Effectiveness of Silver Based Antimicrobial Immersed in a Universal Masterbatch

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Who Gets Infections?
Medical Applications

• Catheters
• Wound dressing
• Hospital bedding
• Dental trays
• Surgical drapes
• Hospital gowns
Infection Onset

Catheter or tube device left in place for three or more days

• Handling and exposure of device corporal end influence time of onset & severity of infection

• Infection occurs at incision where catheter enters blood vessel

• Bacteria detaches from inside of catheter tube and travels into blood stream

• Risk increases with duration of device in the body
Central Venous Catheters

- Inserted into neck, tip resides in superior vena cava
- In place for 1 to 2 months, or longer
- Used for TPN, chemotherapy, dialysis
- Bacteria form on biofilms; ~5,000 US deaths per year
Peripherally Inserted Central Catheters (PICC)

- Line inserted into elbow, tip resides in superior vena cava
- Can dwell for 6 weeks to 6 months
- Can be used for same infusion purposes as central venous catheter, plus drawing blood
Antimicrobial Additive for Plastics:

Considerations:

- Addition level to achieve kill
- Particle form and size
- In-process stability with plastic
- Migration characteristics
- Ultraviolet light exposure
- Heat stability of the antimicrobial
- Chemistry of the polymer
- Amount of active ingredient in the antimicrobial additive
- Stability in water
Antimicrobial Additives

Silver-based

- Silver/Citrate
- Silver sulfadiazine
- Elemental silver
- Silver/zirconium/phosphate
- Silver/ceramic
- Silver nanoparticle

Base metal

- Copper
- Silver/Palladium
- Silver/Platinum
- Zinc
- Silver/zinc/copper zeolite
- Silver/zinc/glass
- Silver/glass/zeolite

Organic

- Triclosan
- Chlorhexidine
- Thiabendazole
- Silver/zeolite

Source: Wiktionary, Online Medical Dictionary
Silver Antimicrobial Additive

- Silver metal, in itself, is not antimicrobial

- Silver ions, a by-product of oxidation, have excellent antimicrobial properties

- Release rate is critical: too slow is ineffective; too fast not suitable for long term dwelling catheter

- Release depends on amount & particle size of carbon and metal powders*

- Also depends on permeability of the polymer composition*

Agion™ Technology

Silver ions bonded to inert zeolite

Unique properties of zeolite make them suitable for selective ion exchange, absorption, separation and catalysis
Agion™ Technology

Silver ions attack multiple targets in the microbe to prevent it from growing to a destructive population. This tri-modal action fights cell growth in three ways:

1. Prevents respiration by inhibiting transport functions in the cell wall
2. Inhibits cell division (reproduction)
3. Disrupts cell metabolism
## Price/Performance Comparison

<table>
<thead>
<tr>
<th>Technology</th>
<th>Positives</th>
<th>Negatives</th>
<th>$ Price/lb.*</th>
<th>Antimicrobial Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oligon® (BLACK)</td>
<td>- Disperses well when compounded</td>
<td>- Expensive</td>
<td>$1,500 - $2,500</td>
<td>Very Good</td>
</tr>
<tr>
<td></td>
<td>- Already on the market</td>
<td>- Silver leaching</td>
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<tr>
<td></td>
<td>- Proven efficacy</td>
<td>- Black is the only color</td>
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</tr>
<tr>
<td>Agion™ (SILVER)</td>
<td>- Proven efficacy</td>
<td>- Expensive!</td>
<td>$2,000 - $2,500</td>
<td>Very Good</td>
</tr>
<tr>
<td></td>
<td>- FDA approved</td>
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<tr>
<td></td>
<td>- Already on the market</td>
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</tr>
<tr>
<td>Universal MB With Agion™ Antimicrobial</td>
<td>- FDA approved components</td>
<td>- Additional step to tumble blend</td>
<td>$250 – $500</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>- Retention of physical properties</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>- Blends well</td>
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</table>

