AN UPDATE ON HMH NATURAL MINERAL FLAME RETARDANT

Dr. Chris DeArmitt FRSC
- HMH work by Stefan Viering
THE LKAB GROUP IN BRIEF

- World leading producer of upgraded iron ore
- Delivered 25.5 Million MT in 2013, plan to grow to 37 Million MT by 2015
- Two underground mines in Kiruna and Malmberget and open pit mining in Svappavaara
- Producer of 90% of EU’s iron ore
- ~4,400 employees
- 30 companies in 15 countries
  - E.g. Drilling, Concrete, Explosives, Railway, Harbour, Construction.
- Turnover 2013: SEK 23.65 Billion
FOCUS CREATES SPECIALISATION

We focus our R&D resources on mineral and application development in the areas of:

- **Civil Engineering and Construction**
- **Polymers and Coatings**
- **Refractory and Foundry**
MAGNIF – HIGH PURITY MAGNETITE
ROTARY KILN
MAGNETITE ORE

1. Density 5.2 g cm\(^{-3}\)
2. Moh Hardness ~6
3. Semi-conductive
4. Thermally conductive
5. High specific heat capacity
6. Extremely pure

1. Sound deadening, weights
2. Solid surfaces
3. Anti-static, shielding, induction & microwave heatable
4. Lowers cycle time
5. Heat storage
6. Food contact approved
PHLOGOPITE MICA – VHAR REINFORCEMENT
## MINERAL REINFORCEMENTS COMPARED

<table>
<thead>
<tr>
<th>Particle Dimensions (Malvern)</th>
<th>Talc</th>
<th>Calcined Clay</th>
<th>Wollastonite</th>
<th>Phlogopite Mica PW80</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D_{50}$</td>
<td>12</td>
<td>3</td>
<td>3.5</td>
<td>37</td>
</tr>
<tr>
<td>$D_{90}$</td>
<td>40</td>
<td>10</td>
<td>13</td>
<td>95</td>
</tr>
<tr>
<td>Aspect Ratio</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Very High</td>
</tr>
</tbody>
</table>
THE MINERAL

Phlogopite Mica

- Density 2.8 gcm\(^{-3}\)
- Refractive Index 1.60
- Hardness (Mohs) 2.5 – 3
- pH 8 - 9
- Color – pale bronze
- Loss on ignition 1000ºC 1 - 3%
- Composition KMg\(_3\)(AlSi\(_3\)O\(_{10}\)) (OH)\(_2\)
SEM OF PHLOGOPITE MICA PW80

Mag = 2.00 K X  
10μm  
EHT = 5.00 kV  
WD = 12 mm  
Detector = SE2  
Photo No. = 685
## REINFORCEMENT COMPARISON IN PA6

<table>
<thead>
<tr>
<th>Property</th>
<th>Talc 40%</th>
<th>Calcined Clay 40%</th>
<th>Wollastonite 40%</th>
<th>Phlogopite Mica 40%</th>
<th>GF 40%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexural Modulus (MPa)</td>
<td>7400</td>
<td>6120</td>
<td>5514</td>
<td>10370</td>
<td>11980</td>
</tr>
<tr>
<td>Flexural Strength (MPa)</td>
<td>120</td>
<td>150</td>
<td>135</td>
<td>155</td>
<td>290</td>
</tr>
<tr>
<td>Tensile Modulus (MPa)</td>
<td>7470</td>
<td>6313</td>
<td>5450</td>
<td>11160</td>
<td>13215</td>
</tr>
<tr>
<td>Break Stress (MPa)</td>
<td>74</td>
<td>87</td>
<td>83</td>
<td>95</td>
<td>195</td>
</tr>
<tr>
<td>Break Strain (%)</td>
<td>2.8</td>
<td>6.4</td>
<td>8.4</td>
<td>1.7</td>
<td>2.6</td>
</tr>
<tr>
<td>Unnotched Charpy (kJm⁻²)</td>
<td>28.5</td>
<td>80</td>
<td>No Break</td>
<td>29</td>
<td>79</td>
</tr>
<tr>
<td>Notched Charpy (kJm⁻²)</td>
<td>3.5</td>
<td>6.4</td>
<td>6.4</td>
<td>4.0</td>
<td>12.8</td>
</tr>
<tr>
<td>Shrinkage (=) (%)</td>
<td>0.65</td>
<td>1.31</td>
<td>1.06</td>
<td>0.58</td>
<td>0.1</td>
</tr>
<tr>
<td>Shrinkage</td>
<td></td>
<td>(%)</td>
<td>0.97</td>
<td>1.66</td>
<td>1.64</td>
</tr>
<tr>
<td>Warpage (%)</td>
<td>0.32</td>
<td>0.35</td>
<td>0.58</td>
<td>0.29</td>
<td>0.88</td>
</tr>
</tbody>
</table>
CUSTOMER FEEDBACK

“It’s magic”
high performance coatings company

“It blew everything else out of the water”
leading plastics manufacturer

“significantly better than everything else”
Fortune 500 company
ULTRACARB – NATURE’S OWN FLAME RETARDANT
HMH: A BLEND OF TWO MINERALS

**Huntite:**
magnesium calcium carbonate

\[
\text{Mg}_3\text{Ca} (\text{CO}_3)_4 + 1 \text{kJ/g} \\
\rightarrow 3\text{MgO} + \text{CaO} + 4\text{CO}_2
\]

