Mineral/Microfibrillated cellulose composite materials: Engineered minerals and product forms

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An Imerys and Omya Venture
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Introduction: Mineral/Microfibrillated cellulose (MFC) composites

- MFC: High aspect ratio / surface area utility for increased hydrogen bonding in fibre-based structures, viscosification, reinforcement...
- **Cost effective** grinding-based method to produce mineral/ MFC composites from minerals and cellulose
- Cellulose fibres are co-processed with mineral particles. The mineral particles act as micro-grinding media, thus, reducing the energy requirement
- Process accomplished using **robust, industrially proven grinding equipment**
- **Scalable**
- Commercialised as FiberLean MFC®
- 10,000 dry metric tonnes pa of fibril capacity (40,000 dry metric tonnes of mineral/ MFC composite) operational across three continents. Further capacity under construction
- FDA FCN for food contact paperboard
Introduction: Mineral/Microfibrillated cellulose (MFC) composites

- Processing and handling of mineral/ MFC composites are dominated by the high viscosity of MFC
  - Arises from presence of high surface area hydrophilic fibrils.
  - Typical fibre solids is ~ 1-2%

Photograph (a) and micrograph (b) of mineral/ MFC composite showing the high viscosity and fibrillar structure
Introduction: Fibrils and Fibres

- Structure performance relationships

**Properties**
- Fibril length / width
- Aspect ratio / surface area
- Engineered fibrils
- Microgel-like or discrete
- Surface charge
- Surface hydrophobicity
- Colour
- ... 

**Fibre Sources**
- Wood-free v mechanical
- Kraft v sulphite
- Long fibre v short fibre
- Virgin v recycle
- Tree-based v other biomass
- ... 

**Performance**
- Enhancement of web properties (mechanical, porosity, surface, optical)
- Viscosification/ rheological property modification
- Reinforcement
- Stand-alone objects
- Barrier
- Cost-effectiveness
- Re-use
- ... 

**Applications**
- Paper/ Packaging
- Building materials
- Coatings
- Oil field
- Food and beverage
- Non-wovens
- Composites
- Electrical/ electronic
- ...
Introduction: Minerals

- Structure performance relationships

**Properties**
- Particle size
- Particle shape
- Particle packing
- Crystal microstructure
- Colour
- Reflectance
- Absorbance
- Scattering efficiency
- Refractive index
- Specific gravity
- Hardness
- Chemical composition
- Surface character
- ....

**Performance**
- Opacity
- Clarity
- Gloss
- Density modification
- Wear / abrasion resistance
- Barrier
- Blocking
- Flame retardant
- Mechanical reinforcing
- Chemical delivery/ reaction
- ........

**Applications**
- Paper/ Packaging
- Building materials
- Coatings/ inks
- Oil field
- Food and beverage
- Non-wovens
- Composites
- Electrical/ electronic
- Abrasives
- Filtration
- Ceramics
- ........
There is a variety of mineral sources:

- Calcium Carbonate
- Ground marble/ limestone
- Ground chalk
- Precipitated
- Kaolin
- Hydrous
- Calcine
- Halloysite
- Andalusite
- Ball Clay
- Bauxite
- Bentonite
- Clinoptilolite
- Diatomite

- Dolomite
- Expandable Graphite
- Feldspar
- Fused Alumina
- Fullerenes
- Fused Silica
- Mica
- Natural Graphite
- Perlite
- Specialty Carbon Black
- Synthetic Graphite
- Vermiculite
- Zirconia
- …

Each have their own unique properties and attributes that are utilized in a broad spectrum of applications…
Introduction: Minerals

- Within each source the forms can vary naturally and be engineered
- e.g. Calcium carbonate:
  - Ground and precipitated forms:
    - High level of control over crystal morphology and dimensions
Introduction: Minerals

- Kaolin: Can be engineered for very high shape factor
Introduction: Mineral/fibril composites

- There are a multitude of options available to the formulator...

- The selection of fibre and mineral type, as well as the ratio between them, is tailored for each application.
Recycled Fibres

- Mineral/ MFC composites prepared from mixed office waste and OCC
- Tensile properties at ~ equivalent to/ better than virgin NBSK controls

Mixed office waste feed

Mineral / MFC Composites with Recycled Pulps

50% OCC/ 50% kaolin mineral/ MFC composite (right) and control with NBSK
Applications: Viscosity Modification

- 50% NBSK/50% mineral/MFC composites
- Can control viscosity with choice of mineral shape factor.
- Low shape factor for high solids application
- High shape factor for high viscosity

![Mineral/MFC Composites with High Shape Factor Minerals](chart.png)
Applications: Barrier

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<th>Test</th>
<th>Base</th>
<th>Base + MFC layer</th>
<th>Base + Coating</th>
<th>Base + MFC layer + Coating</th>
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</table>
Applications: Electronics

50% NBSK/50% graphite mineral/MFC composite slurry and sheet

20% NBSK/80% mineral/MFC composite printed electronic substrate
Product forms

- **Slurry** – *Available* supply via satellite plant built on-site
  - Low solids: ~2% MFC fibre solids
  - For trials: delivered in IBC tanks or road tanker
- **Press cake** – *Available* for trials, delivered in IBC bags
  - Medium solids: between ~10-15% MFC fibre solids
- **Pellets** – *Future* supply via merchant plant (*developmental*)
  - High solids: ~37.5% MFC fibre solids (75% total solids)
- Solids content depends on FiberLean® MFC product supplied
Trials and Press Cake re-dispersion

**Slurry**
- **Bottles** (lab trials)
  10 litre (2.65 US Gallon) = 200 g (~8 oz) dry MFC
- **Barrels** (pilot trials)
  220 litre (60 US Gallon) = 4.4 kg (~10 lb) dry MFC
- **IBC Tanks** (pilot & full scale trials)
  1000 litre (265 US Gallon) = 20 kg (~44 lb) dry MFC
- **Trucks/ISO tanks** (full scale trials)
  25 meter³ (6600 US Gallon) = 500 kg (~1100 lb) dry MFC

Largest shipments to date supplied for trials:
- 80 Transitanks = 1600 kg (~3500 lb) dry MFC
- 7 Trucks = 3500 kg (~7700 lb) dry MFC

**Press Cake**
- **IBC Bags** (full scale trials)
  Bag weight ~ 1000 kg (~2200 lb) = 150 kg (~330 lb) dry MFC

Largest shipments to date supplied for trials:
- 292 bags = ~44 tonnes (~48 short tons) of dry MFC

**Make-down Unit**
Re-dispersion from Press Cake to Slurry:
- ✓ Rapid Installation/Pack-up
- ✓ Throughput
- ✓ Quality
- ✓ Safety
Conclusions

- Mineral/MFC composites are produced using a cost-effective, robust process and have proven full-scale availability.
- Mineral/MFC composites can be produced using a wide range of minerals and pulps.
- Variations in the selection of pulp and mineral allow the formulator to select in favour of a wide range of properties.
- Recycled pulp streams can be used.
- We believe that mineral/MFC composites are an important additive for a wide range of applications.
- These mineral/MFC composite materials have been commercialised as FiberLean MFC®.
Thank you!

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