Engineered Process Additives for the Global Wood-Plastics Composites Market

STRUKTOL COMPANY OF AMERICA
Wood Innovations 2012

Juan M. Bravo

Struktol Company of America

- Member of the Schill & Seilacher family of companies
- Manufacturing in:
  - Stow, OH
  - Hamburg, Germany
  - Böblingen, Germany
  - Pirna, Germany
- Representation in over 100 countries around the world
- STRUKTOL® trade name known around the world
- Products can be found in plastics and rubber as well as man-made fibers, textiles, leather, paper products and wood composites.
STRUKTOL – STOW OHIO PLANT

PRODUCTION REACTION VESSELS
WOOD INNOVATIONS 2012

DUST FREE, PASTILLATED PRODUCTS

PROCESS SIMULATION AND TECHNICAL SERVICE

- Mixing
- Extrusion
- Calendering
- Molding

Expect More…Realize More. Intelligent Additive Solutions
Organic Fiber-Plastic Composites

Consist of 3 essential ingredients:
- Organic flour or fibers
- Polymer
- Additives

Processing:
- Extrusion
- Injection Molding
- Calendaring
- Compression Molding

Expect More...Realize More. Intelligent Additive Solutions

2006 - Worldwide Market Share
Polymers used for WPC in N. America ~ 2007

Market Size = > 750,000 MT

PVC
Currently Growing

- PVC
- PP
- PE
- Other

BACKGROUND ~ 2000 - 2008

NORTH AMERICA:

- Volume grew to approximately 750,000 MT by 2007
- Growth driven mainly by decking market
- Growing at 10-15% per year until 2008
- Only 20-25% of total material used for outdoor decking
- Formulations: Using basic lubricant packages
- Process rates low
BACKGROUND ~ 2000 - 2008

OTHER PARTS OF WORLD:
- China: Mainly HDPE/WPC Decking
- S. Korea: Mainly PP and PP/HDPE Blends
- Australia: HDPE and PVC/WPC
- Europe: Mainly PP but some HDPE as well. Produces more engineered products
- S. America: Very little production of WPC. Some Activity in Mexico, Columbia, Chile and Argentina.

TRENDS - USA
- After some significant product failures, companies adjusted formulations and processing to lower costs and produce higher quality products.
- USA started early (~2002) in optimizing equipment and formulations to produce high output rates while maintaining quality. Productions speeds of 2.5 m/min or more were now typical.
- The slowdown starting in 2008 basically flattened the growth of WPC in USA.
Further changes in equipment design and configuration allowed for even greater improvements in output rates.

For example:

- Use of agglomerators such as pellet mills to produce in a two step process rather than direct extrusion.
- Use of "vent stuffers" in earlier extruder designs that had problems with material being pulled out or clogging the vacuum vents.

Some of the problems associated with poorly functioning vacuum vents not removing enough moisture.
TRENDS - USA

“Vacuum Stuffers”
Hydraulic cylinders alternately push material down into vent while still pulling a vacuum.

An example of optimization of output rates using lubricants in HDPE/WPC to lower costs
FORMULATIONS/EQUIPMENT

- Strandex license technology
- Cincinnati Milacron Conical Twin Screws E80 and E86 with crammer
- Products: 1 x 5.5" boards, 2 x 2" (2) posts
- Pre-blended formulation:

<table>
<thead>
<tr>
<th>Material</th>
<th>Level, %</th>
</tr>
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<tbody>
<tr>
<td>HDPE Resin</td>
<td>27</td>
</tr>
<tr>
<td>Wood Flour</td>
<td>62</td>
</tr>
<tr>
<td>Lubricant</td>
<td>4</td>
</tr>
<tr>
<td>Talc</td>
<td>3</td>
</tr>
<tr>
<td>Phenolic Resin</td>
<td>2</td>
</tr>
<tr>
<td>Pigment Masterbatch</td>
<td>2</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>100</strong></td>
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PROCESSING CONDITIONS:

