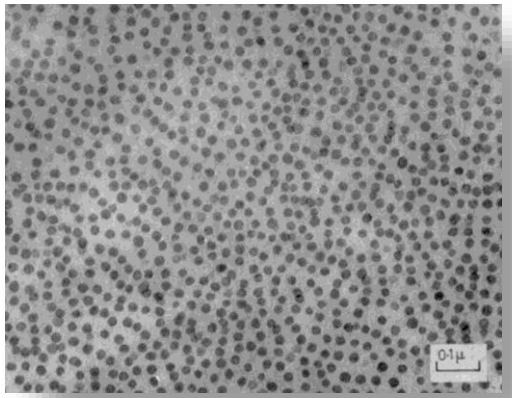
Butadiene Based Rubber Mid Block



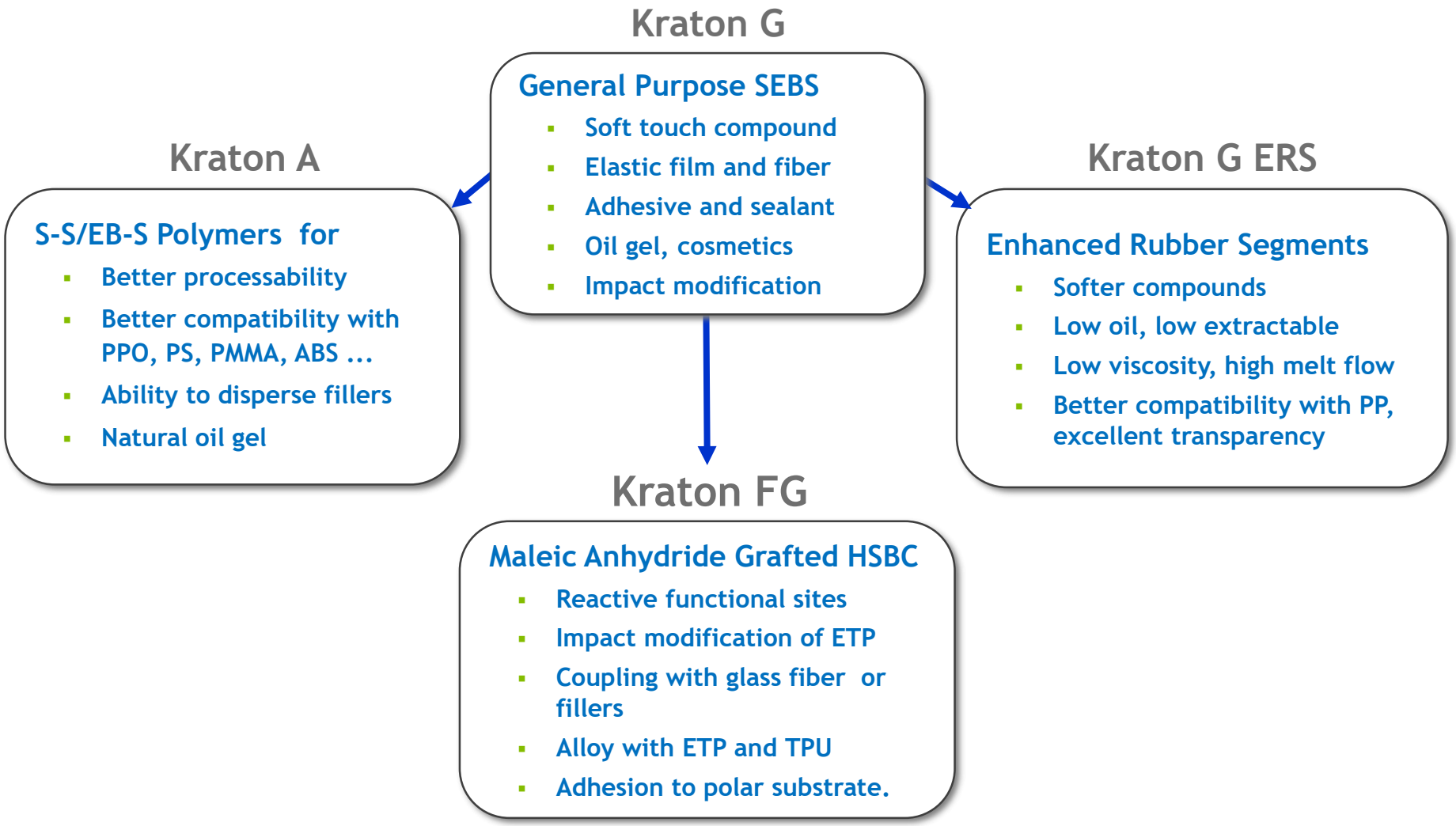
Morphology of SBC Polymer



TEM micrograph (S/EB=20/80%)



Kraton™ HSBC Major Product Lines



The New KFPC Mailiao Manufacturing Plant

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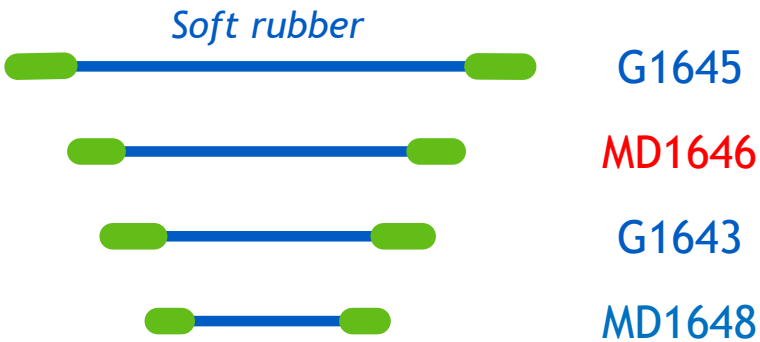
A new developmental product MD1646VO

MD1646VO Summary



Features/Benefits

- Enhanced rubber segment structure → Soft, good compatibility with PP
- Low polystyrene content → high elastic recovery, low hysteresis, good kink resistant
- Higher melt flow than G1645 → Lower processing temperature, easier post process handling

Potential Applications

- Medical tubing
- Medical Film, e.g., IV bags
- PVC alternative (coated fabric, sheet, film, wire & cable)
- Hot melt adhesives
- PP impact modifier
- TPE compounds

MD1646VO General Properties

Polymer	MD1646VO	G1645MO	G1643MS
Solution Viscosity (cP), 25% @ 25°C	570	955	210
MFR (g/10min) @ 230°C, 2.16 kg	13	3.5	19
MFR (g/10min) @ 230°C, 5 kg	49	13	75
PSC (%)	13	13	19
Hardness (Shore A)	38	38	52
Tensile Strength (MPa)*	10.4	11.9	14
Ultimate Elongation (%)*	1,050	1,180	>600
Product Form	Pellet**	Pellet	Pellet

* Properties measured on film cast from toluene solution.
** MD1646VO is dusted with organic dust and is available in 25 kg bag or 625 kg bulk box.

