# A Unique Compounding Ingredient, the Key to

# Higher Hardness Better Processing Rubber Compounds


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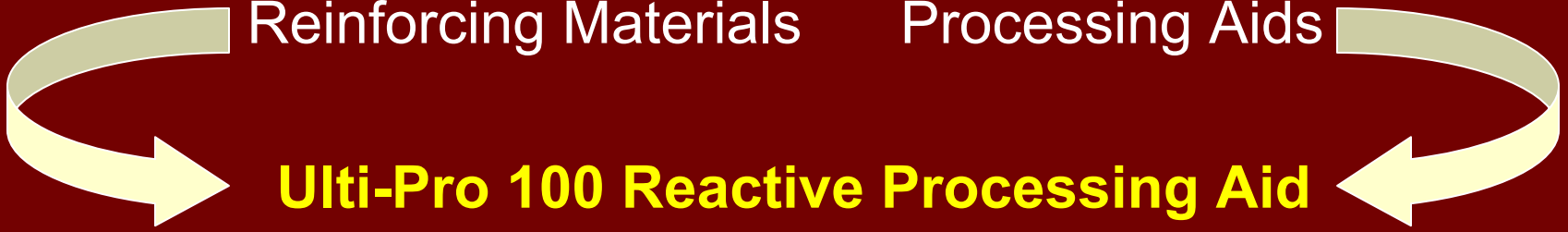
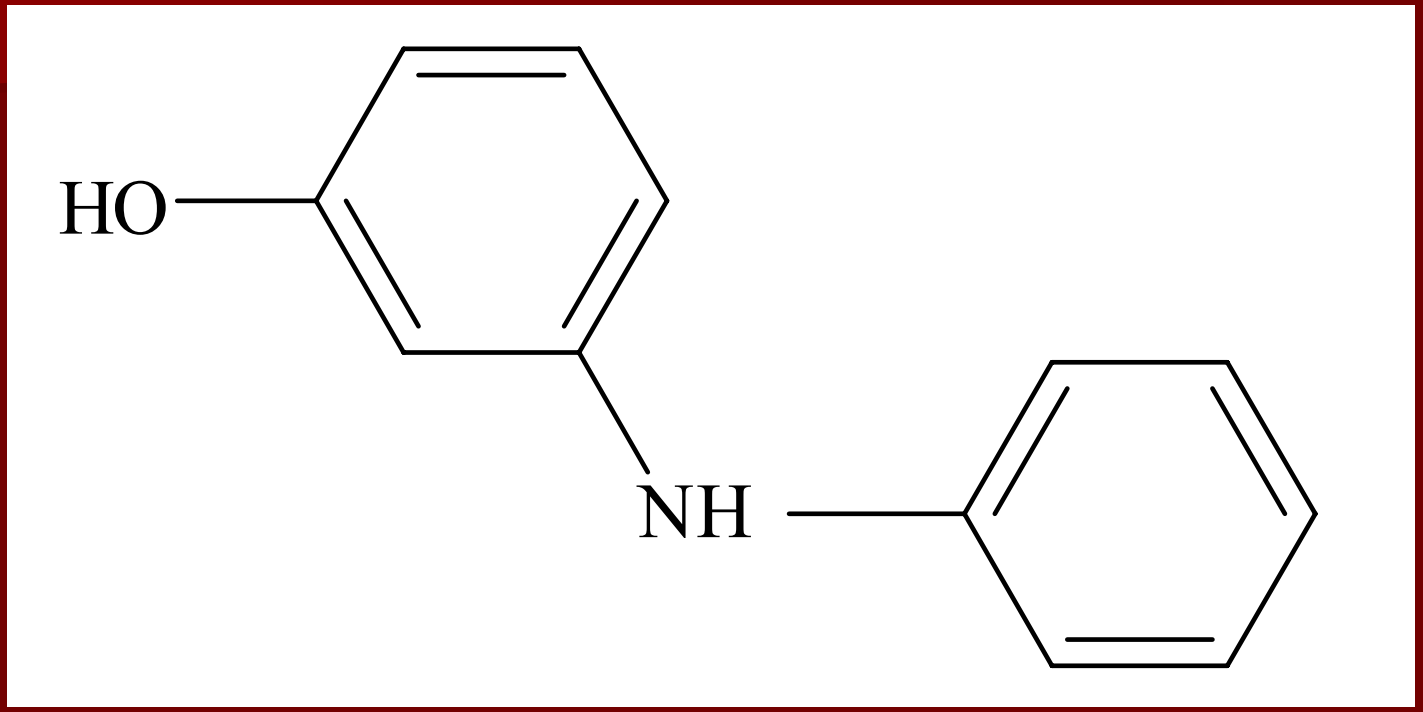
# Outline:

- Chemistry of Ulti-Pro® 100 Reactive Processing Aid
- Current Technology:




- Examples using Ulti-Pro 100
  - NR/SBR apex (beadfiller) compound
  - SBR/BR tread compound

# Chemistry of Ulti-Pro 100




| | | |
|---|---|---|
| Melt Point | 80°C | U.S. Patent 6,541,551 |
| Formula Weight | 185 | EP 1,358,262 |

# Current Technology

| | Manufacturer | Chemical Composition |
|---|---|---|
| Epolene™ N34W | Eastman Chemical Co. | Low MW polyethylene |
| LIR 30 | Kuraray Co. Ltd. | Liquid polyisoprene |
| Pliolite® S6H | Eliokem, Inc. | High styrene SBR resin |
| SP6701 | Schenectady International | Phenolic resin |
| Struktol® WB-212 | Struktol Co. of America | Fatty acid emulsion |
| Sundex® 790T | Sunoco | Aromatic Oil |
| Vestenamer® 8012 | Degussa Corporation | Trans-polyoctenamer |
| Ulti-Pro® 100 | INDSPEC Chemical Corp. | M-hydroxydiphenylamine |

**As control compounds the following were also considered:**

+ 10 phr carbon black
- 10 phr carbon black

| | Control | Control -10 Black | Control +10 Black |
|---|---|---|---|
| **1st Mix Stage, Internal Mixer** | | | |
| SIR-20 Natural Rubber | 100 phr | 100 | 100 |
| N-330 Carbon Black | 70 | 60 | 80 |
| TMQ | 2 | 2 | 2 |
| Zinc Oxide | 5 | 5 | 5 |
| Stearic Acid | 2 | 2 | 2 |
| | | | |
| **2nd Mix Stage, 2 Roll Mill** | Remill | Remill | Remill |
| | | | |
| **3rd Mix Stage, 2 Roll Mill** | | | |
| Insoluble Sulfur | 2.5 | 2.5 | 2.5 |
| MBS | 1.5 | 1.5 | 1.5 |
| **Total Parts** | **183.0** | **173.0** | **193.0** |

## Added at a 3 part level:

| | |
|---|---|
| •Epolene™ N34W | Low MW polyethylene |
| •Struktol® WB-212 | Fatty acid emulsion |
| •Sundex® 790T | Aromatic Oil |

