APPLIED MINERALS INC.

DRAGONITE™

Halloysite for reinforcement and processing improvement in polymer foams

AMI - PolymerFoam2012 - October 9th

Dr. Chris DeArmitt - CTO

APPLIED MINERALS INC.

Agenda

- Applied Minerals
- Halloysite structure & properties
- Enhancing plastics
- Case study: Cycle time reduction
- Case study: Injection molded foam
- Case study: Extruded foam
- Commercial aspects
- Conclusions

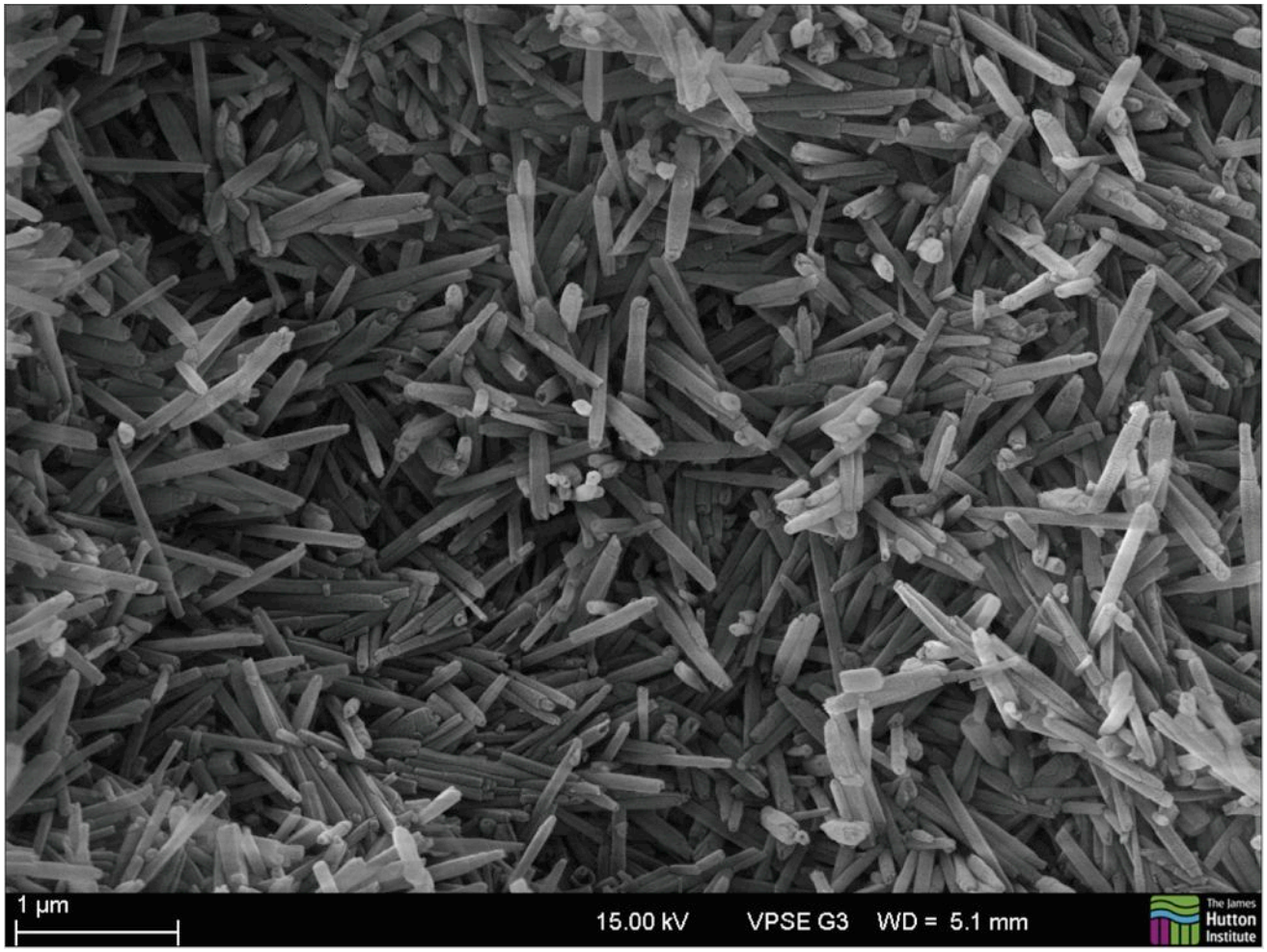
Applied Minerals at a Glance

- US based publicly traded SEC reporting company