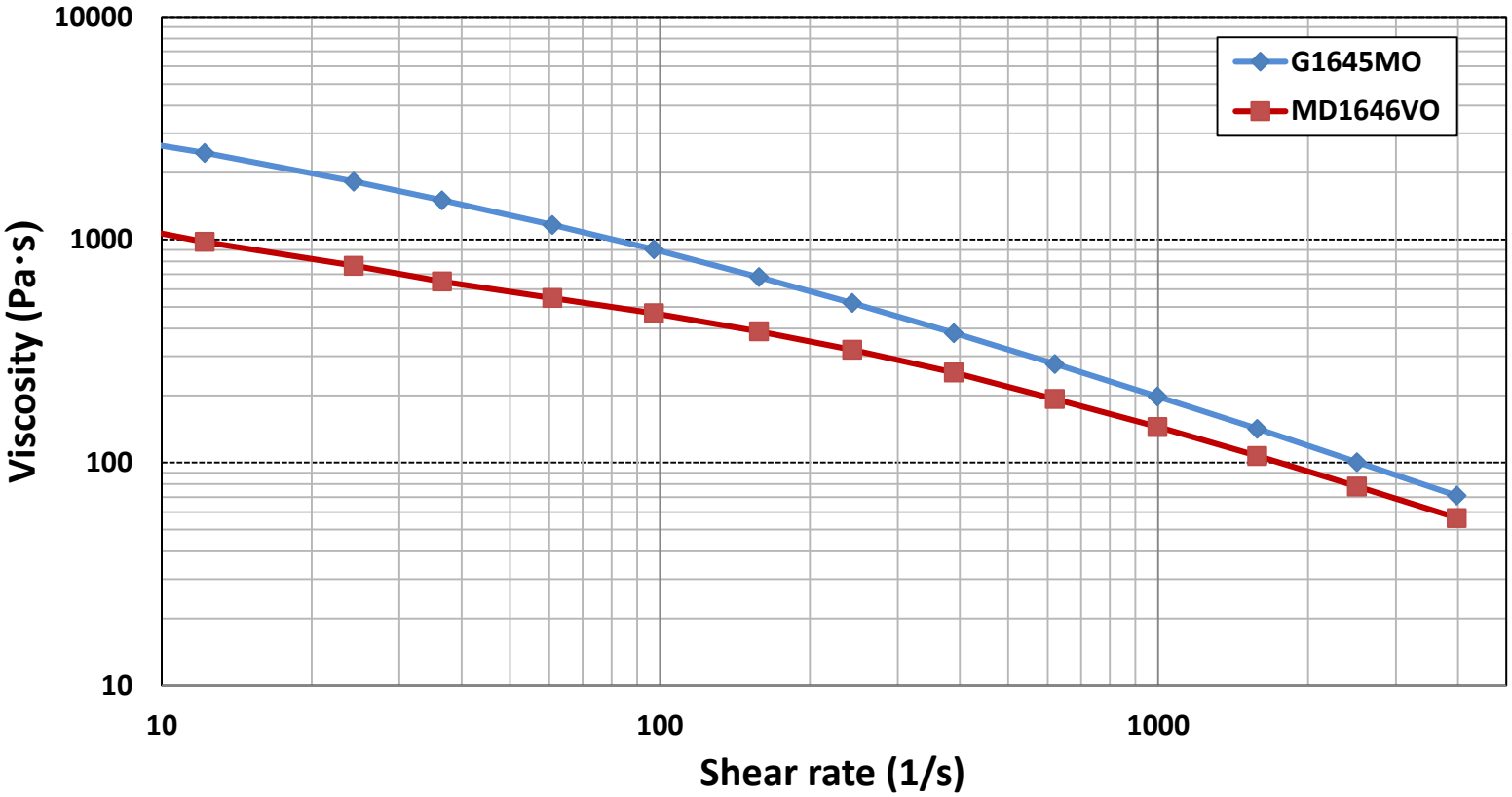
The new developmental polymer MD1646VO has lower solution viscosity and higher melt flow than G1645, yet it retains key properties of G1645.

Elasticity - Melt and Solution Cast Films

Hysteresis	Melt Cast Films				Solution Cast Films	
	MD1646VO		G1645MO		MD1646VO	G1645MO
	MD	CD	MD	CD		
Hysteresis with 100% elongation						
First cycle tensile set (%)	5.2	5.9	4.6	5.0	5.4	4.8
First cycle energy recovered (%)	91	90	93	93	91	93
Second cycle tensile set (%)	5.8	6.6	5.1	5.5	6.0	5.3
Second cycle energy recovered (%)	94	94	96	95	95	96
Hysteresis with 300% elongation						
First cycle tensile set (%)	9.3	10.6	8.0	9.2	9.9	8.3
First cycle energy recovered (%)	91	90	93	92	91	93
Second cycle tensile set (%)	10.5	11.9	8.8	10.1	11.2	9.0
Second cycle energy recovered (%)	95	95	97	96	95	97

MD1646VO has slightly less elastic recovery compared with G1645MO.

Melt Viscosity at 230°C



MD1646VO has lower shear viscosity than G1645MO
→ less energy consumption
→ lower processing temperatures

Other Properties

Properties	MD1646VO	G1645MO
Tan δ peak by DMA (°C)	-22.5	-22.8
Vertical rebound (%)	32	29
Compression set, RT/22h (%)	9.3	5.9
Compression set, RT/70h (%)	13.2	8.2

Dampening Properties

Elastic Sealing Properties

MD1646VO has better dampening properties than conventional HSBC polymers and slightly poorer sealing properties at room temperature than G1645MO.