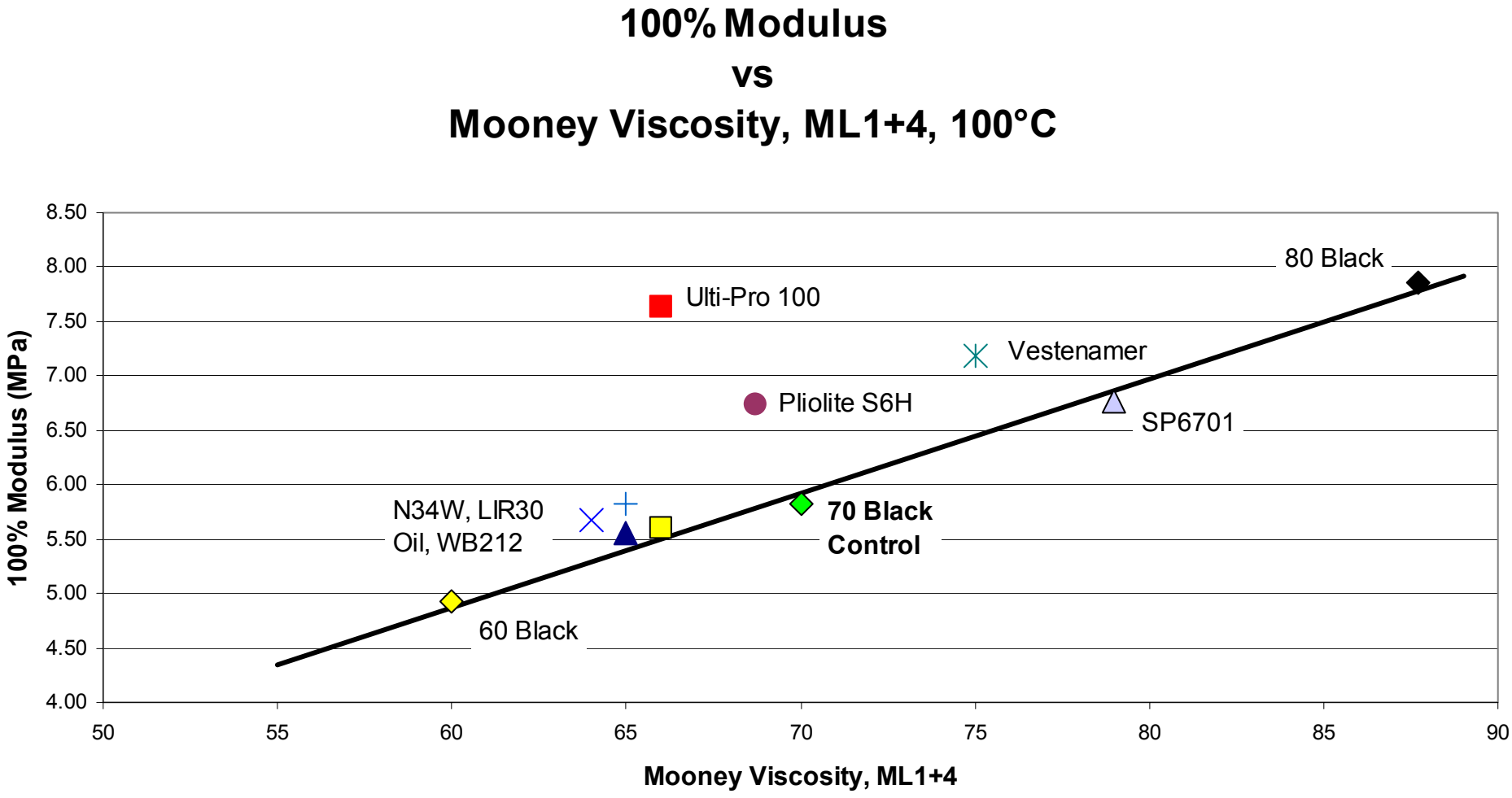
## Added at a 3 part level with Hexamethylenetetramine (HMTA) methylene donor:

| | |
|---|---|
| •SP6701 (with 0.33 HMTA) | Phenolic resin |
| •Ulti-Pro® 100 (with 1 HMTA) | M-hydroxydiphenylamine |

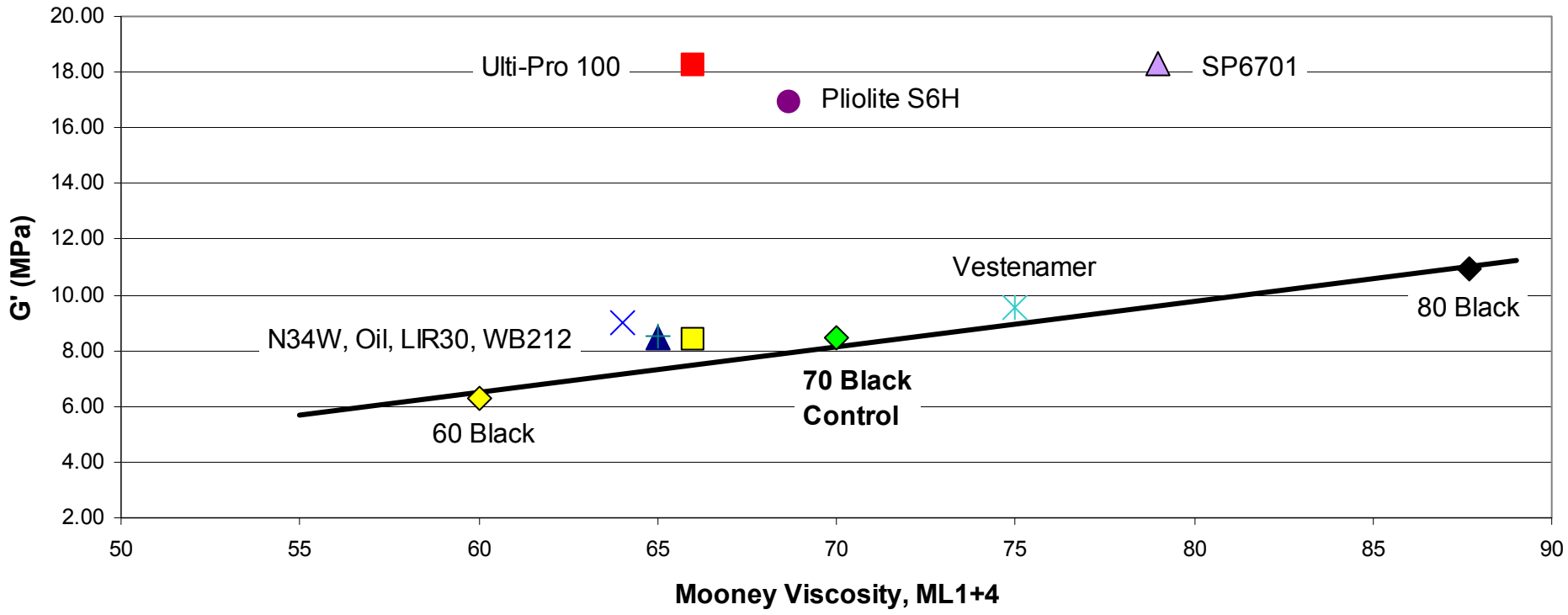
## Added at a 10 part level:

| | |
|---|---|
| •Vestenamer® 8012 | Trans-polyoctenamer |
| •LIR 30 | Liquid polyisoprene |
| •Pliolite® S6H | High styrene SBR resin |