- Owner and operator of the Dragon Mine Halloysite Clay Deposit in Utah USA
- Over 30 years of proven reserves
- Product grades marketed under the *Dragonite*™ trade name
- World renowned technical experts in geology, minerals characterization, plastics and materials
- Over $ 7M invested to date in resource characterization and quantification
- Became commercial in 2010 with 30 000 tons annual capacity and expanding significantly in 2012

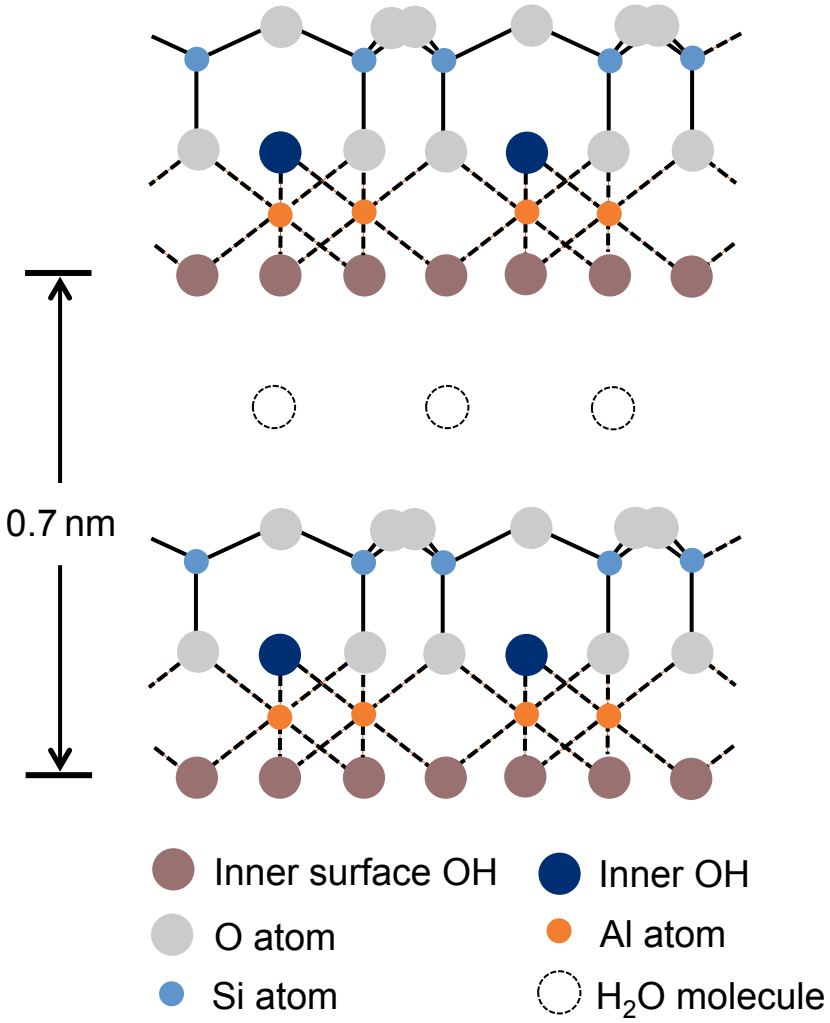
Technology Description - What is Halloysite?

