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# A New Semi-Crystalline Styrenic Block Copolymer for Elastic Films, Fibers and Compounds

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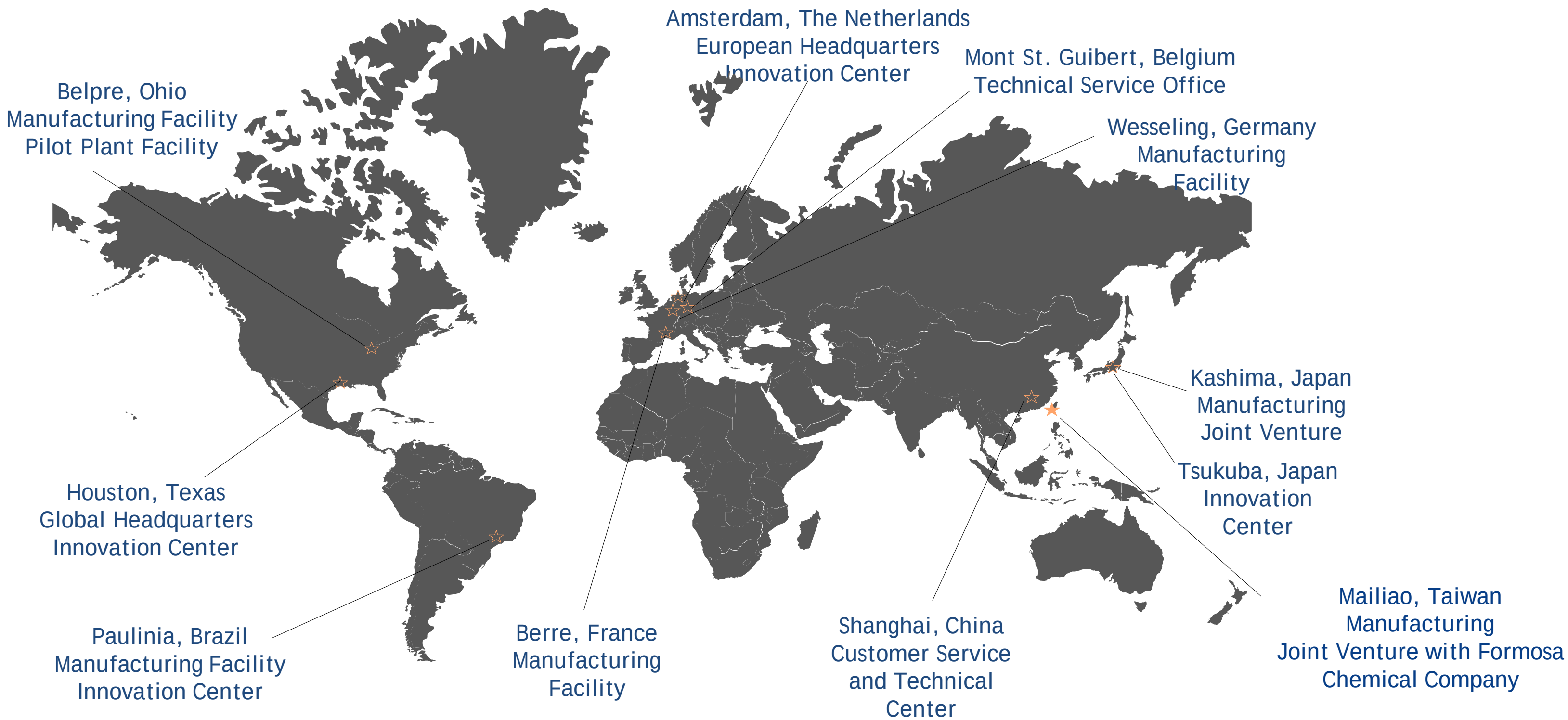
# Kraton Corporation is the SBC Market Leader




- Original inventor of SBC chemistry 50 years ago, with leading market share positions in the end-use markets we serve and helped to create.
  - A leader in anionic polymerization. Designer and manufacturer of custom SBC solutions with the broadest portfolio offering in the industry.
  - Only SBC producer with true worldwide manufacturing footprint (U.S., Europe, South America, Asia Pacific).
  - Unmatched commitment to customer service and R&D, with over 1000 patent applications and granted patents.
- Kraton has a portfolio of recently commercialized products and a pipeline of technologies under commercialization.