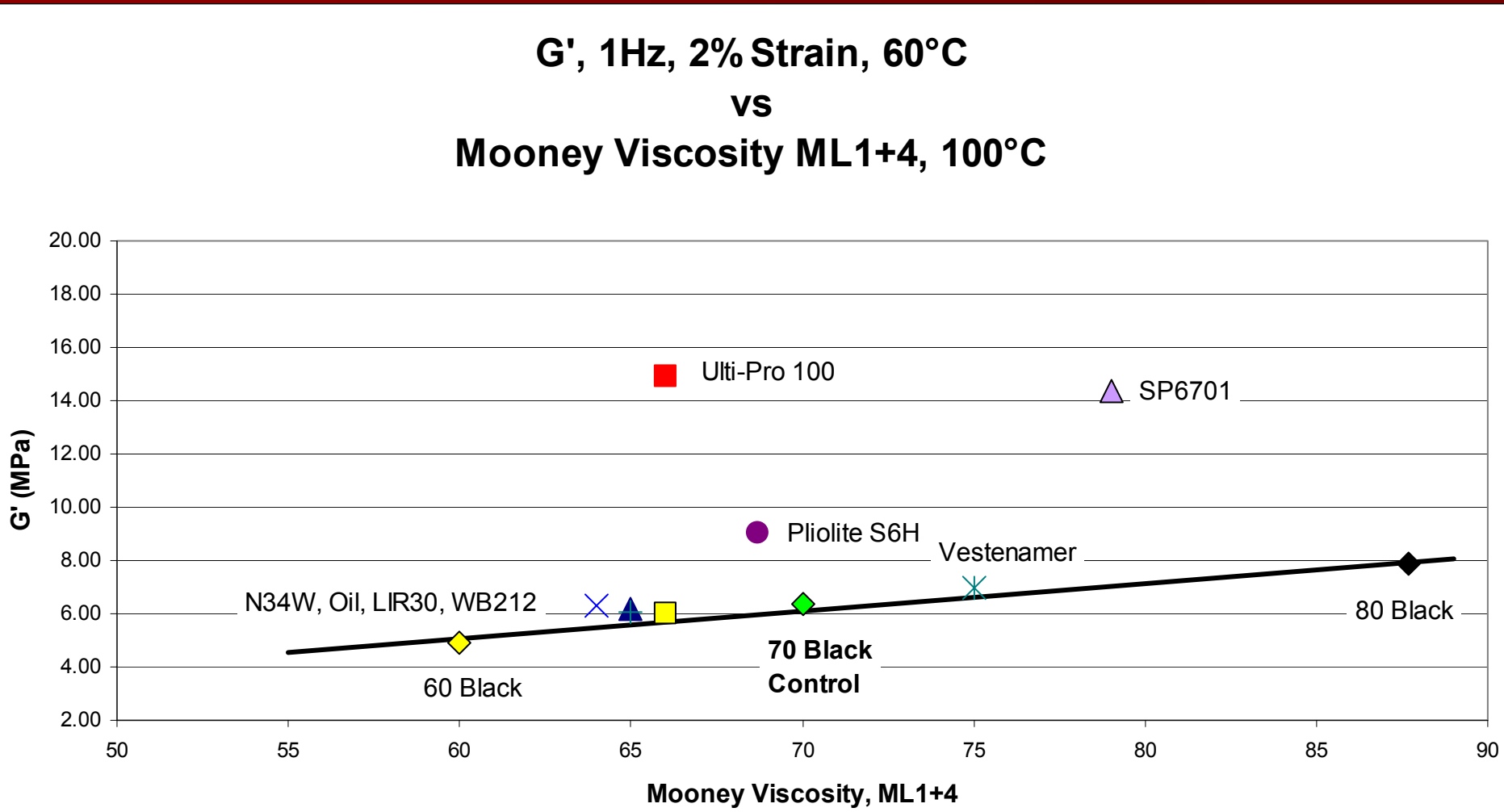
# Tensile Modulus



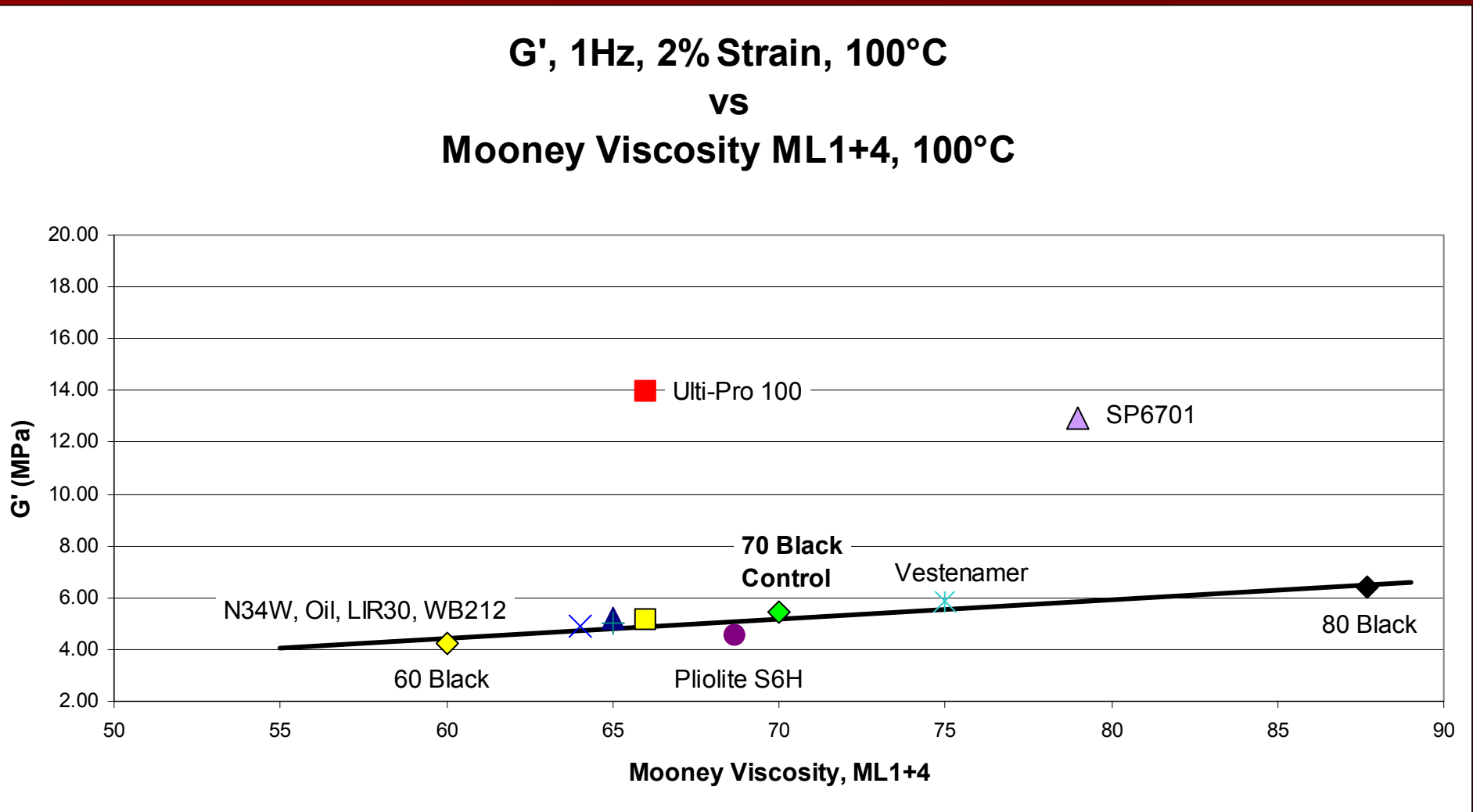
# Dynamic Properties, 23°C



# Dynamic Properties, 60°C



# Dynamic Properties, 100°C



# Only Ulti-Pro 100:

- Reduces the compound Mooney viscosity

# And

- Increases modulus over a wide temperature range.