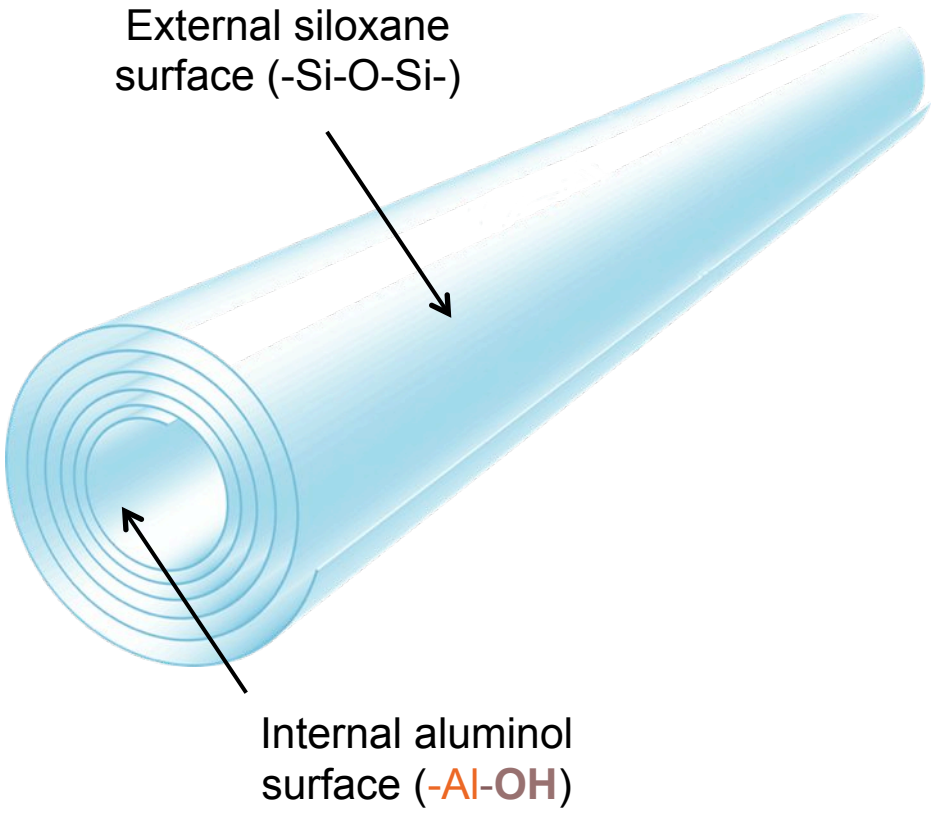
- Halloysite is a natural aluminosilicate clay with a hollow tubular morphology
- Naturally exfoliated morphology means no need to chemically separate particles and makes for easy dispersion
- Halloysite nanotubes typically have diameter ~50nm with lengths ranging from 1 to 2 microns giving an aspect ratio of ~20
- Traditional uses include fine china, fillers in paints and paper, food extenders, catalysts and molecular sieves

Dragonite™ SEM



Dragonite Chemistry





Dragonite™ Intrinsic Properties and Applications

High aspect ratio

- Reinforcement of plastics, elastomers, coatings etc.

High surface area

- Catalysts, adsorbents, carrier, elastomers, immobilization, nucleation of crystal growth and foam cell formation

Hollow

- Controlled release, thermal insulation, light-weighting, wicking, membranes, reverse osmosis

Bound water

- Fire retardance, temperature indicator, foaming agent

Markets Addressed

Plastics

Productivity +20%
Mechanicals +20%
Flame retardance

Coatings

UV cure speed +20%
Mechanicals +20%
Improved adhesion

Environment

Oil clean-up
Soil remediation
Heavy metal sequestration

Elastomers

Reinforcement
Flame retardance
Thermal stability

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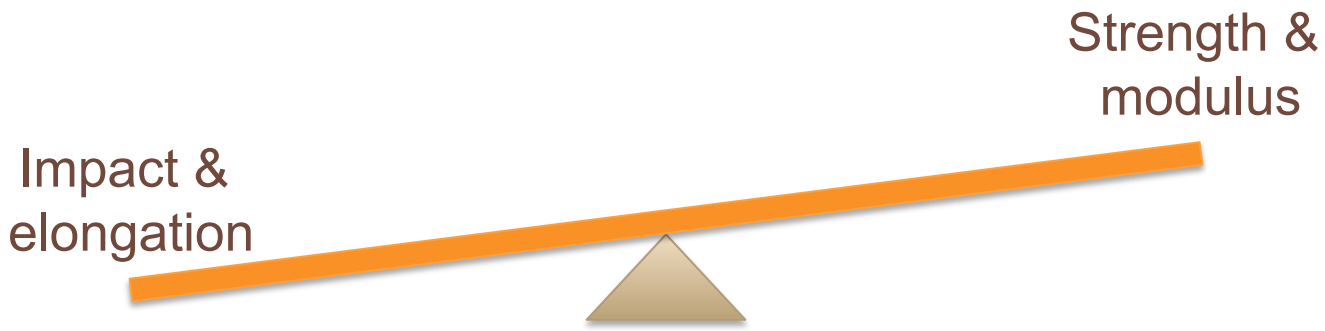
Dragonite in Plastics