# Presentation Outline

- Introduction and polymer descriptions
- Thermal properties
- Rheological properties
- Mechanical properties
- Chemical resistance
- Fiber properties
- Blends with oil and HDPE
- Summary and Conclusions

# Polymer Descriptions

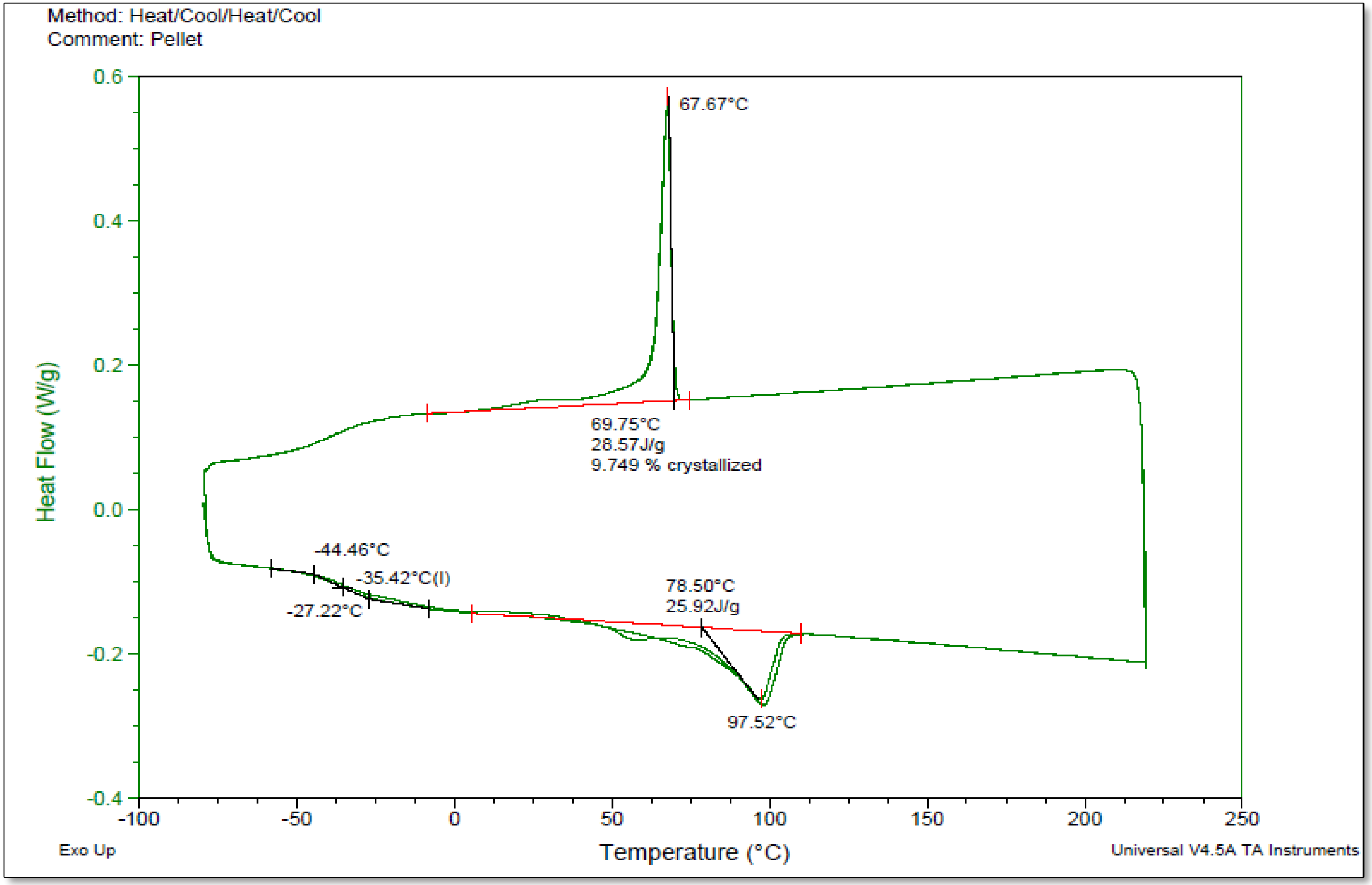
## (SCBC polymers compared to conventional SEBS polymers)