# Example using Ulti-Pro 100:

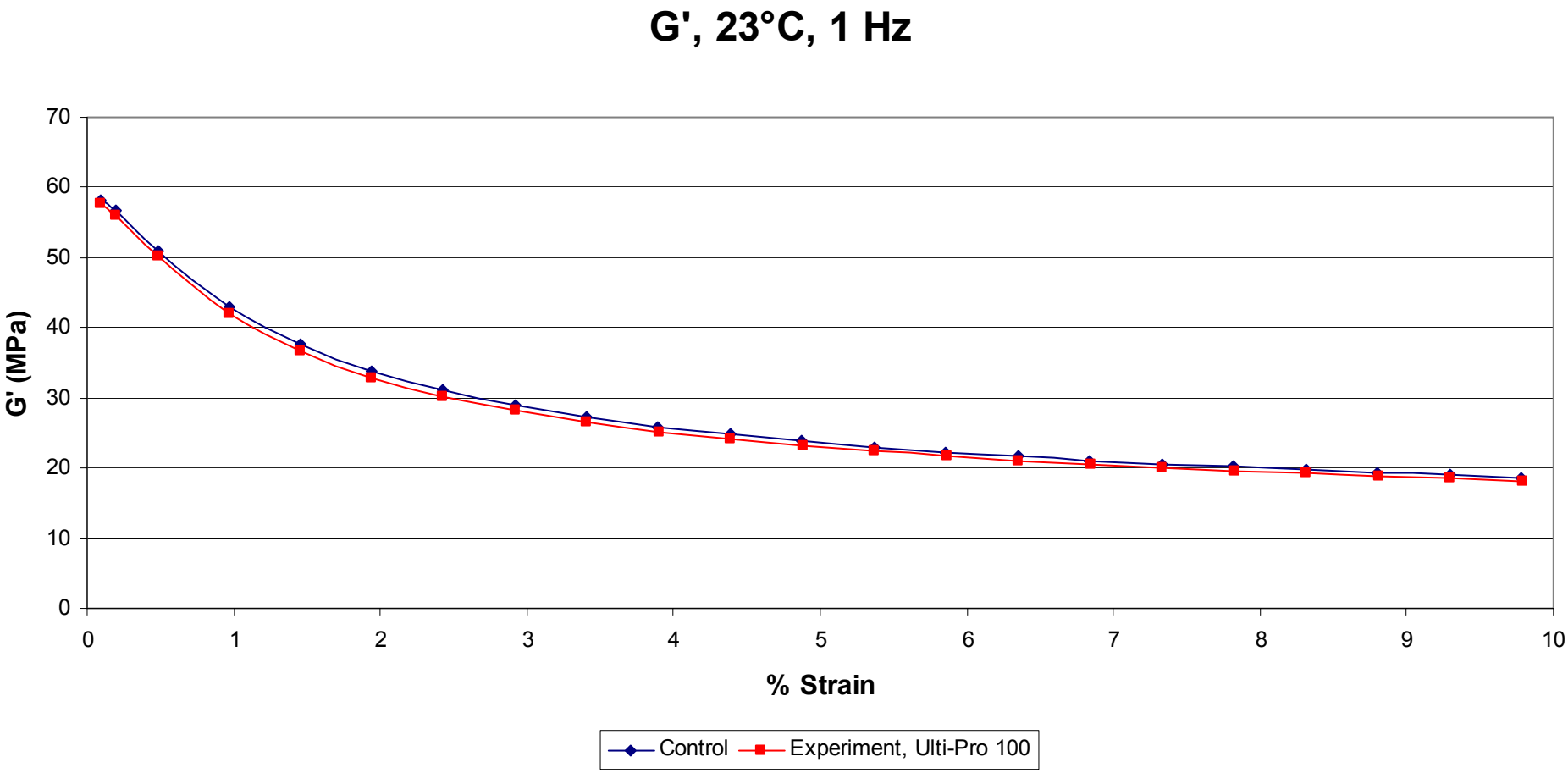
- NR/SBR apex (beadfiller) compound

| | Control | Experiment, 3 phr Ulti-Pro 100 |
|---|---|---|
| **1st Mix Stage, Internal Mixer** | | |
| CV-60 Natural Rubber | 80 phr | 80 |
| SBR 1502 | 20 | 20 |
| N-330 Carbon Black | 70 | 70 |
| Aromatic Oil | 5 | 5 |
| TMQ | 2 | 2 |
| Zinc Oxide | 5 | 5 |
| Stearic Acid | 2 | 2 |
| | | |
| **2nd Mix Stage, 2 Roll Mill** | | |
| **Schenectady SP6701** | **10** | **6** |
| **Ulti-Pro 100** | | **3** |
| | | |
| **3rd Mix Stage, 2 Roll Mill** | | |
| Insoluble Sulfur | 2.5 | 2.5 |
| TBBS | 0.8 | 0.8 |
| **HMMM** | **2.5** | **3.5** |
| CTP | | 0.1 |
| **Total Parts** | **199.8** | **199.9** |

| | Control | Experiment Ulti-Pro 100 |
|---|---|---|
| Mooney Viscosity (100°C) | | |
| $M_{L1+4}$ | 75 | 69 |
| Mooney Scorch (125°C) | | |
| T5, minutes | 20.0 | 17.9 |
| T35, minutes | 27.8 | 26.8 |
| MDR Rheometer Cure (160°C) | | |
| $M_H$, dN-m | 49.89 | 54.76 |
| $M_L$, dN-m | 2.46 | 2.58 |
| $t_S2$, minutes | 2.19 | 2.42 |
| t'50, minutes | 11.41 | 9.45 |
| t'90, minutes | 35.62 | 29.69 |