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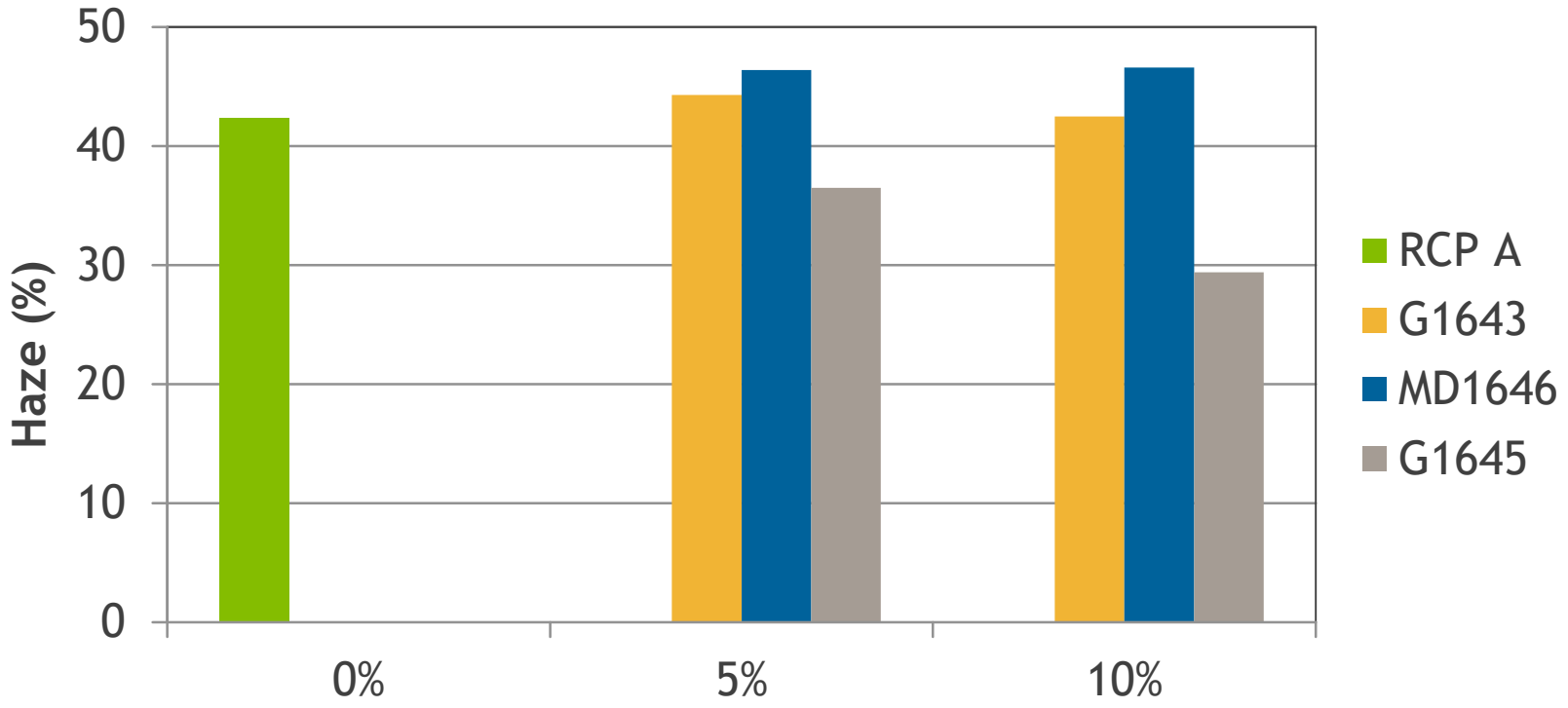
Polypropylene Random Copolymer (RCP) Impact Modification

Experimental

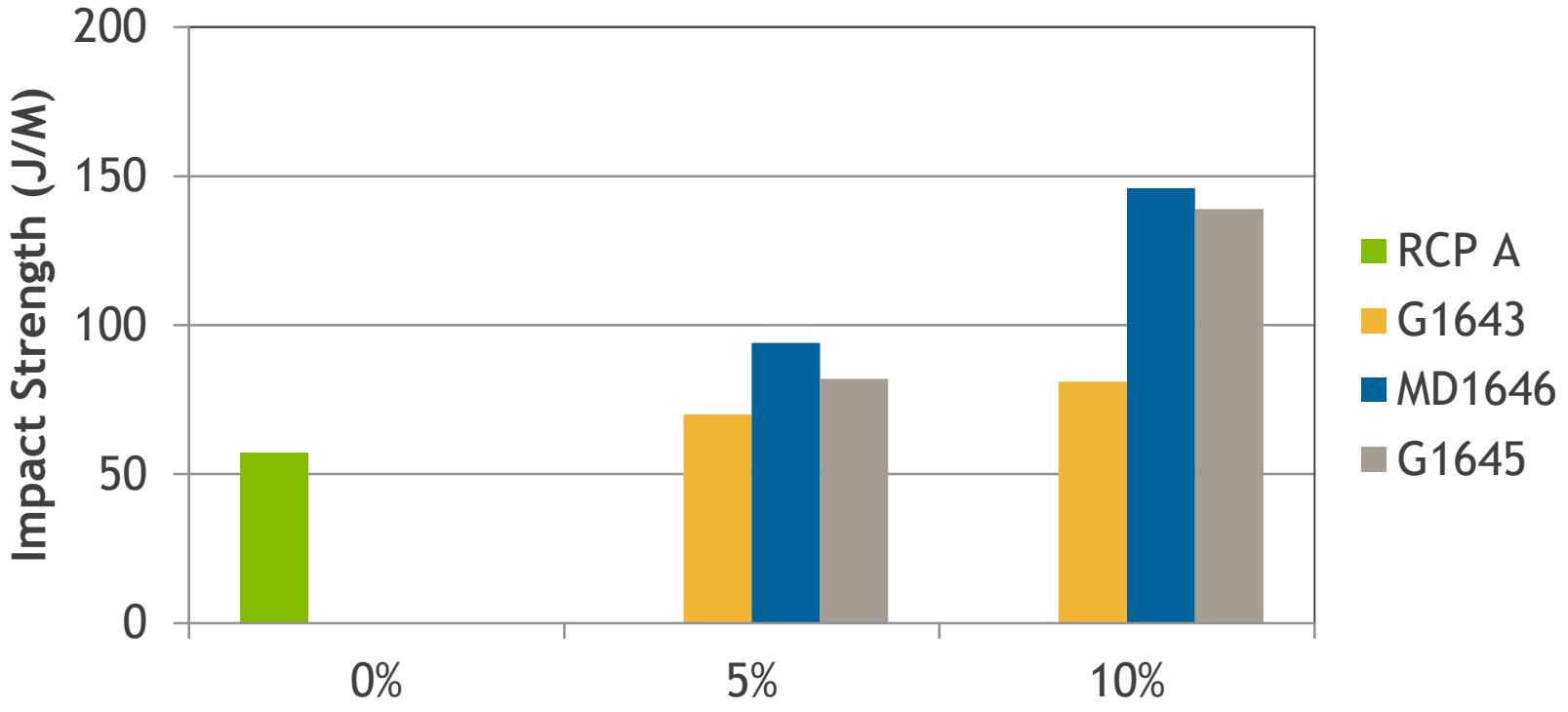
- Dry blend HSBC polymers with RCP at 5% and 10% ratios
- Measure injection molded plaques
  - Light transmission
  - Haze
  - Flexural modulus
  - Notched Izod at 23°C and 4°C
- Two polypropylene random copolymers tested
  - RCP A
    - A barefoot grade for cast film application
    - MFR = 12
  - RCP B
    - A clarified with enhanced optical properties
    - MFR = 12