<table>
<thead>
<tr>
<th>EXTRUDER</th>
<th>E86</th>
<th>E86</th>
<th>E80</th>
<th>E80</th>
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<tr>
<td>PRODUCT</td>
<td>1 x 5.5&quot;</td>
<td>1 x 5.5&quot;</td>
<td>2 x 2&quot; (2)</td>
<td>2 x 2&quot; (2)</td>
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<tr>
<td>LUBRICANT</td>
<td>ZNST + EBS</td>
<td>TPW 604</td>
<td>ZNST + EBS</td>
<td>TPW 604</td>
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<tr>
<td>ZONE 1, °C</td>
<td>182</td>
<td>193</td>
<td>177</td>
<td>177</td>
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<tr>
<td>ZONE 2, °C</td>
<td>182</td>
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<td>ZONE 3, °C</td>
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<td>ZONE 4, °C</td>
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<td>SCREW COOLER, °C</td>
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<tr>
<td>DIE ZONE 1, °C</td>
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<tr>
<td>DIE ZONE 3, °C</td>
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<td>DIE ZONE 4, °C</td>
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<td>SCREW RPM</td>
<td>32.5</td>
<td>27</td>
<td>33.1</td>
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<tr>
<td>CRAMMER RPM</td>
<td>38.2</td>
<td>28.6</td>
<td>44.5</td>
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PROCESSING RESULTS

<table>
<thead>
<tr>
<th>EXTRUDER</th>
<th>E86</th>
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</tr>
<tr>
<td>LUBRICANT</td>
<td>ZNST + EBS</td>
<td>TPW 604</td>
<td>ZNST + EBS</td>
<td>TPW 604</td>
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<tr>
<td>OUTPUT RATE, m/min.</td>
<td>1.5</td>
<td>2.4</td>
<td>0.9</td>
<td>1.5</td>
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<tr>
<td>OUTPUT RATE, kg/hr.</td>
<td>374</td>
<td>575</td>
<td>231</td>
<td>377</td>
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<tr>
<td>% INCREASE</td>
<td>54%</td>
<td></td>
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</tbody>
</table>

If a manufacturer has a total of 8 extruders, 4 each of E86 and E80, based on the output rate improvements making 1 x 5.5" boards on all eight machines, we can estimate that a 50% gain in output rate will be equivalent to adding 4 new extruders to his plant! Total output gained is over 1,300 kg/hour.

Other Observations:
- Better dispersion of color concentrate (less streaking)
- Reduced scrap levels
- Elimination of 1 raw material feed system

TRENDS - USA

- Proper selection of lubricants have eliminated many problems in processing at higher extrusion rates.
- Lubricants are now optimized for use in WPC products and problems such as blooming or migration have been eliminated.
- Introduction of lower cost processing lubricants without losing effectiveness... Especially in the case of co-extruded capstock production.
CURRENT TRENDS - USA

- Problems with high extrusion rates and poor quality or not enough lubricant

Expect More…Realize More. Intelligent Additive Solutions

 CURRENT TRENDS - USA

- Some of the problems associated poor quality lubrication.

Expect More…Realize More. Intelligent Additive Solutions
TRENDS - USA

- Decking continues to be the major WPC product produced but fencing, railing and other applications are growing.
- HDPE is still dominant polymer used but PVC has been growing in recent years. PVC weathers very well and can be foamed quite easily.
- Foamed PE and PP WPC have not been commercially successful.

Even with all of these advancements, problems with color fading, water absorption, decrease in flexural strength and other properties still persist.

Focus now has switched to producing more durable products and more “engineered” articles.

Introduction of co-extruded capstocks, advanced coupling agents, flame retardants, etc.
**Current Product Limitations**

- The flexural modulus and tensile strength significantly lower than that of wood.
- Composites containing 50% or greater wood fiber can still be adversely affected by moisture (warping and tannin staining) and microbial action.
- There are stability and weathering issues (significant color fading) with olefin based products.
- Very expensive vs. traditional products.

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**CURRENT USA DECK PRICES***

- $2.40/m: Premium pine wood for decking
- $5.74 – $8.16/m: Lower end HDPE decking
- $6.19/m: Lower end Capped HDPE decking
- $9.18 – $13.32/m: Higher end HDPE decking
- $14.93/m: Cellular PVC decking

*Prices obtained from various “big box” stores in $USD July 2012
TRENDS - Europe

- Europe market is different in that gardens tend to be smaller so demand for deckboard is less.
- Europe has focused on higher end engineered products including automotive applications.
- Trends like co-extruded deckboard are more slow to gain acceptance.
- Russia seeing growth in the WPC market.