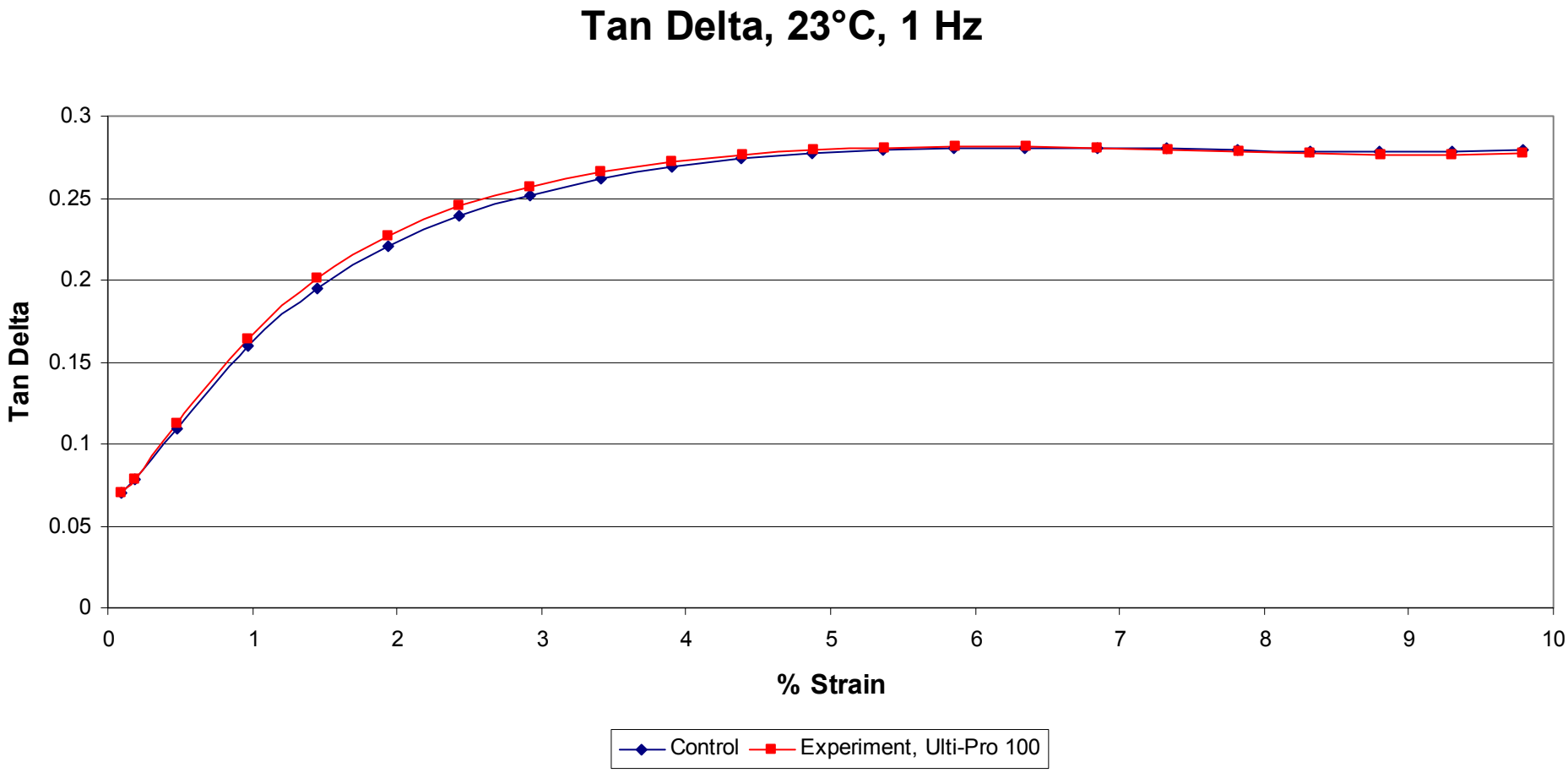
| | Control | Experiment Ulti-Pro 100 |
|---|---|---|
| Shore A Hardness | 94 | 93 |
| Tensile Properties | | |
| 5% Modulus (MPa) | 2.82 | 2.94 |
| 10% Modulus (MPa) | 3.48 | 3.52 |
| 25% Modulus (MPa) | 4.18 | 4.15 |
| 50% Modulus (MPa) | 5.05 | 5.01 |
| 100% Modulus (MPa) | 7.53 | 7.56 |
| 200% Modulus (MPa) | 13.84 | 13.93 |
| 300% Modulus (MPa) | | |
| Tensile Strength (MPa) | 17.1 | 16.9 |
| Elongation (%) | 249 | 244 |
| Energy to Break (N-m) | 10.24 | 10.24 |
| Die C Tear (N/mm) | 59 | 62 |