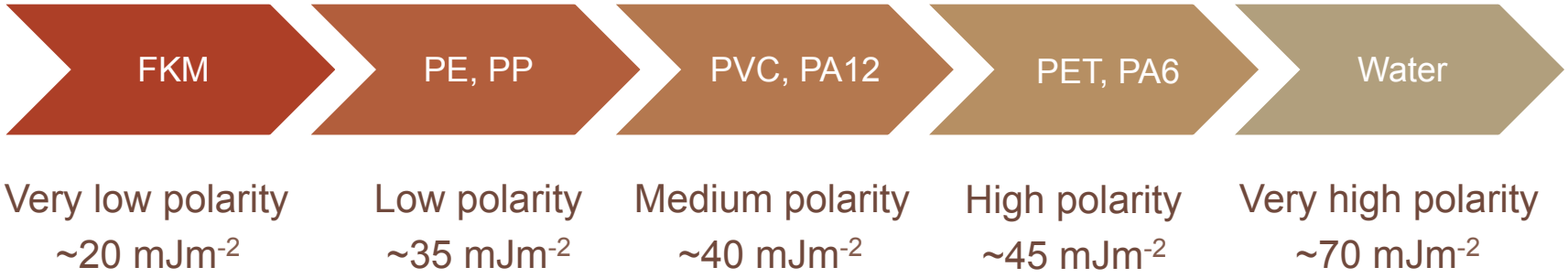
Plastic Type	Mechanical Enhancement	Cycle Time Reduction	Clear Film	Flame Retardance
PE	✔	✔	✔	✔
PP	✔	✔	✔	✔
EVA	✔	TBD	✔	✔
PA6	✔	TBD	TBD	✔
PA12	✔	✔	TBD	✔
PVC	✔	TBD	✔	✔
PLA	✔	TBD	✔	✔
Epoxy	✔	TBD	TBD	✔
EPDM	✔	TBD	TBD	✔
Suggested Grade	Dragonite™ XR or HP	Dragonite™ HP	Dragonite™ HP	Dragonite™ XR

Property See-Saw



- Isotropic fillers retain impact but do not reinforce
- Reinforcing fillers ruin impact resistance and elongation to break
- Halloysite reinforces and retains or improves impact and elongation
- This is possible due to shape, surface area and easy dispersibility

Dispersibility of Halloysite and Polarity



- Halloysite has been shown to disperse well in all types of system, from apolar to very polar
- Wetting through the tubes gives mechanical bonding even in cases where no specific chemical interaction takes place
- In thermosets, thermoplastics and elastomers, effective reinforcement is reported even without dispersants or coupling agents
- Dispersants and coupling agents may also be used

Dragonite in Semi-crystalline Plastics

Property	HDPE	PP	PVC	PA6
Modulus (%)	**+30**	**+27**	**+6.5**	**+22**
Yield Strength (%)	**+15**	**+23**	**+5**	**+13.5**
Notched Izod	**No change**	**+40**	**No change**	**No change**
Nucleation	**Yes**	**Yes**	*	**Yes**

All at **1 weight % loading** incorporated using standard twin-screw extruder
* PVC has very low crystallinity, nucleation not yet investigated

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Case Study #1
Cycle Time Reduction for HDPE Part

PHASE 1:

Drop-in solution: Significant cycle time reduction

	Virgin HDPE	HDPE + 1% Dragonite HP	Savings
Cycle time per part (seconds)	107	80	25%
Parts per hour	34	45	32%
Cost per part ($)	8.07	7.53	7%
Effective cost of HDPE ($/lb)	**0.85**	**0.76**	**11%**

PHASE 2:

Additional savings through thin-walling

Better mechanicals enables thin-walling:

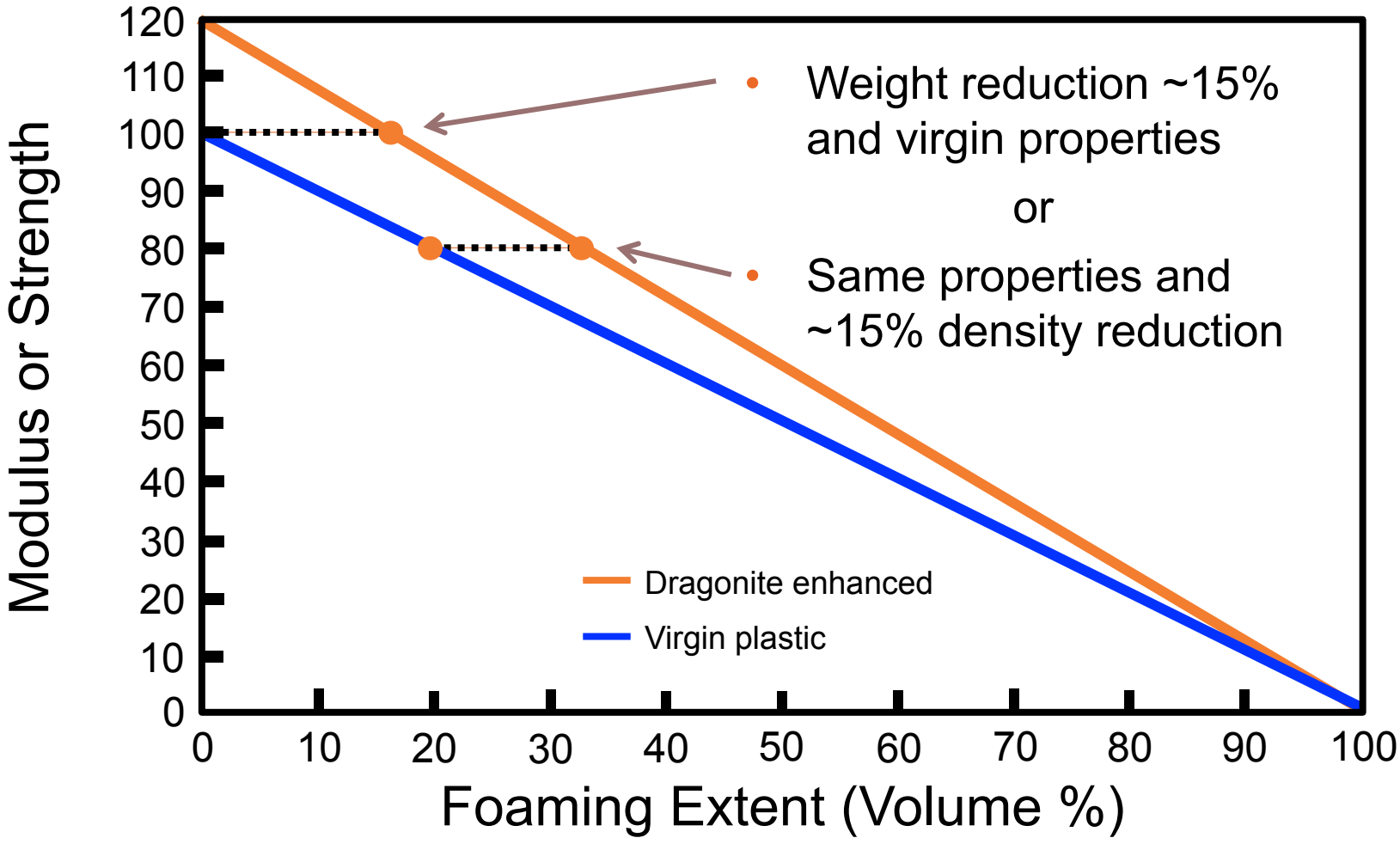
- 5-10% reduction in wall thickness
- 10% further reduction in cycle time
- 5–10¢ per lb additional savings

- At 1 wt% Dragonite-HP loading, the customer achieved a 25% reduction in cycle time resulting in significant manufacturing cost reduction
- Results based on actual commercial process of the end user
- The customer was able to reduce the visibility of sink marks by >60%
- A 20% increase in stiffness without affecting impact resistance of the final part
- Also validated in PP copolymer and homopolymer
- Applies to injection molding and extrusion