Haze of RCP A and ERS Polymers Blends



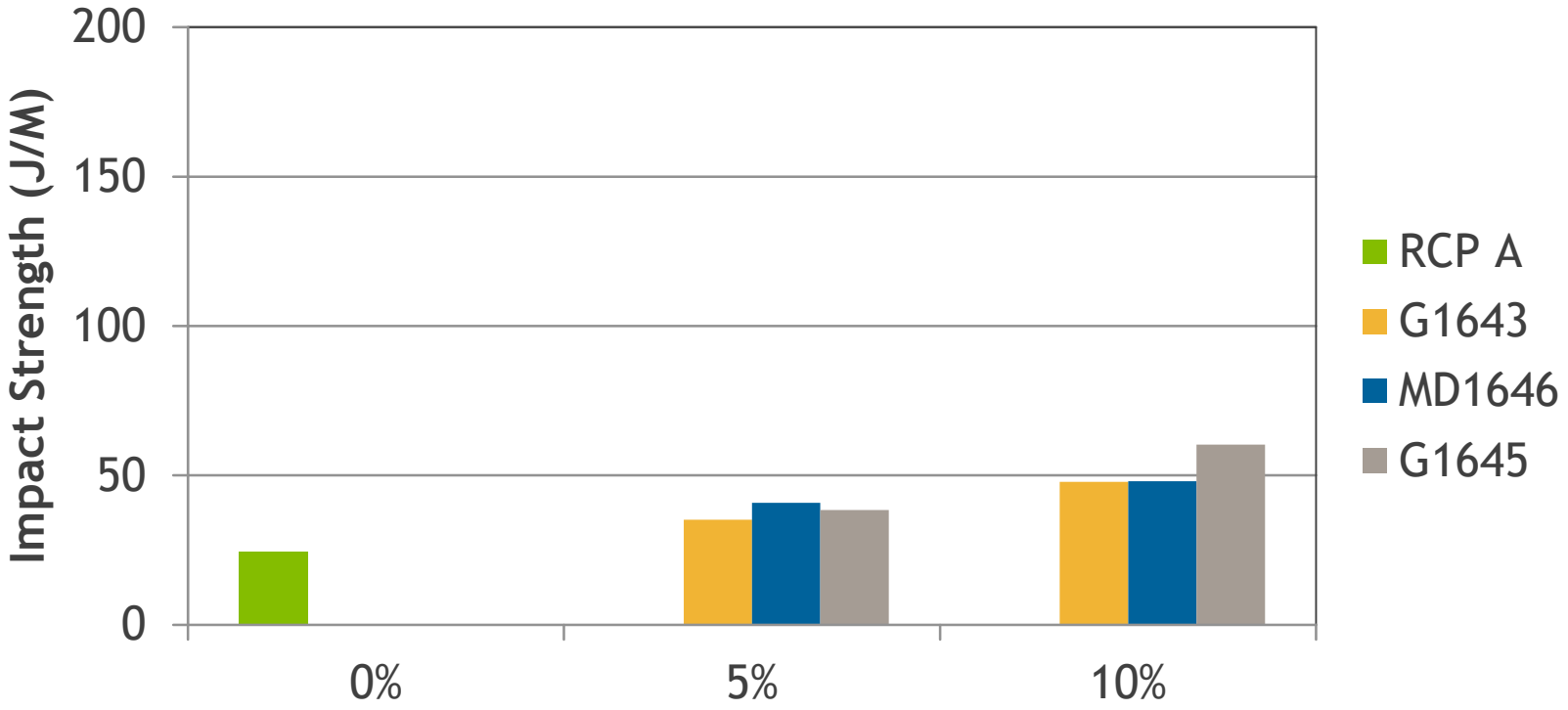
Addition of MD1646 or G1643 does not change the haze of RCP A significantly. G1645 reduces the haze of RCP A.