| Polymer/ Property | Molecule Design | MFR (2.16 kg@230ºC) (g/10 min) | Polystyrene Concentration (wt. %) | Diblock Concentration (wt. %) | Shore A Hardness | Polymer Form |
|---|---|---|---|---|---|---|
| G 1652 | SEBS, Normal Vinyl | 2 | 30 | < 10 | 73 | Crumb |
| MD1653 | SEBS Normal Vinyl | 20 - 28 | 30 | <10 | 73 | Dense Pellet |
| SCBC1 | Semi-Crystalline Block Copolymer | 4-6 | 25 | <10 | 63 | Dense Pellet |
| SCBC2 | Semi-Crystalline Block Copolymer | 22-40 | 25 | <10 | - | Dense Pellet |

- SCBC polymers are made using conventional anionic chemistry.
- SCBC polymers are triblock copolymers with polyethylene crystallinity.
- Like olefin block copolymers, the PE crystallinity acts as the anchor for the elastic blocks.

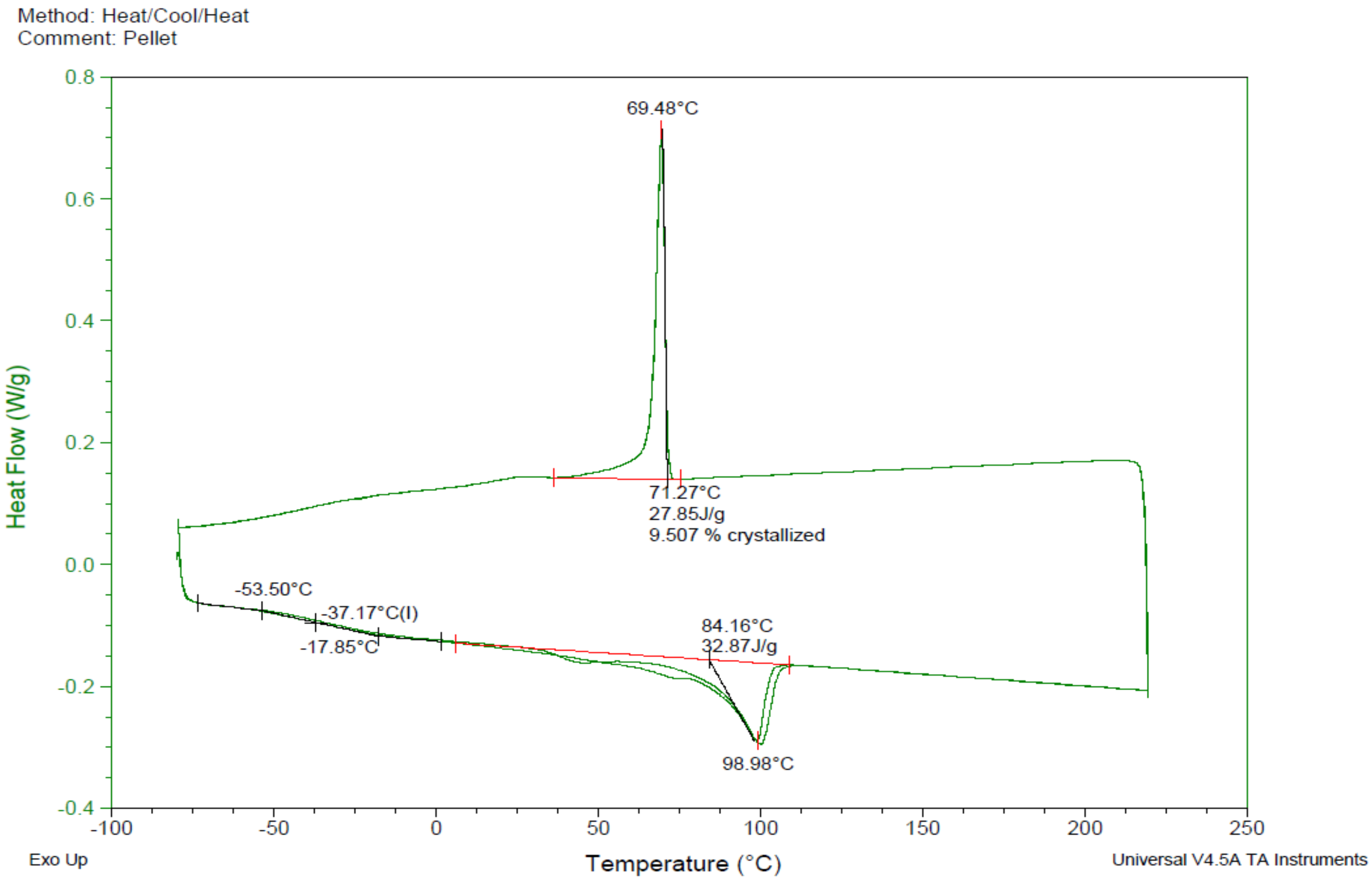
# SCBC1 DSC

(Distinct crystalline melting peak and crystallization peak, higher mid-block Tg than conventional SEBS polymers)



# SCBC2 DSC

(lower molecular weight than SCBC1, similar thermal transitions to SCBC1)