# Dynamic Properties, 23°C



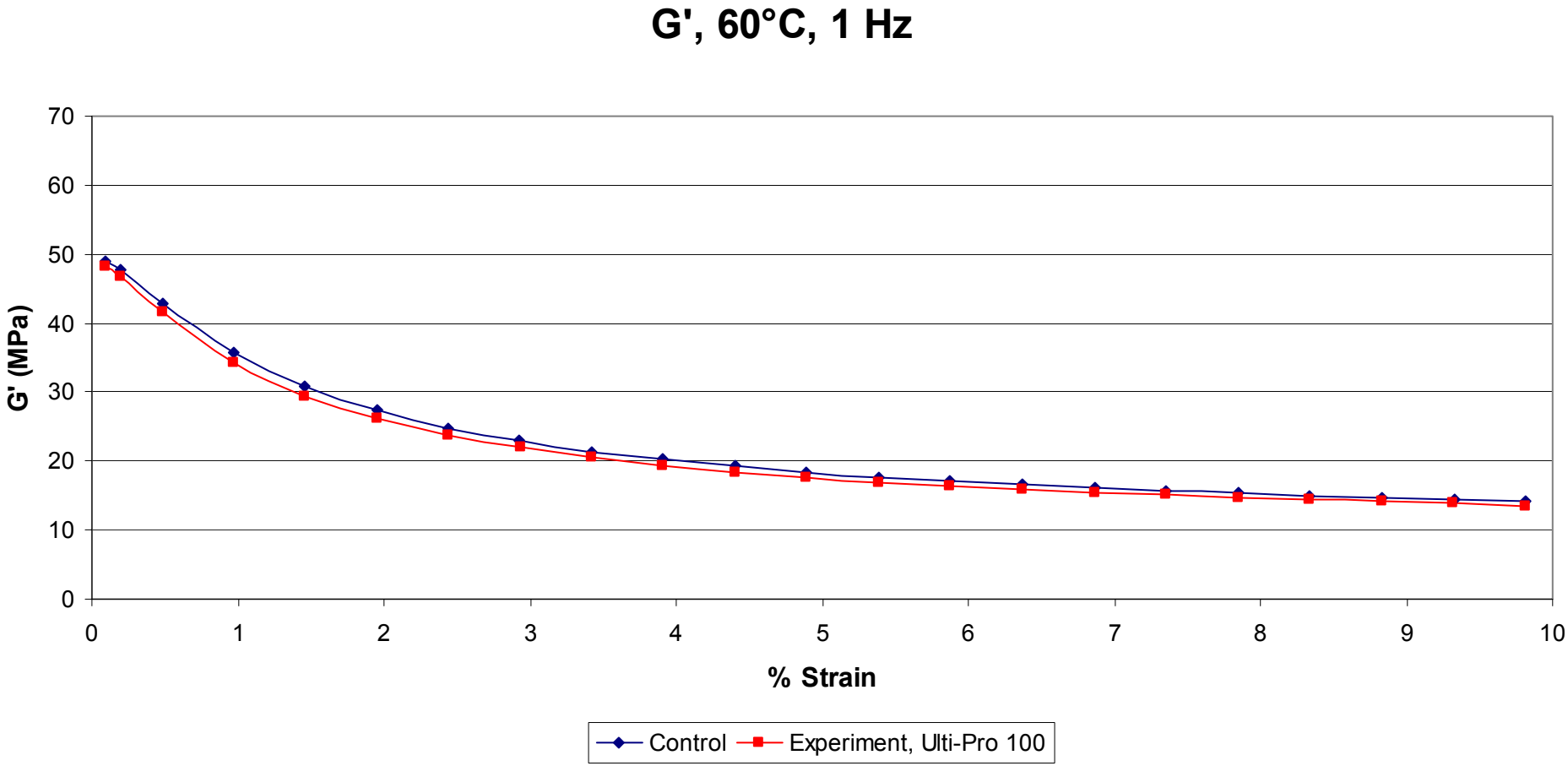

TA Instruments ARES-RDA, Rectangular Specimen, Tested in Torsion

# Dynamic Properties, 23°C



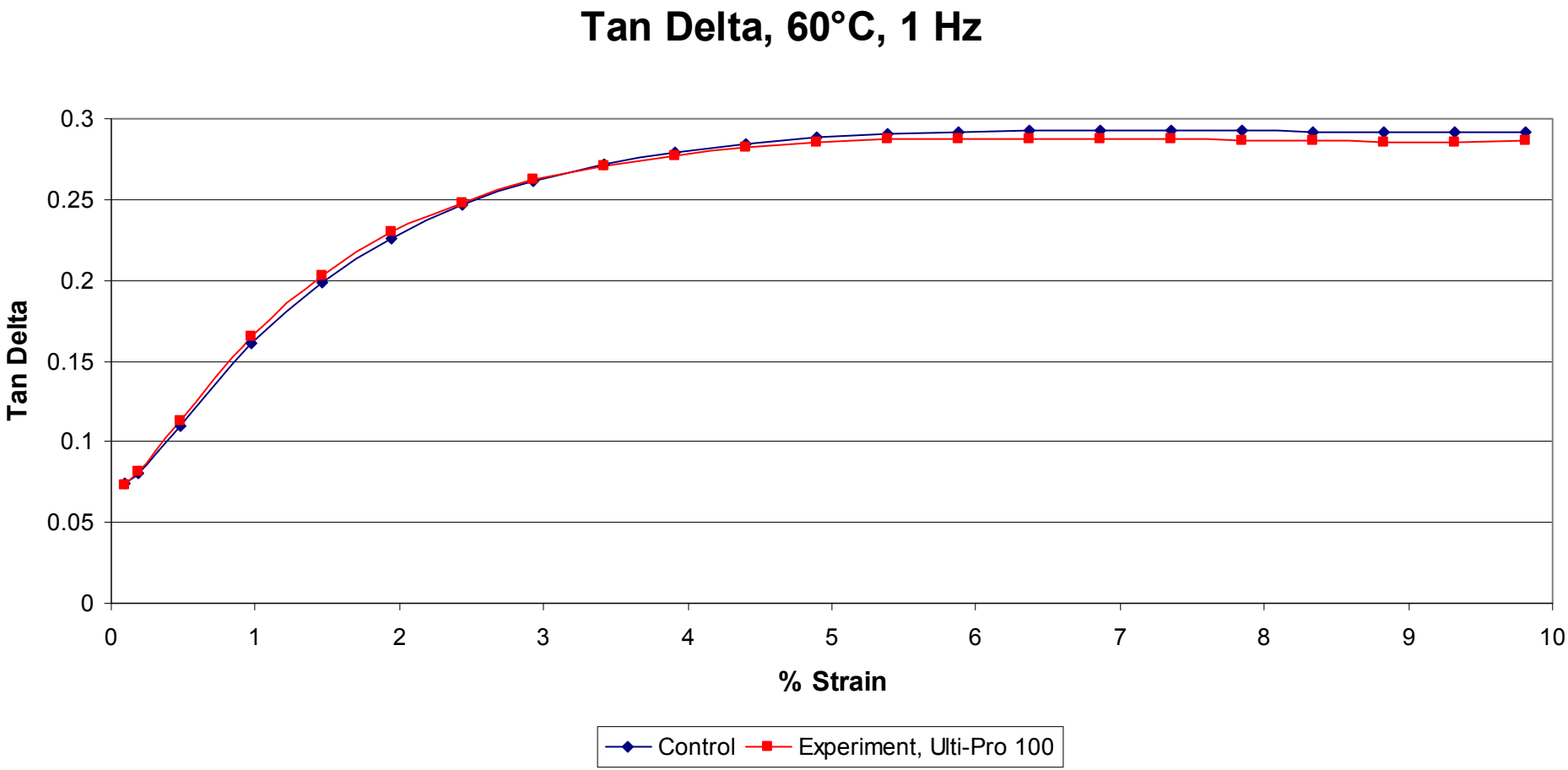

TA Instruments ARES-RDA, Rectangular Specimen, Tested in Torsion

# Dynamic Properties, 60°C




TA Instruments ARES-RDA, Rectangular Specimen, Tested in Torsion

# Dynamic Properties, 60°C




TA Instruments ARES-RDA, Rectangular Specimen, Tested in Torsion

# Conclusions:

In a NR/SBR apex compound, compared to Schenectady SP6701, Ulti-Pro 100:

- Significantly lowered the Mooney viscosity
- Maintained all other properties

# Example using Ulti-Pro 100:

- SBR/BR tread compound

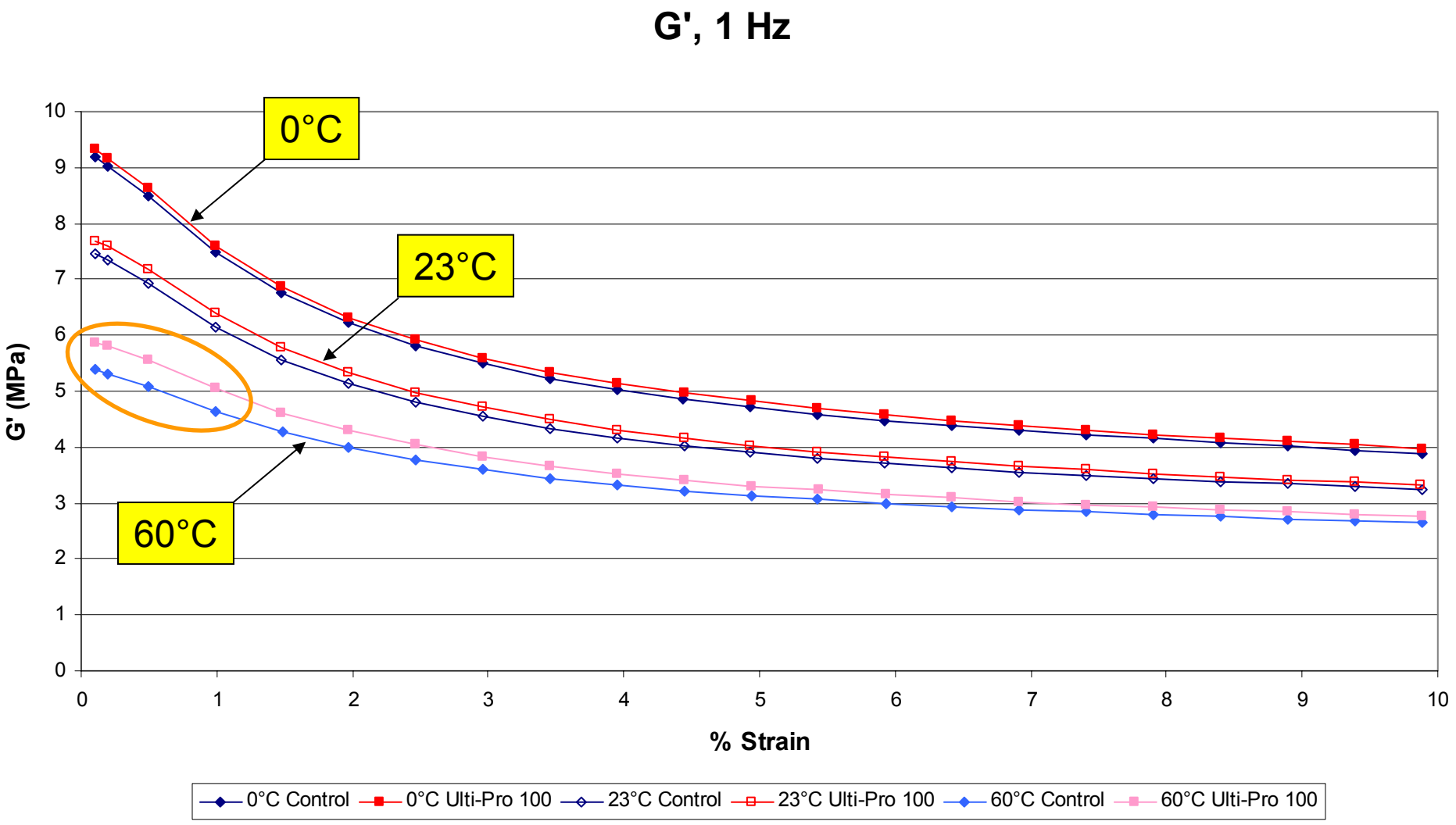
| | Control | Experiment, 1.5 phr Ulti-Pro 100 |
|---|---|---|
| **1st Mix Stage, Internal Mixer** | | |
| SBR 1712 | 96.25 phr | 96.25 phr |
| Taktene 1203 BR | 30 | 30 |
| N-234 Carbon Black | 50 | 50 |
| 6PPD | 1 | 1 |
| Zinc Oxide | 3 | 3 |
| Stearic Acid | 2 | 2 |
| Wax | 1 | 1 |
| | | |
| **2nd Mix Stage, 2 Roll Mill** | Remill | Remill |
| | | |
| **3rd Mix Stage, 2 Roll Mill** | | |
| Insoluble Sulfur | 2.0 | 2.0 |
| TBBS | 1.8 | 1.8 |
| **Durez 13355** | **3** | |
| **Ulti-Pro 100** | | **1.5** |
| **HMTA** | | **0.5** |
| CTP | | 0.2 |
| **Total Parts** | **190.05** | **189.25** |