Notched Izod Impact at 23°C for RCP A



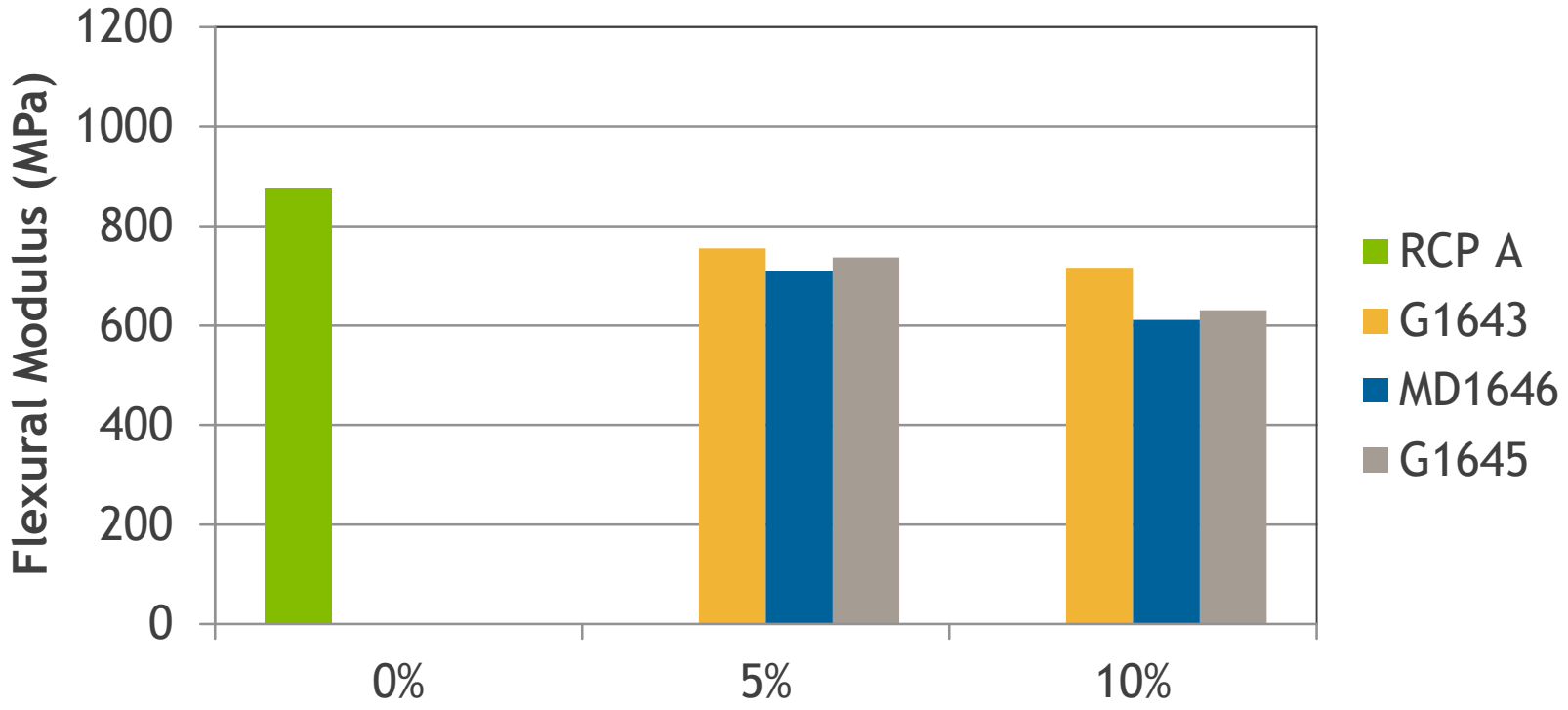
Impact strength of RCP A increases at 5% addition of ERA polymers. G1643 has less effect than MD1646 and G1645 in modifying RCP A.

Notched Izod Impact at 0°C for RCP A



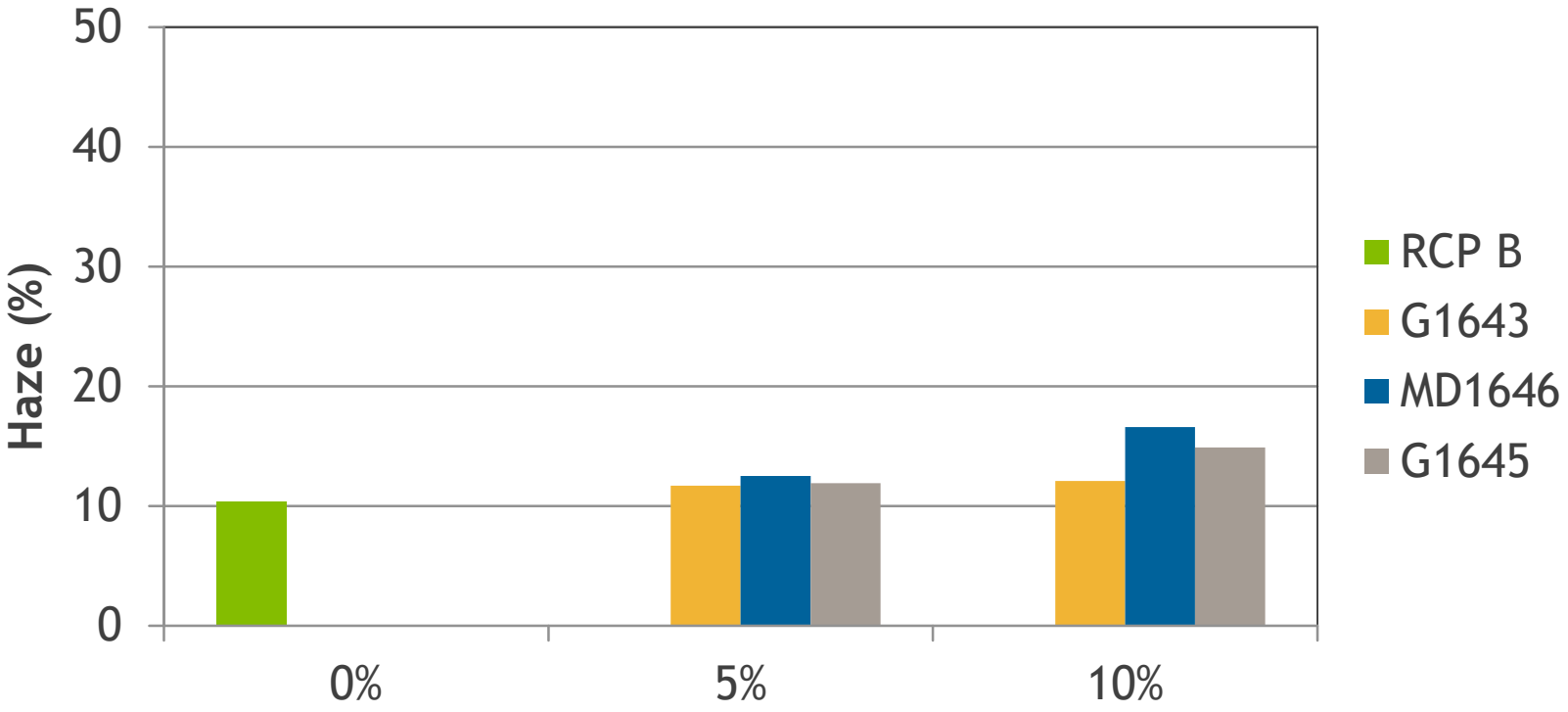
Impact strength of RCP A at 0°C increases with the addition of ERS polymers. G1645 has slightly more effect.