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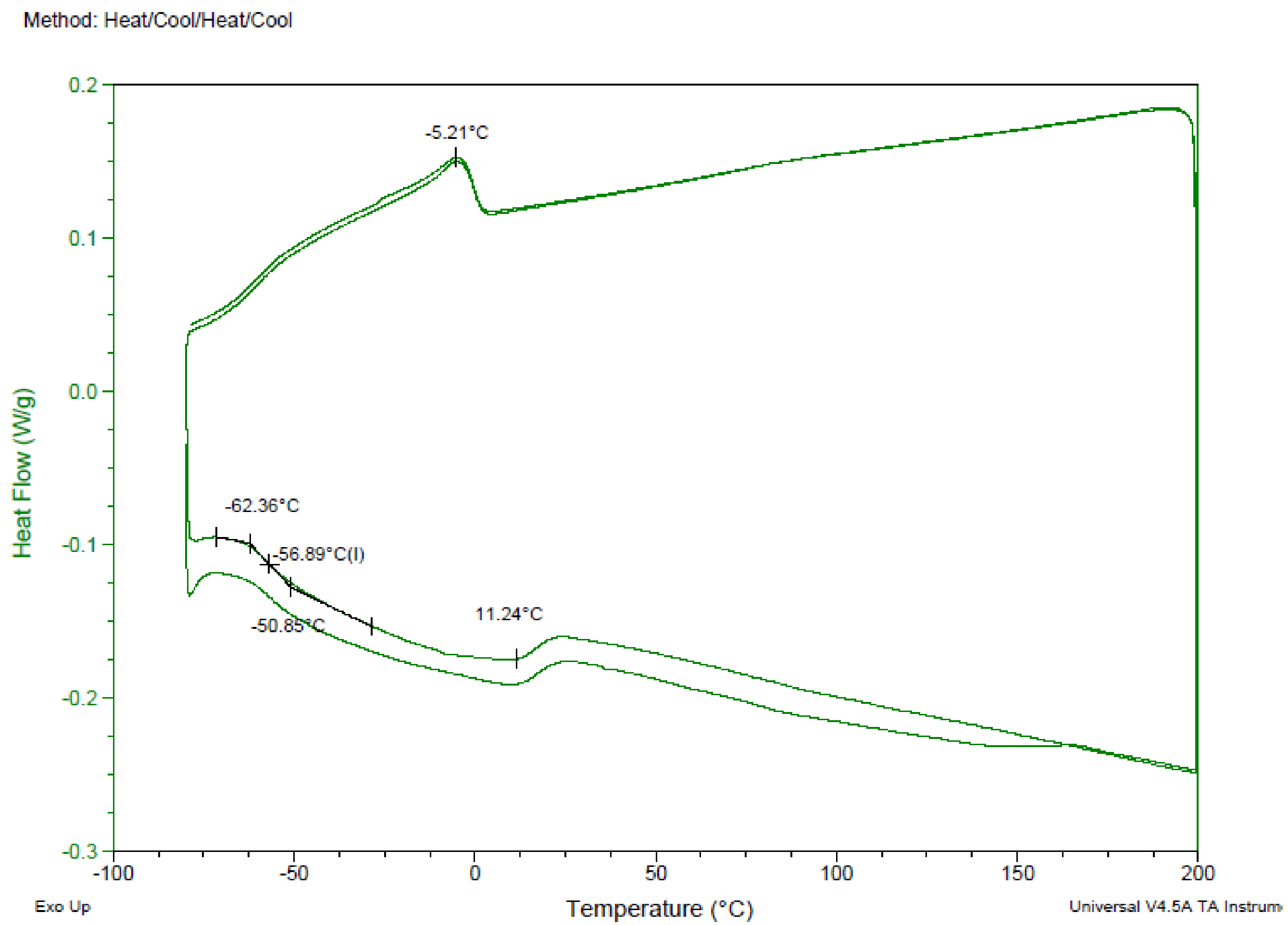