TRENDS - China

- China now has substantial WPC production.
- Some of the largest producers have more than 100 extruders.
- The difference is their output rates are in general much lower than with US or European made extruders.
- Worldwide Chinese made WPC extruders have seen tremendous growth. Machines now seen in Mexico, Colombia, Turkey, Vietnam, etc.
TRENDS - China

- Main production is still decking but are starting to introduce new types of products.
- Most WPC production is for export but domestic demand is growing, especially with government projects that specify the use of WPC products.

TRENDS – South Korea

- Main production is still decking but are starting to introduce new types of products.
- Most WPC production is for export but domestic demand is growing, especially with government projects that specify the use of WPC products.
- S.Korean production has mainly been based on PP and PP/HDPE blends in order to meet relatively high standard specifications.
TRENDS – Southern Asia

- Growth is slower than in China but significant.
- Most WPC production is for export but domestic demand is growing, especially with government projects that specify the use of WPC products.
- Australia has substantial production in WPC decking but is produced by only a couple of companies.
- New Zealand has some activity in WPC.

TRENDS – Canada

- 7 years ago Canada had substantial production of WPC decking.
- Canada relied heavily on exports to the US market and when the Canadian dollar strengthened substantially against the US dollar, they struggled to compete resulting in the closing of many companies. Only a few producers are left.
TRENDS – Latin America

- Had some WPC production in the past but very limited.
- Recently new companies have been started for WPC production. Mainly focused on products other than decking. For example, corrugated roofing materials to replace aluminum.

Ecomadera- Mexico

HDPE WPC
Because of limited supply of wood flour in some areas, companies have been creative with using many different types of fillers including fibers from the blue agave used to make tequila, paper, and “tetrapack” trimmings.
Products for WPC

Coupling Agents
TPW 243 Pastille
TPW 244 Powder
Coupling Agent for PE/WPC

- Special Process Considerations.
- Not Just Compatibilizer.
- MOE Improvement is significant vs. MAH

TPW 243 vs. MAH Couplers - HDPE/WPC

<table>
<thead>
<tr>
<th>Description</th>
<th>Yield Load Lbs.</th>
<th>MOR</th>
<th>MOE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Struktol Lube TPW 104 with Struktol TPW 243 Coupling Agent</td>
<td>180.0</td>
<td>12,412</td>
<td>972,511</td>
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<tr>
<td>Struktol Lube TPW 113 with MAH #2</td>
<td>182.3</td>
<td>12,569</td>
<td>947,951</td>
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<tr>
<td>Struktol Lube TPW 104 with MAH #3</td>
<td>125.6</td>
<td>9,822</td>
<td>898,420</td>
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<tr>
<td>Struktol Lube TPW104 with MAH #1</td>
<td>137.8</td>
<td>10,154</td>
<td>893,716</td>
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<tr>
<td>Struktol Lube TPW 113 with Struktol TPW 243 Coupling Agent</td>
<td>173.5</td>
<td>11,645</td>
<td>891,459</td>
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<tr>
<td>Struktol Lube TPW 426 with MAH #3</td>
<td>142.1</td>
<td>10,770</td>
<td>810,176</td>
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<tr>
<td>Struktol Lube TPW 426 with MAH #4</td>
<td>114.0</td>
<td>8,900</td>
<td>806,950</td>
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<tr>
<td>Struktol Lube TPW 426 with Struktol TPW 243 Coupling Agent</td>
<td>152.2</td>
<td>11,160</td>
<td>780,692</td>
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<tr>
<td>Struktol Lube TPW 113 with MAH #3</td>
<td>161.9</td>
<td>10,652</td>
<td>748,258</td>
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<tr>
<td>Struktol Lube TPW 104 with MAH #1</td>
<td>128.7</td>
<td>9,242</td>
<td>726,083</td>
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<tr>
<td>Struktol Lube TPW 104 with MAH #2</td>
<td>103.4</td>
<td>8,362</td>
<td>682,886</td>
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<tr>
<td>Struktol Lube TPW 426 with MAH #1</td>
<td>148.1</td>
<td>9,812</td>
<td>657,197</td>
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<tr>
<td>Standard Formulation using TPW 113 and MAH #1</td>
<td>147.9</td>
<td>9,298</td>
<td>555,573</td>
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</tbody>
</table>
TPW 243 vs. MAH Couplers - HDPE/WPC