Flexural Modulus of RCP A Blends



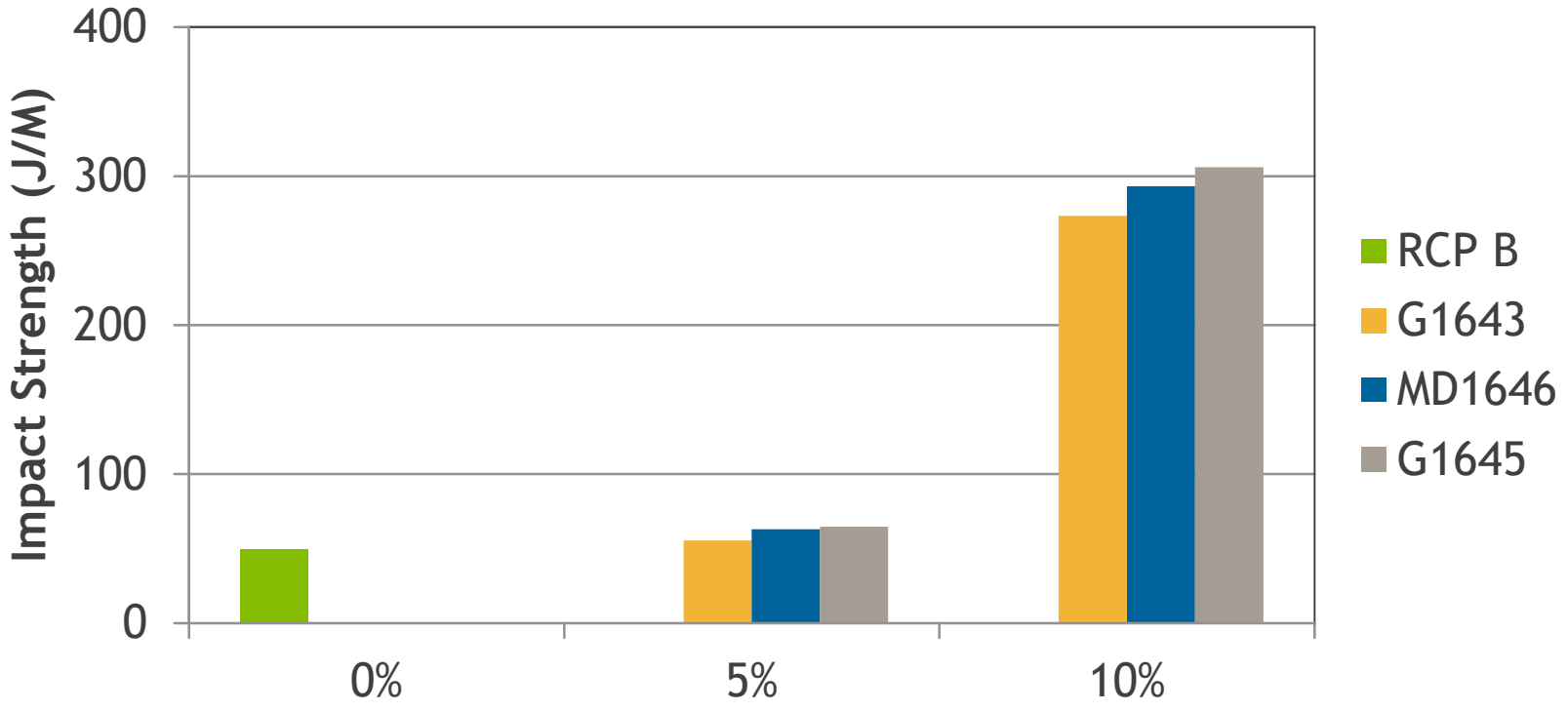
Modulus decreases with increased amount of ERS polymers. G1643 has less effect on modulus than G1645 and MD1646.