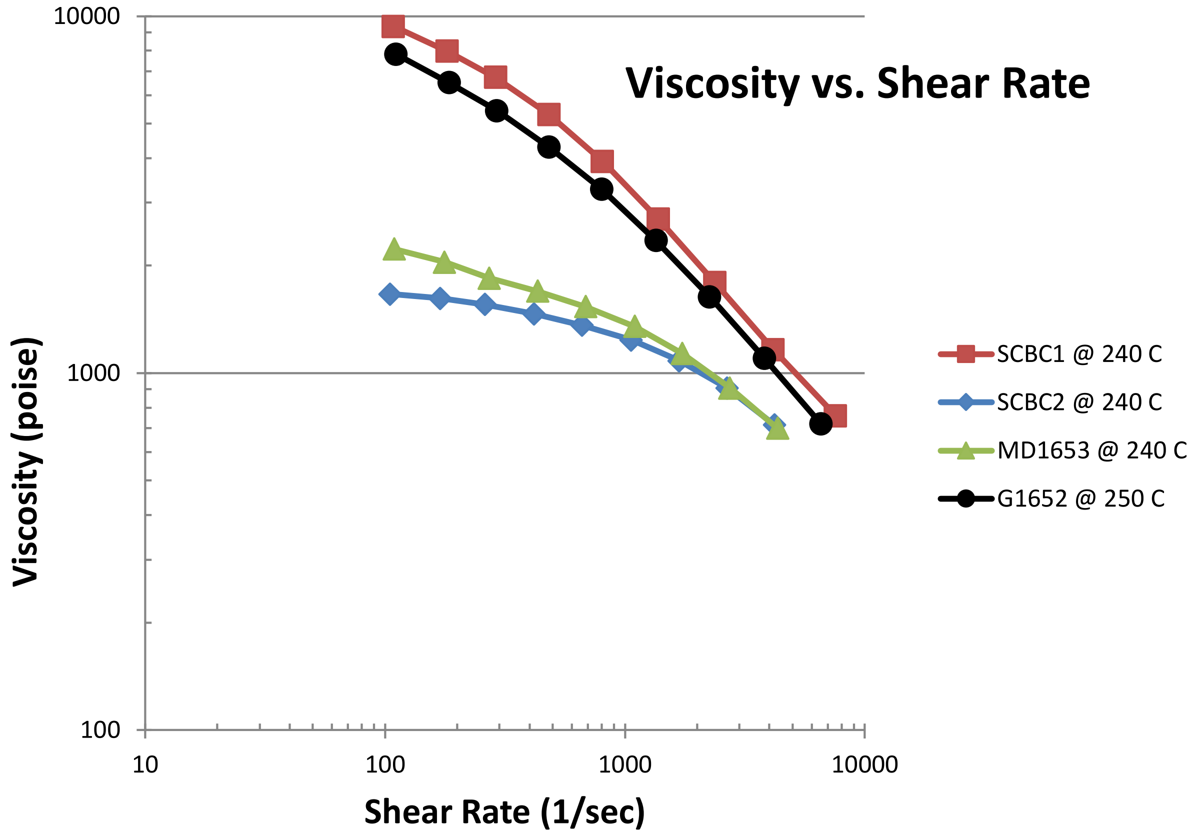
# G1652 DSC

