POSS® Overview and Applications

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Overview

- What is POSS®?
- POSS® Flow Aids
- Dispersants for Pigments & Fillers
- Pricing and Availability
- POSS® production and safety
- Conclusions
POSS® Molecular Structure

Organic Groups
- Silane (-Si-H)
- Methyl
- Ethyl
- iButyl
- iOctyl
- Phenyl
- Acrylate
- Methacrylate
- Epoxy
- Vinyl
- Fluoroalkyl
- Alcohols
- Amines
- Thiols
- Carboxylic acid
- Sulfonic acid
- PEG/PEO
- etc…
POSS® in Brief

- Molecular filler
- Dissolves
- High stability
- High rigidity
- Customizable
- Reactive versions (epoxy, acrylate etc.)
- Safe
- Scaled-up and cost-effective
- Flow aids, dispersants, friction reduction etc.

Hybrid Plastics™
POSS® is a **unique** hybrid organic-inorganic composition.
What can POSS® do for you?

- Packaging
- Medical & Dental
- Mechanical
- Oil & Gas
- Semiconductors
- Wire & Cable
- Aerospace
- Optical
- Sports & Leisure
POSS® Flow Aids
Flow Enhancement in PPO/PPE

5% POSS in PPO/PPE

MFI Increase

POSS Type

170% 196% 348% 183% 83% 75% 59% 0% 50% 100% 150% 200% 250% 300% 350% 400%

AM0265 AM0270 AM0275 MS0805 MS0825 OL1118 SO1450

MFI Increase

POSS Type

100% 150% 200% 250% 300% 350% 400%

AM0265 AM0270 AM0275 MS0805 MS0825 OL1118 SO1450

Hybrid Plastics™

US 6, 759,460 & US 2004/0138355 Asahi Chemical
POSS® Flow in PPO / PPE

Neat PPO - translucent

PPO with silicone - opaque

PPO with POSS - transparent, less color

Flow Enhancement in COC with POSS®

Increasing Melt Flow
with POSS® Masterbatch

<table>
<thead>
<tr>
<th>Amount of POSS® Flow Masterbatch</th>
<th>Increase in MFI (%)</th>
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<tbody>
<tr>
<td>10%</td>
<td>37</td>
</tr>
<tr>
<td>25%</td>
<td>156</td>
</tr>
<tr>
<td>50%</td>
<td>467</td>
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260°C 2.16kg Topas® 6013 MFI 9g / 10min
POSS® Enhanced Cyclic Olefin Copolymer

- POSS® needed to mold thin-walled part
- Weight reduction (30%) compared to GF/FR PP
- Retained mechanical & thermal performance
- Improved anti-icing
- Reduced dust build-up
- Increased operating temperature range
POSS® Flow PA6 Masterbatch

Increasing Melt Flow with POSS® Masterbatch

<table>
<thead>
<tr>
<th>Amount of POSS® Flow Masterbatch</th>
<th>Increase in MFI (%)</th>
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</thead>
<tbody>
<tr>
<td>10%</td>
<td>26</td>
</tr>
<tr>
<td>20%</td>
<td>55</td>
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</tbody>
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POSS® Flow PEEK Masterbatch

Increasing Melt Flow with POSS® Masterbatch

- 10% POSS®: 27%
- 20% POSS®: 82%
- 50% POSS®: 504%

Decreasing Extruder Torque with POSS® Masterbatch

- 10% POSS®: 17%
- 20% POSS®: 28%
- 50% POSS®: 57%

315°C 5.0kg Vestakeep® 4000P MFI 12g / 10min
POSS® Flow Aids for Complex Parts
POSS® Flow PEI Masterbatch

Increasing Melt Flow with POSS® Masterbatch

- Amount of POSS® Flow Masterbatch:
  - 10%: 15
  - 25%: 46
  - 50%: 154

315°C 5.0kg Ultem® 1000P MFI 13g / 10min
POSS® Flow PPS Masterbatch

Increasing Melt Flow with POSS® Masterbatch

Amount of POSS® Flow Masterbatch

- 10%: 25
- 25%: 74
- 50%: 206

315°C 5.0kg Fortron® 0300 MFI 69g / 10min
POSS® Flow Development Scheme

- **Extruder**
  - Twin Screw Monitor Torque

- **MFI**
  - Repeated Standard Conditions

- **Rheology**
  - Cone / Plate Capillary Injection Molding

- **Quality**
  - Tensile Tests
    - DMA
    - GPC
    - DSC
    - TGA

- **Product Release**
  - Spec Sheet
    - MSDS
  - Pricing

MATERIALS:
- PSulfone
- PES
- PPSU
- PAI
- COC
- PA6
- PEEK
- PPS
- PEI
Why use POSS® Flow Aids?

