MEMORANDUM FOR PRS (In-House Publication)

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Blanski, Rusty; Phillips, Shawn; Lee, Andre, "The Preparation and Properties of Polymer/Nanoparticle Blends Using POSS™" (VuGraphs)

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(Statement A)
The Preparation and Properties of Polymer/Nanoparticle Blends Using POSS™

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POSS/Polymer Blends

• **GOAL**: We are looking to increase the use temperatures of polymers by blending in **Polyhedral Oligosilsesquioxanes (POSS)**

• Several polymers were looked into as candidates for blending: Polyethylene, Polystyrene, Polycarbonate, and Styrene-Butadiene Rubber
- Easier to tailor the organic side groups of the POSS molecule to give a polymer-soluble species
- Simple blending techniques can be used instead of copolymerization with reactive POSS monomers
- Potential Drop-in molecular modifier without requiring expensive replacement of processing equipment
POSS = Polyhedral Oligomeric Silsesquioxane General Synthesis

$$RSiCl_3 + H_2O \rightarrow$$

$R = $ cyclopentyl vinyl

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POSS = Polyhedral Oligomeric Silsesquioxane General Synthesis

\[ \text{Cl}_2\text{Ru}(=\text{CHPh})(\text{PCy}_3)_2 \]

Toluene/Styrene - C\textsubscript{2}H\textsubscript{4}

Styrenyl POSS

\[ \text{H}_2 \text{Pd/C} \]

Phenethyl POSS
POSS = Polyhedral Oligomeric Silsesquioxane General Synthesis

1. Cl₂Ru(=CHPh)(PCy₃)₃
4-Methylpentene, -C₆H₆
2. Pd/C H₂ 500 PSI

4-MP POSS
Preparation of Polymer-POSS Blends

- Traditional Processing
- Place Polystyrene in Extruder
- Add POSS
- Blend 2-5 Minutes
- Use a DACA for small scale (4 g)
Preparation of Polymer-POSS Blends

- **Traditional Processing:**
- **Brabender Mixer**
- Place Polystyrene in Mixer at temperature
- Add POSS
- Blend 5-10 Minutes
- Grind
- Press into disks/extrude/injection mold
Miscibility of POSS

50 wt % Phenethyl$_8$T$_8$ in 2 million mol. wt. Polystyrene

R = Phenethyl

- Demonstrated Complete Miscibility
- Grey domains represent miscible POSS/polystyrene
- Black dots are POSS crystallites (<100 POSS molecules)
- 30% increase in surface hardness observed
# POSS-Polymer Blends

## Selected Data for POSS-Polymer Blends

<table>
<thead>
<tr>
<th>Resin</th>
<th>POSS compound</th>
<th>Processing Temp. °C</th>
<th>Appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polystyrene</td>
<td>Phenethyl₈T₈</td>
<td>177</td>
<td>Clear</td>
</tr>
<tr>
<td>BPA polycarbonate</td>
<td>Phenethyl₈T₈</td>
<td>300</td>
<td>Clear</td>
</tr>
<tr>
<td>SB Rubber</td>
<td>Phenethyl₈T₈</td>
<td>100</td>
<td>Clear</td>
</tr>
<tr>
<td>HDPE</td>
<td>Octyl₈T₈</td>
<td>120</td>
<td>Cloudy</td>
</tr>
<tr>
<td>HDPE</td>
<td>4-MP₈T₈ (2)</td>
<td>120</td>
<td>Cloudy</td>
</tr>
</tbody>
</table>
Addition of POSS into PS

5% Phenethyl8T8 in Chevron PS

No Change in modulus at ambient Temperatures
Small Change in $T_g$ observed
Conclusions

- POSS can be blended and dispersed into many polymers
- The organic side groups on the POSS molecule are extremely important in determining the solubility of the POSS in polymers
- The addition of the more soluble Styrenyl POSS into styrene leads to an increase in surface hardness without adversely affecting polymer properties
- POSS can be thought of as functionalized silicas with the side groups acting as solubility enhancers