Ideal Foam Nucleating Agent

- High surface area
- Irregular shape / anisotropic
- Easily dispersible
- Reinforcing
- Nucleates crystal growth
- Safe
- Inexpensive
- Natural
- Available

Foam Mechanical Properties



Case Study #2
Foamed injection molded HDPE parts

Property	HDPE 897	No HNT	1% HNT	3% HNT	1% HNT from MB	1% HNT from MB
Pressure (psi)	1000	1000	1000	1000	1000	**2200**
Shot Size (inch)	2.1	1.6	1.6	1.6	1.6	**1.4**
Color	Natural	White	Yellow	Yellow	White	**White**
Mean weight (g)	4.414	4.205	4.242	4.242	4.235	**4.048**
Shrinkage (%)	**4**	0.8	1.2	0.4	0.8	**1.2**
Density (%)	**0**	8.25	8.8	8.25	9.3	**13.6**
Flex Modulus (kpsi)	**133**	139	150	147	151	**152**
Flex Strength (psi)	**3412**	3373	3477	3488	3468	**3430**
Elongation (%)	**150-450**	320-475	140-325	55-225	60-190	**31-360**
Notched Izod	**NB**	11.62	13/HB	12.75	14.6	**13.6**

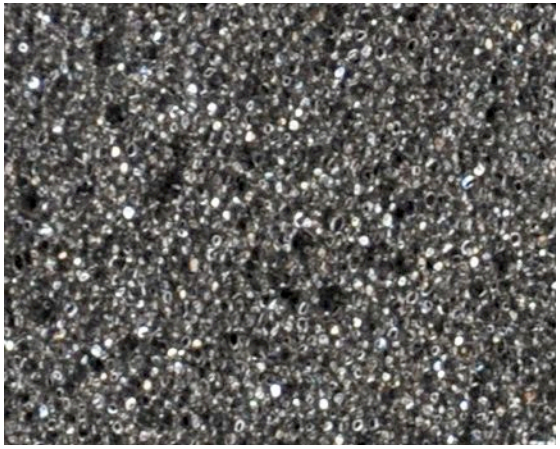
2.2 % KibbeChem AccuLite 250 Endothermic except Sample 1 none used and Sample 6 1.1%
Temperature and back pressure kept constant