0.8 PHR Reduction

| | Control | Experiment Ulti-Pro 100 |
|---|---|---|
| Mooney Viscosity (100°C) | | |
| $M_{L1+4}$ | 59 | 53 |
| Mooney Scorch (135°C) | | |
| T5, minutes | 26.3 | 28.7 |
| T35, minutes | 32.0 | 35.0 |
| MDR Rheometer Cure (160°C) | | |
| $M_H$, dN-m | 18.92 | 19.77 |
| $M_L$, dN-m | 1.92 | 1.88 |
| $t_S2$, minutes | 5.92 | 6.84 |
| t'50, minutes | 7.75 | 8.16 |
| t'90, minutes | 12.28 | 12.35 |

| | Control | Experiment Ulti-Pro 100 |
|---|---|---|
| Shore A Hardness | 65 | 66 |
| Tensile Properties | | |
| 5% Modulus (MPa) | 0.45 | 0.47 |
| 10% Modulus (MPa) | 0.64 | 0.65 |
| 25% Modulus (MPa) | 0.98 | 0.98 |
| 50% Modulus (MPa) | 1.34 | 1.34 |
| 100% Modulus (MPa) | 2.10 | 2.11 |
| 200% Modulus (MPa) | 5.30 | 5.25 |
| 300% Modulus (MPa) | 10.42 | 10.17 |
| Tensile Strength (MPa) | 17.3 | 18.0 |
| Elongation (%) | 420 | 441 |
| Energy to Break (N-m) | 11.96 | 13.04 |
| Die C Tear (N/mm) | 47 | 48 |

# Dynamic Properties




TA Instruments ARES-RDA, Rectangular Specimen, Tested in Torsion

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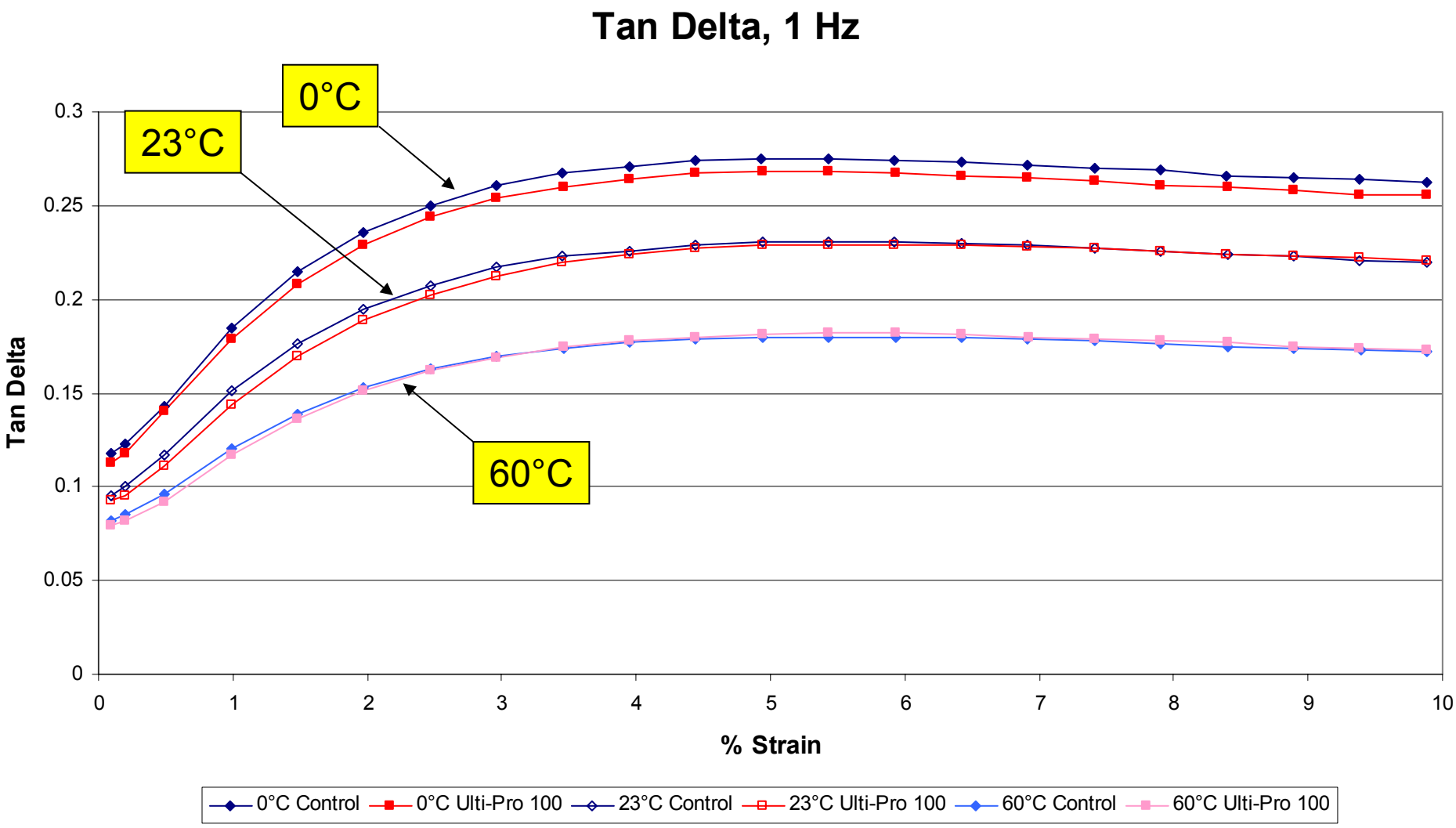