(A typical SEBS DSC scan; some crystallinity, low melting point and crystallization temperature, very broad peaks)



# Rheology

(SCBC polymer rheology compared to conventional SEBS polymer rheology, similar viscosity to shear rate response, very narrow MWD compared to polyolefins)



# Cast Film Tensile Properties

## (A comparison to conventional SEBS polymers)

| Polymers | MD1653 | | G1652 | | SCBC1 | | SCBC2 | |
|---|---|---|---|---|---|---|---|---|
| Film Direction/Property | MD | TD | MD | TD | MD | TD | MD | TD |
| 100% Modulus, MPa | 2.7 | 2.6 | 4.9 | 1.6 | 3 | 2.7 | 3.1 | 3 |
| 300% Modulus, MPa | 6.6 | 5.8 | 8.4 | 3.6 | 6 | 5.4 | 6 | 5.7 |
| 500% Modulus, MPa | 31 | 23 | 17 | 11 | 11 | 9.7 | 7.3 | 7.1 |
| Ultimate Stress, MPa | 40 | 38 | 42 | 37 | 19 | 20 | 8.3 | 7.9 |
| Strain at Break, % | 560 | 620 | 760 | 770 | 610 | 640 | 760 | 770 |

- Equivalent modulus (up to 300% strain) to 30 % styrene SEBS polymers
- High strain at break and reasonable tensile strength.
- The tensile strength is dependent on the molecular weight.

# Cast Film Elastic Properties

## (100 % Strain Hysteresis Test)

| Polymers | MD1653 | | G1652 | | SCBC1 | | SCBC2 | |
|---|---|---|---|---|---|---|---|---|
| **Film Direction/Property** | **MD** | **TD** | **MD** | **TD** | **MD** | **TD** | **MD** | **TD** |
| **50% Modulus load, MPa** | 2.2 | 2.1 | 3.7 | 1.4 | 2.1 | 2 | 2.2 | 2.1 |
| **50 % Modulus unload, MPa** | 1.2 | 1.1 | 1.7 | 1.1 | 1.6 | 1.5 | 1.7 | 1.6 |
| **Tensile Set, %** | 16 | 14 | 11 | 4 | 5.7 | 7.7 | 6.6 | 7.2 |
| **Recovered Energy, %** | 52 | 52 | 44 | 82 | 82 | 82 | 78 | 78 |

- SCBC polymers are very elastic up to 100 % strain.
- The cylindrical polystyrene domain morphology adversely affects the elasticity of 30 % styrene SEBS polymers. They are still used in many elastic compounds.