**Hydromagnesite:**
hydrated magnesium carbonate

\[
\text{Mg}_5(\text{CO}_3)_4(\text{OH})_2\cdot4\text{H}_2\text{O} + 1 \text{kJ/g} \\
\rightarrow 5\text{MgO} + 4\text{CO}_2 + 5\text{H}_2\text{O}
\]
THE THREE STAGE FR MECHANISM OF HMH
HYDROMAGNESITE & HUNTITE DECOMPOSITION

![Graph showing the decomposition of Hydromagnesite and Huntite at different temperatures.](image_url)
TOTAL HEAT RELEASE OF HMH AND ATH

Data retrieved from 50kW cone calorimeter
PARTICLE MORPHOLOGY

HMH

Huntite

ATH
## NATURAL HMH VERSUS SYNTHETIC ATH

<table>
<thead>
<tr>
<th></th>
<th>HMH</th>
<th>ATH</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shape</strong></td>
<td>Platy</td>
<td>Spherical</td>
</tr>
<tr>
<td><strong>FR activity range</strong></td>
<td>220°C – 700°C</td>
<td>180°C – 280°C</td>
</tr>
<tr>
<td><strong>Evaporation enthalpy</strong></td>
<td>-1000 kJ/kg</td>
<td>-1000 kJ/kg</td>
</tr>
<tr>
<td><strong>Water release</strong></td>
<td>&gt;220°C</td>
<td>&gt;180°C</td>
</tr>
<tr>
<td><strong>Cementicious char</strong></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Bulk density (at feeding)</strong></td>
<td>0.3g/cm³ (0.3g/cm³)</td>
<td>0.6 g/cm³ (0.4g/cm³)</td>
</tr>
<tr>
<td><strong>BET surface</strong></td>
<td>10m²/g (15m²/g)</td>
<td>4m²/g (7m²/g)</td>
</tr>
<tr>
<td><strong>Processing temperature</strong></td>
<td>&lt;220°C @ 1 bar</td>
<td>&lt;180°C</td>
</tr>
<tr>
<td><strong>High shear kneading</strong></td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
THE FOUR-FLIGHTED BUSS KNEADER

BUSS
MX-Series

excellence in compounding
MX-30 SETUP

FR1  Polymer  Additive  FR2

FR3
KNEADER CONFIGURATION

Screw MX 30 l/d=22
Four-flighted

Screw MKS 30 l/d=20
Three-flighted

Transport Element  Kneading Element  Low shear Kneading El.  Transition Element  Restriction-Ring Element  Reversed Flight Elements  EVI Transport Elements  Kneader Screw Extension for flanged Discharge
EVA + ULTRACARB LH3 + PATH

Ingredients

26.5% Elvax 265 A (EVA)
3.75% Compoline CO/LL (MAH)
6.5% Eltex PF6130 AA (LLDPE)
1.5% Silmaprocess AL 1142A (Processing aid)
0.75% Silmastab AE 1527 (Stabilizer)
30.5% UltraCarb LH3 (oil abs. 25 ml/100g)
30.5% fine pATH (oil abs. 30 ml/100g)

Instructions

Feed polymers, additives and processing aids in the first hopper of a Buss Co-Kneader MX-30, feed the UltraCarb LH3 in port 2, and the ATH in port 3. Let it run at 600 rpm and 15kg/h.

Tensile Strength: 11 MPa
Elongation @ Break: 230%
Dispersion: very good
LOI: 35.5
EVA + ULTRACARB LH3

Ingredients

26.5% Elvax 265 A (EVA)
3.75% Compoline CO/LL (MAH)
6.5% Eltex PF6130 AA (LLDPE)
1.5% Silmaprocess AL 1142A (Processing aid)
0.75% Silmastab AE 1527 (Stabilizer)
61.00% UltraCarb LH3

Instructions

Feed polymers, additives and processing aids in the first hopper of a Buss Co-Kneader MX-30 and split feed the UltraCarb LH3 in port 1+2 and let it run at 600 rpm and 15kg/h. Do not exceed 260°C (750rpm) as the EVA may start to degrade.

Tensile Strength: 13 MPa
Elongation @ Break: 186%
Dispersion: very good
LOI: 34.5
EVA + ULTRACARB LH3 + PLASTOMER

Ingredients
20.0% Elvax 265 A (EVA)
6.5% Lucene LC180 (Plastomer)
3.75% Compoline CO/LL (MAH)
6.5% Eltex PF6130 AA (LLDPE)
1.5% Silmaprocess AL 1142A (Processing aid)
0.75% Silmastab AE 1527 (Stabilizer)
61.00% UltraCarb LH3

Instructions
Feed polymers, additives and processing aids in the first hopper of a Buss Co-Kneader MX-30 and split feed the UltraCarb LH3 in port 1+2 and let it run at 600rpm and 15kg/h.

Tensile Strength: 15 MPa
Elongation @ Break: 276%
Dispersion: very good
LOI: 32.5
CONCLUSIONS

- Mixtures of hydromagnesite and huntite are effective fire retardants proven in use since the 1980s
- Very high aspect ratio phlogopite combines exceptional heat stability, mechanical properties and barrier performance
- Magnetite offers electrical, thermal and radiation properties
- These minerals are 100% natural
- Security of supply and ISO certified
- Cost effective with global logistics
- Assistance to help customers find the best solution
Information herein is intended for guidance only and given in good faith but without guarantee. LKAB Minerals is not responsible for the product’s suitability for a particular purpose. The only warranty LKAB Minerals makes is the express written warranty extended on the sale of its products.

THANK YOU! – QUESTIONS?