RCP B Haze of Blends



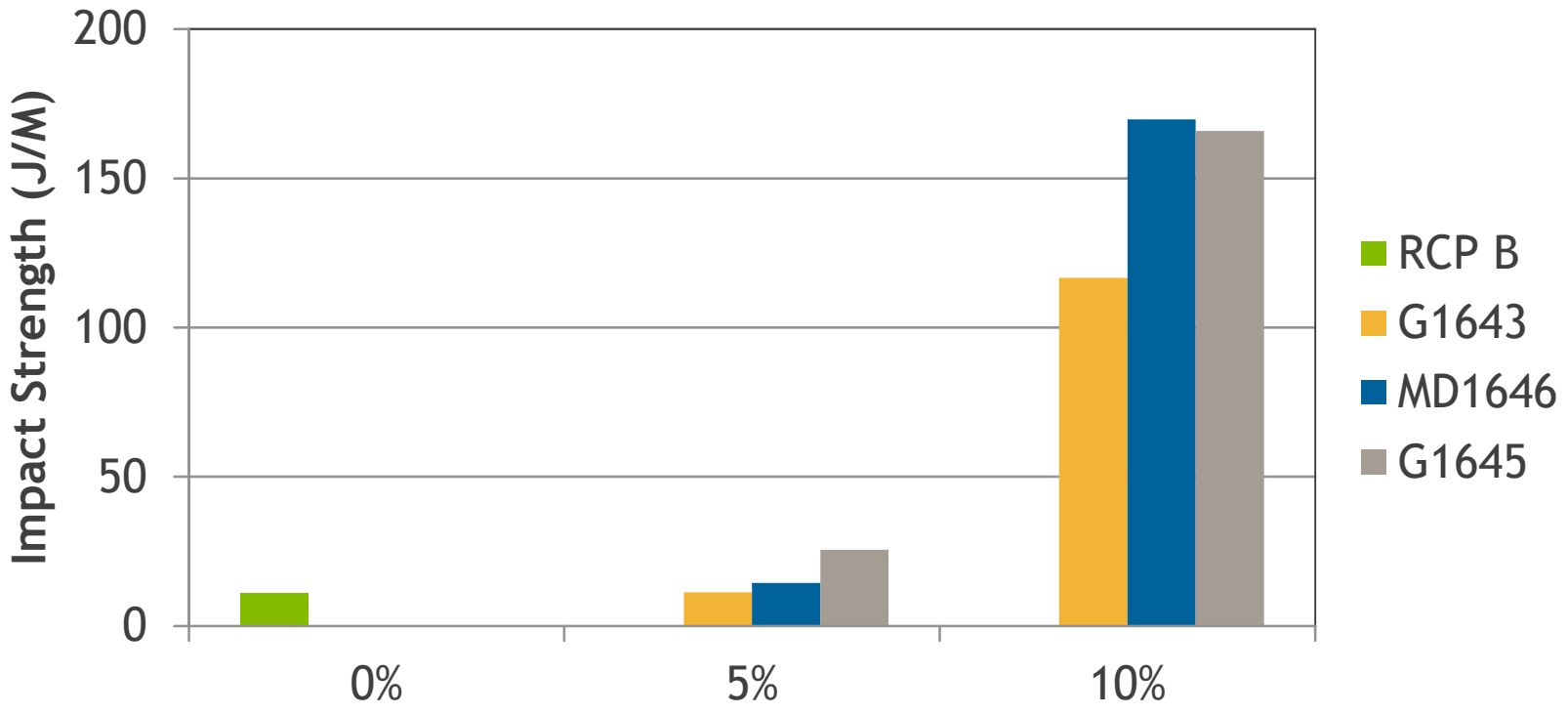
Addition of ERS polymers increases haze slightly. G1643 has the least effect on haze value.

RCP B Notched Izod Impact at 23°C



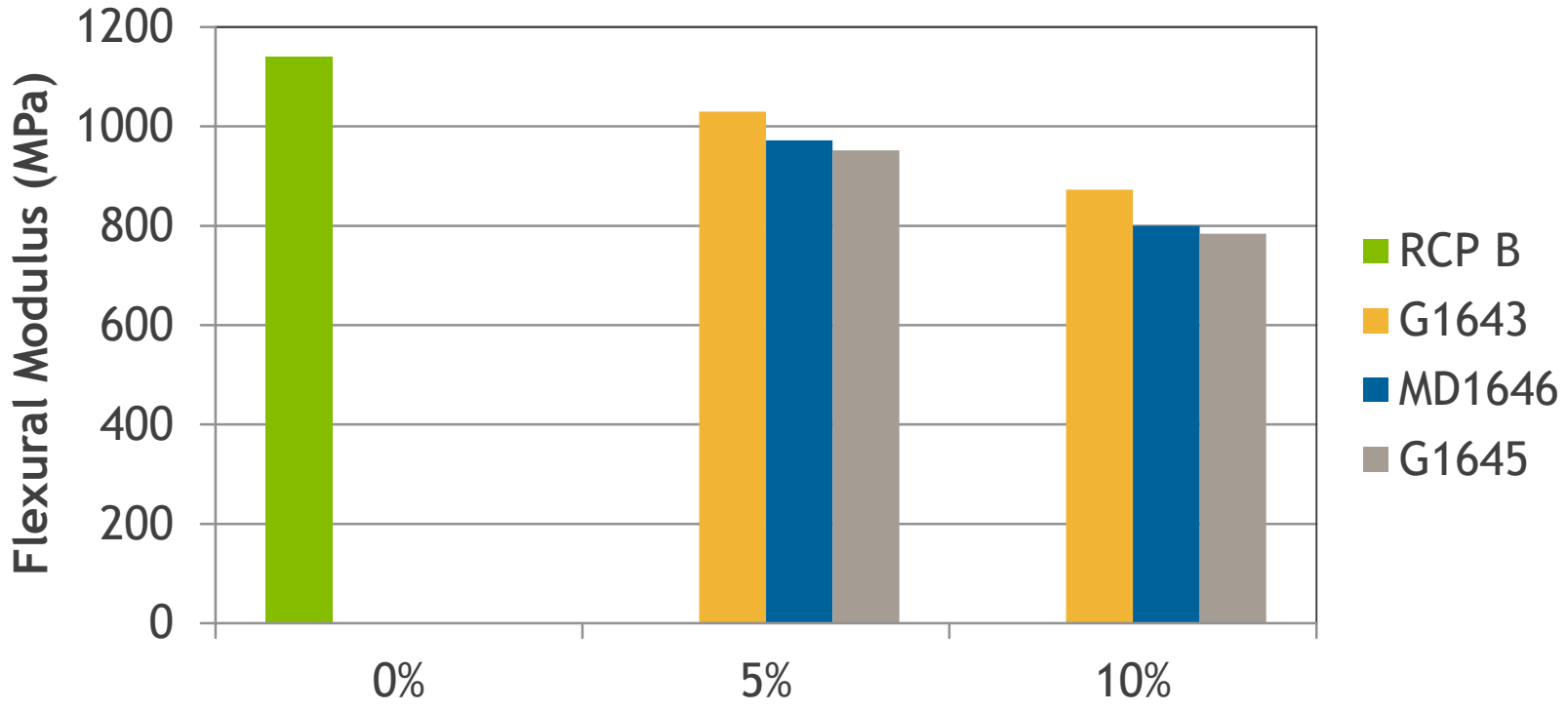
Impact strength of RCP B increases with 5% addition of ERS polymers. All three polymers have similar effect.

RCP B Notched Izod Impact at 4°C



Impact strength of RCP A at 0°C increases significantly with10% addition. MD1646 and G1645 have more effect than G1643.