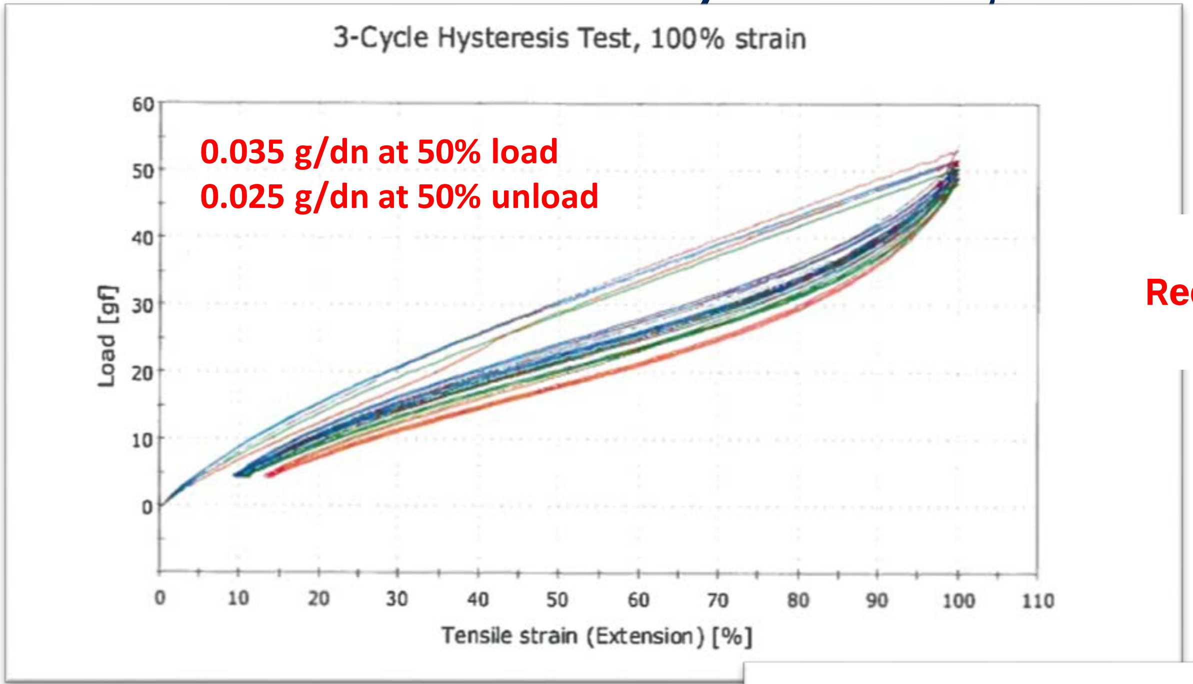
# Chemical Resistance

(SCBC organic solvent and oil resistance compared to a high styrene Kraton A polymer)

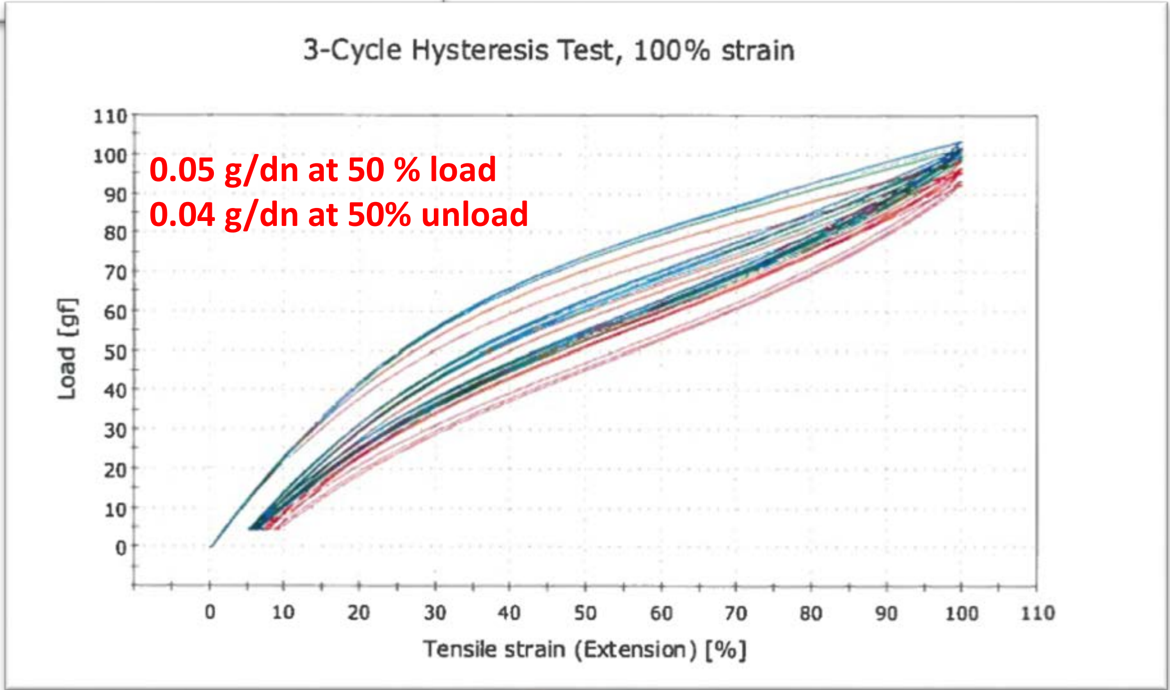
| Test/Polymer (at room temperature) | SCBC1 | A1536 (high styrene) |
|---|---|---|
| **Swell in Cyclohexane (% @8 hr.)** | 80 | Dissolved |
| **Insoluble in Cyclohexane (%)** | >99 | 0 |
| **Swell in Toluene (% @8 hr.)** | 100 | Dissolved |
| **Swell in Paraffinic Oil (% @1week/2 week)** | 15/25 | 30/45 |

- Kraton A polymers (A1536) have a controlled distribution of styrene in the midblock.
- Kraton A polymers are more resistant to oil absorption than conventional SEBS polymers.
- The SCBC polymers are more resistant to organic solvents and oil than Kraton A polymers and conventional SEBS polymers.