Case Study #2
Foamed injection molded HDPE parts

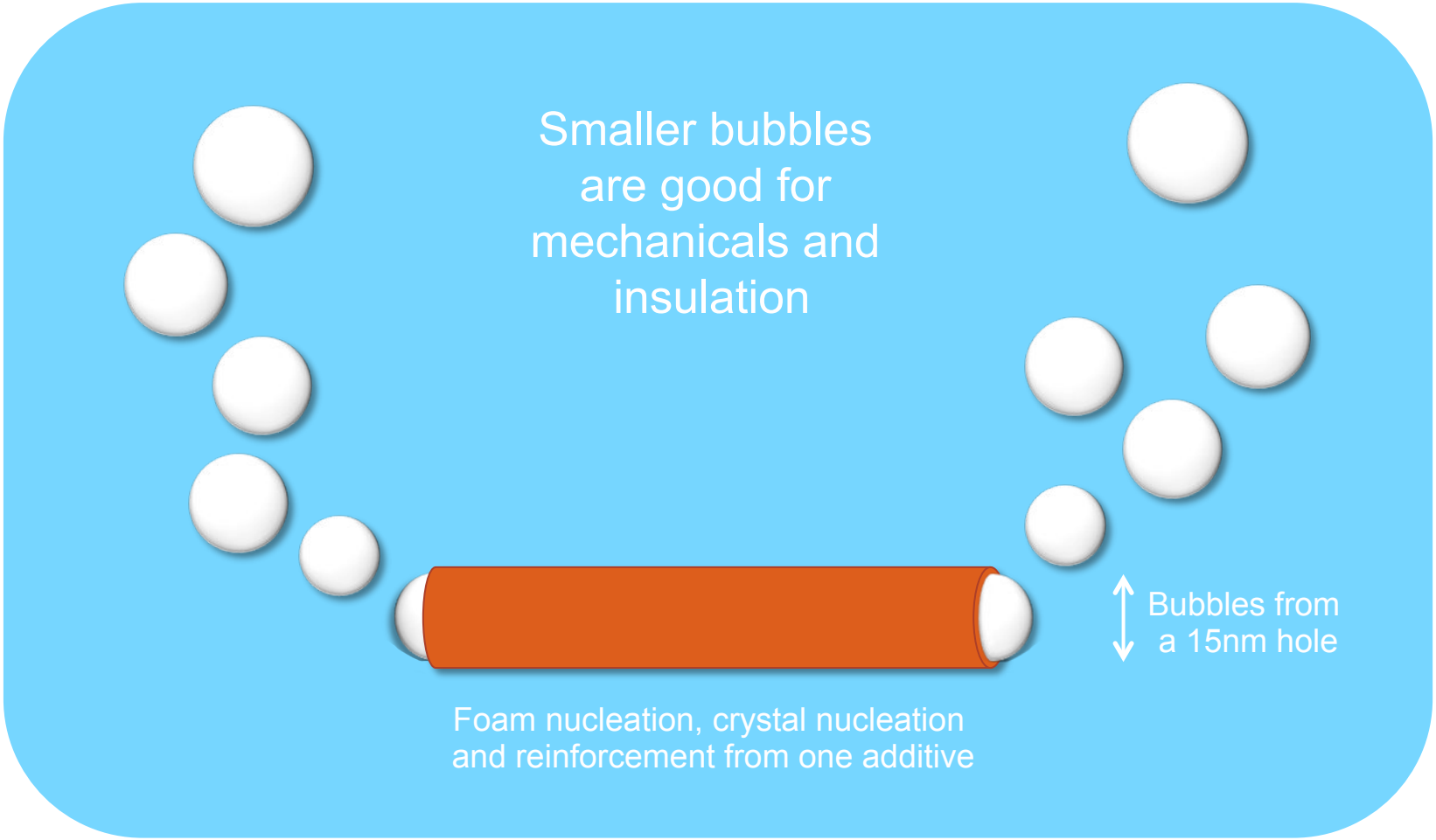
- Nucleation of crystallization gives faster solidification
- Nucleation of cell formation leads to better mechanicals and surface finish
  - 10-15% weight reduction and same mechanicals as unfoamed HDPE or
  - Same mechanicals as present foam but at lower density
- In automotive applications opt for lower density
- Or go for the cost advantage

Case Study #3
Foamed extruded HDPE sheet

- Nucleation of crystallization gives faster solidification
- Nucleation of cell formation leads to better mechanicals and surface finish
- 30% less endo-exo blowing agent needed (KibbeChem AccuLite 416)
- Production speed up by 30-40%
- Cheaper, better products



Next Step: Mesofoam Formation



Tubes hold up to 20 volume % actives
Loading well proven and scaled up with QC method in place

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Technology Status

January 2009 June 2009 May 2010 June 2010 February 2011

- Dragon Mine Halloysite deposit characterized and proven in 2010
- Time to first commercial sale was less than 12 months
- First commercialization in PE, World market $1 BN
- Dragonite saves money even in PE so there is a value proposition in the other more expensive plastics from PP through nylons to PEEK
- Sampling and working with hundreds of companies world-wide
- In advanced development stages in e.g. plastics, coatings and adhesives

Availability and Pricing

- Dragonite HP™ high-purity Halloysite is commercially available from Applied Minerals
- DragoniteHP™ is shipped directly from the Dragon Mine Utah, USA in powder form
- Dragonite/Foam masterbatch concentrates are available through collaboration with KibbeChem
- Supply is > 30ktons / yr to support large-scale applications
- Samples of Dragonite HP™ Powder or MB are available
- Technical support is available from Applied Minerals

Conclusions

- Tubular materials have long held great promise
- Due to high aspect ratio, surface area and easy dispersibility, Halloysite provides effective reinforcement with no downside
- Crystal nucleation gives excellent mechanicals and productivity boost
- Foam nucleation improves mechanicals and lowers weight
- Dragonite™ is 100% natural, safe, cost-effective and abundant enough to support large-scale commercial applications
- The benefits are proven by the rapid development and commercialization of new applications in multiple fields

Thank You For Your Time

Q&A

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