- Drop in solution
- Enhanced flow / processability
- Enables complex or thin-walled parts
- Facilitates mold-release
- Improve aesthetics (e.g. gloss & color)
- Lower processing temperatures
- Retained mechanical properties
- Wide range of polymers:
  PPO, Nylon 6, COC, PEEK, PPS, PPSU, PEI, and more on the way...
POSS® Trisilanol
POSS® Dispersant Stability

20°C / min under Nitrogen
POSS® Dispersant allows Higher Loadings

Viscosity of Titanium Dioxide Dispersed in Oil

- No Dispersant
- POSS® Dispersant

Viscosity @ 10sec⁻¹
TiO$_2$ with POSS$^\text{®}$ Dispersant in PEEK

TiO$_2$ in PEEK
No Dispersant

TiO$_2$ in PEEK
POSS$^\text{®}$ Dispersant

Greater whiteness & better mechanicals
**POSS® Passivated Y₂O₃ in PEEK**

![Graph showing weight % vs. temperature (°C) for POSS® passivated Y₂O₃ in PEEK compared to neat PEEK and POSS® coating.](image)

- **Without POSS®**
- **With POSS®**
- **POSS® Passivation Coating**
- **Y₂O₃**
- **PEEK**
- **Neat PEEK**
POSS® Dispersants Development Scheme

Screen → Rheology → Process → Quality → Product Release

- Test in oil
- Cone / Plate Heated
- Injection Molding
- Tensile Tests
  - DMA
  - GPC
  - DSC
  - TGA
  - TEM
- Spec Sheet
  - MSDS
  - Pricing

Materials:
- Carbon Black
- Magnetite
- TiC
- BN
- TiO₂
- Y₂O₃
- Gd₂O₃

Hybrid Plastics™
Why use POSS® Dispersants?

- Drop in solution
- Enhanced flow / processability
- Improve aesthetics (e.g. gloss & color)
- Better mechanical properties (impact resistance & elongation to break)
- Thermally stable >400°C
- Wide range of fillers:
  - titanium carbide, boron nitride, yttria, silica, titanium dioxide, calcium carbonate, mica, clay, wollastonite, iron oxides, titanium diboride, bismuth subcarbonate, metal particles, carbon black etc...
POSS® Production & Safety
Several of the larger production volume POSS® types are TSCA listed

**Octaisobutyl POSS® MS0825**
US Category IV  Oral LD50 > 5000 mg/kg

**Octamethyl POSS® MS0830**
EU Testing  Oral LD50 > 2000 mg/kg

**Dodecaphenyl POSS® MS0802**
EU Testing  Oral LD50 > 2000 mg/kg

**Does not** require the risk phrase R22 “Harmful if Swallowed”
Fish testing showed no toxicity
FDA food contact approvals underway
POSS® Pricing

- Capacity in the hundreds of tons per annum
- Standard purity > 97%
- Special purity grades available (low metals, electronics grades)

Order Quantity

Pricing (€/kg)

- 100g
- 10kg
- 1000kg

Hybrid Plastics™
• Founded in 1998
• Spin-off from the Air Force Research Lab at Edwards
• Privately held
• Over 20 years experience in POSS®
• Controls POSS® IP
• Experienced management team and materials / polymer scientists
• Supported by excellent labs and production facilities
Summary

• POSS® additives available neat or in masterbatch concentrate

• New POSS® applications and products arriving all the time

• Hybrid Plastics works closely with customers to develop new products

• Call now!
Thanks to: Joe Lichtenhan, Paul Wheeler, Bruce Fu

Thank you!