# 100 % Hysteresis, Elastic Yarns




Spandex Hysteresis at 100 % Strain
**Recovered Energy: 65%, Tensile Set:14.7%**
**(850 dn Yarn)**




SCBC1 Hysteresis at 100% Strain,
Recovered Energy: 77%, Tensile Set: 7.4 %
(1353 dn Yarn)

- Yarns spun at Hills Research
- A future trial is planned with the high melt flow grade (SCBC2)

# SCBC Compounds with Oil and HDPE

- In traditional SBC compounds, oil is used to break up crystallinity in the mid-block and to manipulate the domain structure of the end-block. Homopolymer polystyrene is used to reinforce the end-blocks and increase the modulus of the compound.
- A similar approach was taken for the SCBC compounds except HDPE was used in place of polystyrene. This approach could be useful for elastic packaging and injection molding applications.
- The compounds were made using a Berstorff 25 mm co-rotating, fully intermeshing, twin screw extruder.
- The polymers (SCBC1 and Dow Chemical DMDA 8007 HDPE) were dry blended prior to extrusion.
- The oil (Nyflex 222B) was pre-blended with the polymer crumb.
- The compounds were pelletized using a Gala underwater pelletizer.

# SCBC Compounds*(HDPE and Oil Blends)

| Ingredients/weight % | Blend A | Blend B | Blend C |
|---|---|---|---|
| **SCBC1** | 65 | 60 | 55 |
| **HDPE (**DMDA 8007) | 10 | 15 | 20 |
| **Oil (**Nyflex 222B) | 25 | 25 | 25 |

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* For injection molding a packaging applications

# Cast Film Properties (HDPE and Oil Blends*)

## (Tensile properties and 100 % Strain Hysteresis Test, ½ inch wide strip)

Increasing SCBC1 Concentration ←

Increasing HDPE Concentration →

| Compounds and Polymer | SCBC1 (control) | | Blend A | | Blend B | | Blend C | |
|---|---|---|---|---|---|---|---|---|
| **Film Direction/Property** | **MD** | **TD** | **MD** | **TD** | **MD** | **TD** | **MD** | **TD** |
| **100 % Modulus, MPa** | 3 | 3 | 2.4 | 2 | 3 | 2.4 | 4.1 | 2.6 |
| **300 % Modulus, MPa** | 6 | 5.7 | 4 | 4 | 4.5 | 4.7 | 5.4 | 5.2 |
| **Ultimate Stress, MPa** | 28 | 27 | 20 | 16 | 22 | 17 | 22 | 14 |
| **Strain at Break, %** | 760 | 780 | 1210 | 1050 | 1200 | 1010 | 1080 | 880 |
| **Recovered Energy, %** | 78 | 76 | 54 | 67 | 38 | 66 | 27 | 68 |
| **Tensile Set, %** | 6 | 8 | 16 | 10 | 22 | 9 | 31 | 8 |

- Modulus increases with increasing HDPE concentration.
- Tensile strength decreases and the strain at break increases with the addition of HDPE.
- Elasticity in the machine direction decreases with increasing HDPE.
- Good elasticity in the transverse direction.



* For injection molding and packaging applications

# Summary and Conclusions

- A new semi-crystalline block copolymer is being evaluated.
- The new polymer is elastic and strong and has good compatibility with polyethylene.
- SCBC polymers have good resistance to oil and organic solvents.
- Elastic yarns, fibers and nonwovens are possible with the new SCBC polymers.
- Oil and HDPE can be used to reduce cost and to "tune" the performance of SCBC polymers for packaging and injection molding applications.
- Future work with SCBC2 in fine fibers is being planned.
- SCBC polymers are in the commercial assessment phase at Kraton and are available in small pilot plant quantities for evaluation: contact Lana Culbert at 713-724-3646, lana.culbert@kraton.com

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