*All costs are estimates and are subject to change*
Test Materials

• Universal medical masterbatch polymer alloy – Foster
• Agion AD85H-M fine particle less than 4 um, Zeolite with 20-24% ionic silver
• Agion AK80H-M fine particle less than 4 um, Zeolite with 4-6% ionic silver
• Arkema Pebax 3533 SA01 MED 35 shore D elastomer
• Arkema Pebax 7033 SA01 MED 70 shore D elastomer
• Lubrizol Pellethane 2363 80A 80 shore A TPU elastomer
• Lubrizol Pellethane 2363 55D 55 shore D TPU elastomer
Test Materials

- Evonik Vestamid Care ML Polyamide 12 Medical grade resin
- Celanese Ateva 1081G EVA copolymer 9% VA 95 Shore A
- Chevron/Phillips Marlex m9503H HD Polyethylene 0.31 MFR
- Basell Pro-Fax PF531 Homopolymer Polypropylene 27 MFR
- Total Polypropylene 3281 Homopolymer 1.25 MFR
- Styrolution Terluran GP-35 ABS high melt flow
- Mitsubishi Lupilon H-3000 PC high melt flow
Primary Equipment Used

- Wiley Mill
- 25 liter Pappenmier Mixer
- K-Tron T-20 Feeders
- Conair 304 Pelletizer
- Dri-Air dryers
- Leistritz 27mm Co-rotating twin screw extruder 40/1 L/D
- Arburg Allrounder 28 Ton Injection molding machine with mixing screw
- Davis Standard ¾ inch SS extruder tubing line
- MTS Q Test T&E tester
Process Flow

• Pre-compounded masterbatch on 27 mm TSE (PCL+EVA)
• MB Milled in Wiley Mill
• Two pre-blends were made using the Pappenmier mixer.
  • 40% wt. loading Agion AK80H-M powder blended with milled MB (UMB-A1)
  • 40% wt. loading Agion AD85H-M powder blended with milled MB (UMB-B1)
• Pre blends Fed into TSE with Ktron T-20 loss in weight feeder
• Strand Pelletized with Conair pelletizer
• Molded into ASTM test bars on Arburg 28 Ton All rounder
• Extruded into Tube on Davis Standard ¾ Inch Extruder
Tensile Strength

![Graph showing tensile strength comparison between Control and 10% Univ for various materials.](image-url)
Elongation % At Break

Percentage

Pebax 3533
Pebax 7033
Vestamid Care ML24
Pellethane 2363-80A
Pellethane 2363-55D
ATEVA 1081G
Marlex 9503
ProFax PF-531
Fina 3281 PP
Lupilon S3000UR
Terluran GP35

Control
10% Univ
Antimicrobial Efficacy Testing

ABS with 4% and 12% UMB-A1 to achieve 1% and 3% Agion AK loading
Antimicrobial Efficacy Testing

Polycarbonate with 2.5% and 7.5% UMB-A1 to achieve 1% and 3% Agion AK loading

[Graphs showing antimicrobial efficacy]
Antimicrobial Efficacy Testing

TPU with 10% and 20% UMB-B1 to obtain 4% and 8% Agion AD loading
Antimicrobial Efficacy Testing

Log Reduction

<table>
<thead>
<tr>
<th>Material</th>
<th>1% AK</th>
<th>3% AK</th>
<th>1% AK</th>
<th>3% AK</th>
<th>4% AD</th>
<th>8% AD</th>
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<tbody>
<tr>
<td><strong>ABS</strong> (ASTM E2180)</td>
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<td><strong>PC</strong> (ASTM E2180)</td>
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<td><strong>TPU</strong> (ASTM E2149)</td>
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**Log Reduction of Bacteria**

- **MRSA**
- **CRE**
Summary

• Antimicrobial catheters and medical devices have proven effective in reducing infection
• Silver is a proven antimicrobial additive but very expensive and can compromise the physical properties of some resins
• A universal masterbatch containing Agion™ Silver can be used to lower cost and minimize property loss
• Medical grade UMB containing 40% by wt. Agion AK80H-M let down in PC and ABS resins to obtain 1% and 3% Agion loadings was effective in a 6 log reduction in MRSA and CRE bacteria while maintaining physical properties.
• Medical grade UMB containing 40% by wt. Agion AD85H-M let down in TPU to obtain 4% and 8% Agion loadings was effective in a 6 log reduction in MRSA and CRE bacteria while maintaining physical properties.
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