RCP B Flexural Modulus



Modulus decreases with increased amount of ERS polymers. G1643 has less effect on modulus than G1645 and MD1646.

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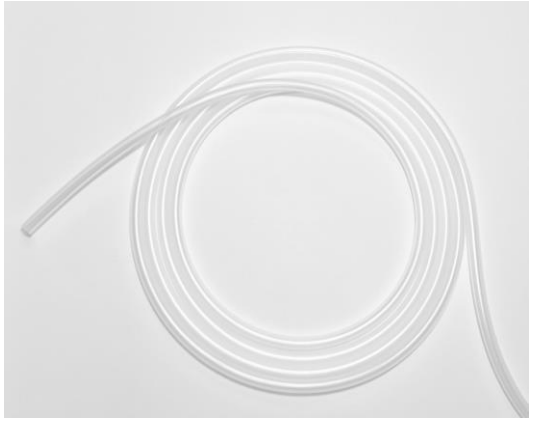
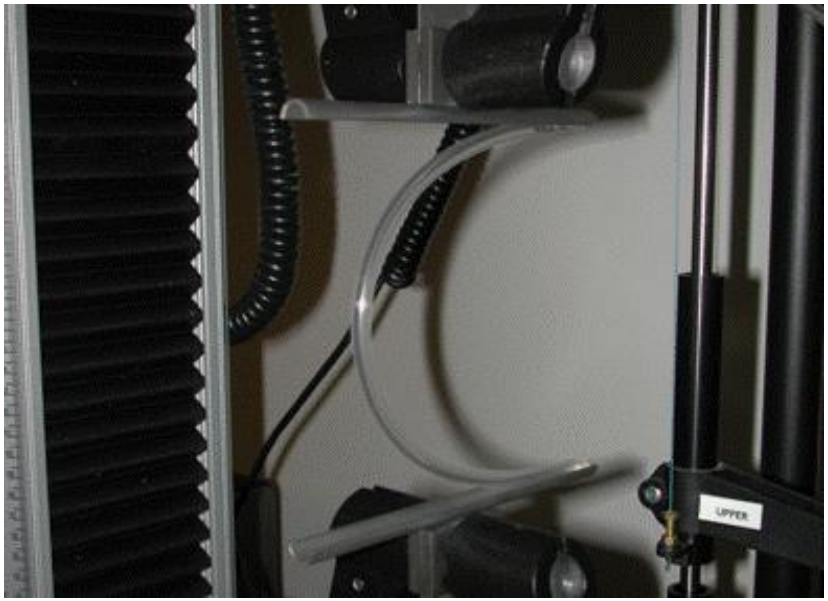
Medical Tubing

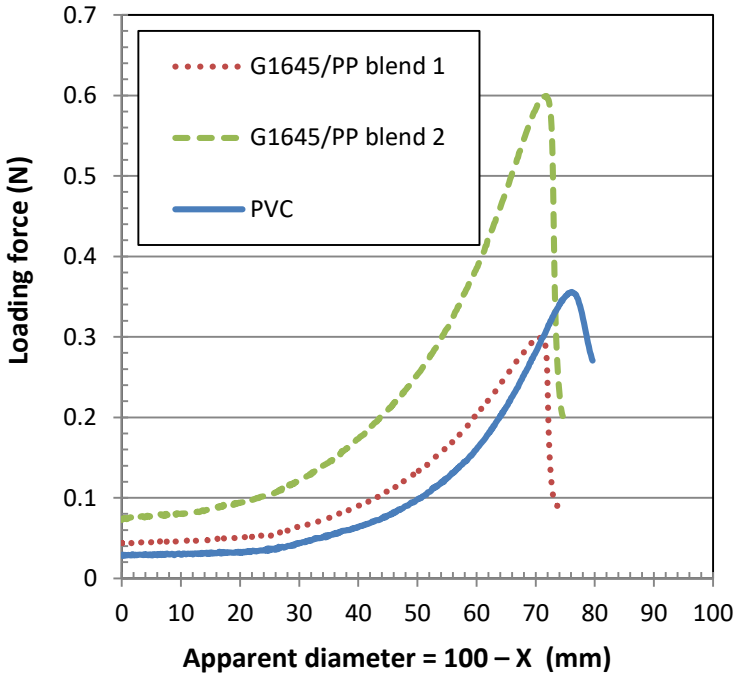
ERS Polymers for Medical Tubing

- Kraton™ ERS polymer RCP blends provide
  - Transparency
  - Good kink resistance
  - Flexibility without addition of phthalate plasticizers
  - USP class VI and ISO10993 biocompatibility
- Recommended Grades
  - G1645, G1642, G1643, MD1646
- MD1646 provides
  - Lower processing temperature
  - Improved color and clarity
  - Easier post processing handling



Kink Resistance Measurement





Internally developed kink resistance test method to measure tubing kink force and apparent diameter at kink point.

Medical Tubing – Kink Resistance

	MD1646VO/RCPP			G1645MO/RCPP		
	60/40	70/30	80/20	60/40	70/30	80/20
Melt Flow (g/10 min)*	17.9	17.3	16.3	8.3	6.8	5.4
Hardness (Shore A)	84	77	64	86	76	65
Haze (%)	13	10	7	16	15	9
Tubing OD (mm)	4.05	4.00	4.07	4.05	4.05	4.05
Tubing wall thickness (mm)	0.53	0.55	0.53	0.53	0.55	0.52
Kink Force (N)	0.53	0.28	0.18	0.53	0.28	0.17
Apparent Diameter (mm)	28	26	28	28	27	29

* Tested at @230°C 2.16 kg

MD1646VO has similar kink resistance as G1645MO when compounded with RCPP. Blends with MD1646VO have slightly lower haze value.

Summary

- **MD1646VO is a new linear triblock ERS polymer with low molecular weight and low polystyrene content that has**
  - Low hardness
  - Good compatibility with PP
  - High elastic recovery, low hysteresis, good kink resistance
  - Low solution and melt viscosities
- **MD1646 can be used as**
  - PP impact modifier
  - PVC alternative (coated fabric, sheet, film, wire & cable)
  - Medical tubing and medical film
  - TPE compounds

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