MOE Data Three Freeze/Thaw Cycles

-35.74%  -34.66%  -29.31%  -17.33%  -21.64%

TPW 243 Pastille
TPW 244 Powder
Coupling Agent for PE/WPC

- Work with any type of lubricant, including those containing metallic stearates.
- Much easier to process than MAH couplers resulting in high output rates without loss of physical properties.
- Excellent reduction in water absorption.
- Excellent property retention AFTER manufacture.
- Does require two step process.
Odor Mask

Was developed to reduce or mask odors in WPC products, especially recycled.
Can neutralize odor or re-odor compound.
Pleasing not overpowering scent.
Easy addition to compound.
Positive Trial feedback.
Developed for WPC but can be used in other non-WPC applications.
Capstocks

Co-extruded surface layer to protect WPC profiles with high quality raw materials.

SA1141 - Capstock

- Minimizes color fade
- Low gloss, low slip surface
- Greatly minimizes water absorption
- Color, UV and other additives can be added by the customer.
- Correct temperature of substrate and capstock are needed to achieve a good bond. (180 degC or above)
**Capstock**

- Initial rejection of a “plastic” looking capped deckboard in US market has largely been overcome with low gloss surfaces and high quality color effects.
- Because of US acceptance of capped deckboard other countries are starting to follow this lead, i.e. China
- Europe and other regions have been slow in accepting this new trend.

**SA1141 - Capstock**

Eliminating the “plastic” look of some capstocks by reducing shine and using advanced colorants.
- Taber 5 finger scratch and mar tester

- Regular HDPE Capstock
- Engineered HDPE Capstock
Taber 5 finger scratch and mar tester

Capstock

- Color, UV and other additives can be added by the customer.
Capstock

- Correct temperature of substrate and capstock are needed to achieve a good bond. (180 degC or above)

Capstock formulations can very flexible

- Custom for specific application or customer.
- Excellent Adhesion to substrate.
- Flame retardant versions.
- Low gloss/High gloss versions.
- Scratch resistant.
SA1221 - Capstock

- Regular Capstock
- SA1221 Capstock with Flame Retardants

Low Cost Lubes for WPC
SA1114 – Low Cost Lube

- For formulation not using MAH type coupling agents.
- Darker color is still acceptable in WPC
- For corestock part of profile where color is not an issue.

SA1149

- For formulation using MAH type CA.
- Darker color is still acceptable in WPC
- Originally designed for use in core part of capstock profiles where color is not an issue.
- In reality darker color has minimal impact on color of final profile.

HDPE/WPC-
Pine wood flour 60%
4%
Lubricant
Flame Retardant Additives and Compounds

SA0832

- Designed to slow down burn rate at lower loadings than traditional FR Compounds.
- Special Process Considerations.
- Different Addition Levels can be used to achieve desired "FR" affect.
SA0832 – Horizontal Burn

- 0% SA0832
- 15% SA0832

Note: This flame retardant and method of use is not effective in many formulations

Viscosity Modifier for Polypropylene

struktrol
RP 11

- Allows customer to use one MFI PP and modify as needed.
- Synergistic Affect gives improved results over Peroxides.
- Consistent Repeatable Results.

LUBRICANT COMPARISON IN WOOD COMPOSITES

EXTRUSION TRIALS
IN PVC.....

Lubricant effect: PVC Compound

- Standard PVC Lubricant Package, 1.5 phr, 50 rpm
- STRUKTOL® TPW 012, 1.5 phr, 50 rpm
- STRUKTOL® TPW 012, 1.5 phr, 100 rpm
A FINAL WORD:

- The use of high quality lubricants is recommended since they can optimize performance with greater efficiency.

The two main forms of reducing costs are:
- Reduction of raw material costs.
- Increase productivity.

- It is very difficult to constantly decrease raw materials costs, especially in formulations that do not contain many ingredients. Improved productivity and the reduction of scrap (off spec material) becomes the most important method to reduce costs and increase profits.

Thank You!

Special thanks to our Product Development team at Struktol for their work.