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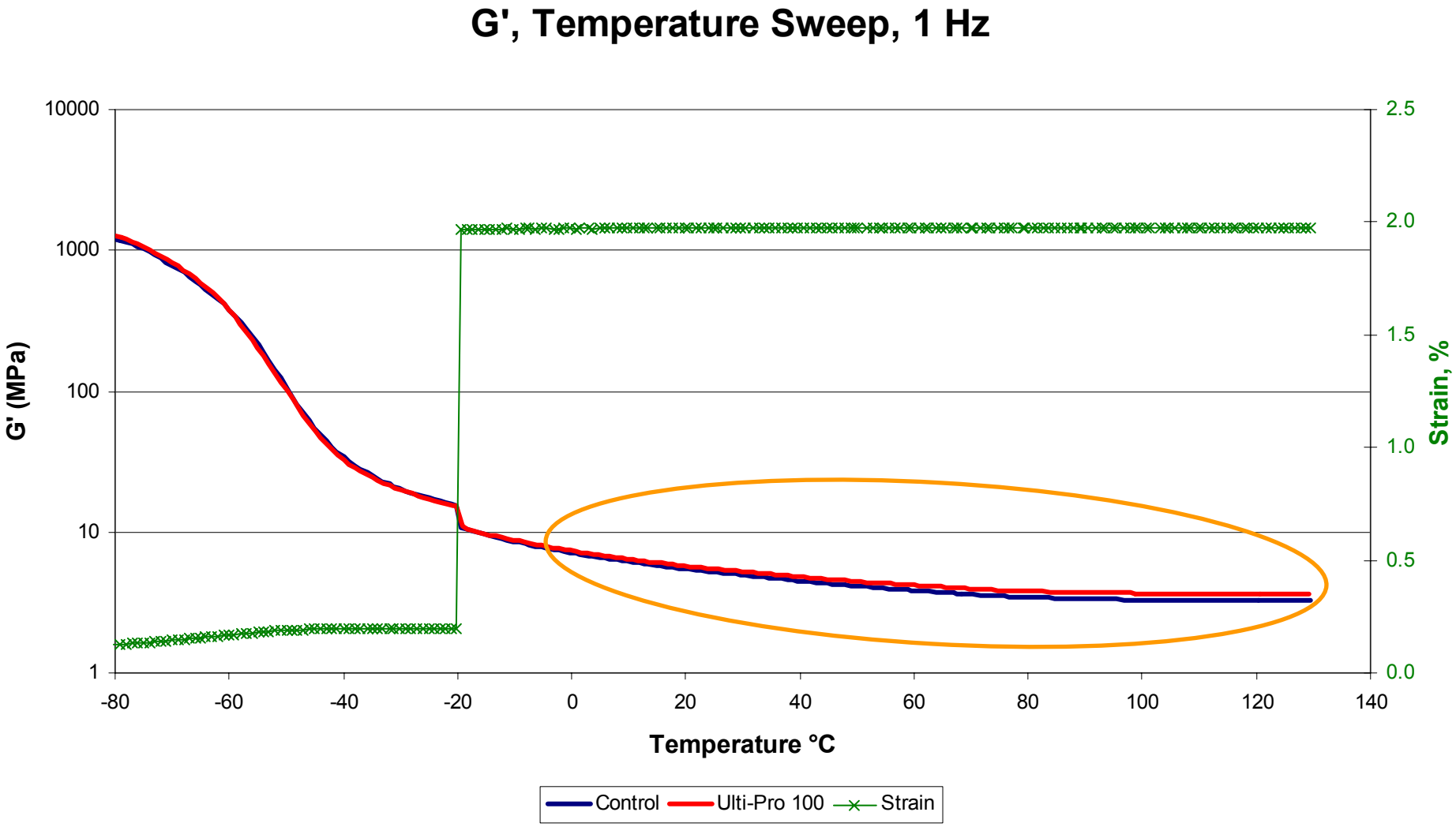


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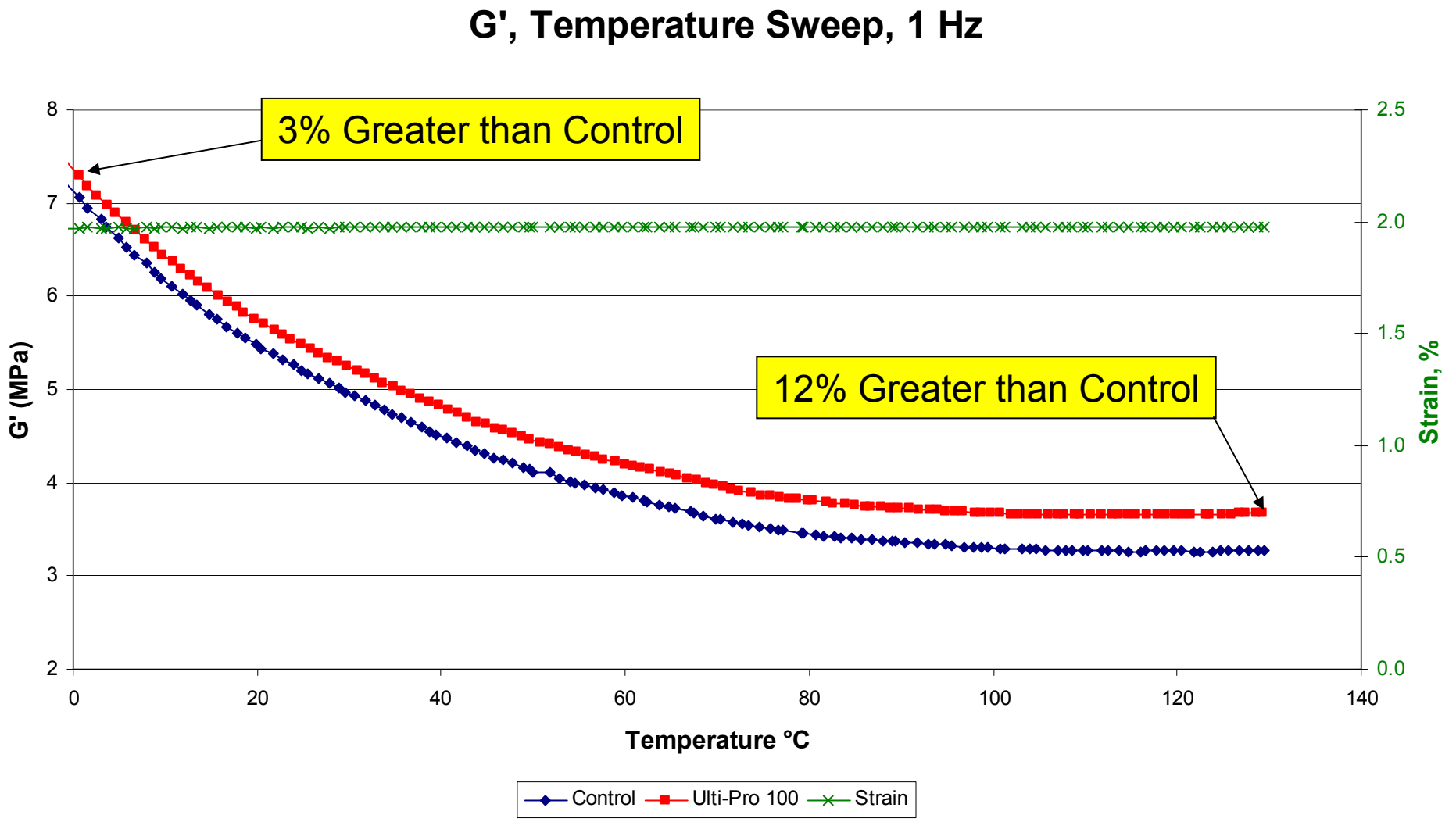


TA Instruments ARES-RDA, Rectangular Specimen, Tested in Torsion

# Conclusions:

In an SBR/BR tread compound, compared to Durez 13355, Ulti-Pro 100:

- Significantly lowered the Mooney viscosity
- Produced greater modulus at high temperature
- Reduced the material usage by 0.8 phr

# Ulti-Pro 100 Reactive Processing Aid:

- Lowers compound viscosity
- Increases modulus
- Maintains modulus at high temperature
- Lowers material usage vs. some phenolic resins