Update On The Development Of Sulfuryl Fluoride As An Alternative To Methyl Bromide

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Sulfuryl Fluoride ($SO_2F_2$)

- Early 1950’s - Research initiated by Dow to develop an alternative structural fumigant without the mercaptan odors associated with methyl bromide
- 1955 - First field tests with sulfuryl fluoride for control of DWT
- 1959 - Patent received for fumigation with sulfuryl fluoride (#2,875,127)
- 1961 - First marketed in US under trade name Vikane* gas fumigant
- 1974 - Sulfuryl Fluoride production initiated at Dow Chemical facility at Pittsburgh, CA.

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Sulfuryl Fluoride ($SO_2F_2$)

- Currently sold under global trade name Vikane* gas fumigant
- Primary use: Structural Fumigation to control Drywood Termites
- Secondary uses: Railcars, Shipping Containers, Artifacts, Beetles
- Currently registered in:
  - USA
  - Caribbean
  - Sweden
  - Germany (use permit)

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More Similarities Between SF & MeBr than Differences

Both are excellent fumigants that:

- have wide pest spectrums
- are non-flammable and odorless
- have similar vapor density and molecular weights
- are non-corrosive in vapor phase
- utilize CT dosage relationship

Dosage = Concentration X Time
# Key Differences: Physical/Chemical Properties

<table>
<thead>
<tr>
<th>Factor</th>
<th>SF</th>
<th>MeBr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formula</td>
<td>SO$_2$F$_2$</td>
<td>CH$_3$Br</td>
</tr>
<tr>
<td>Nature</td>
<td>Inorganic</td>
<td>Organic</td>
</tr>
<tr>
<td>B.P. (°C)</td>
<td>-55.2</td>
<td>3.6</td>
</tr>
<tr>
<td>V.P. (kPa)</td>
<td>1700</td>
<td>190</td>
</tr>
<tr>
<td>Solubility</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water (ppm)</td>
<td>750</td>
<td>17,500</td>
</tr>
<tr>
<td>Solubility</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>
# Key Differences: Fumigant Properties

<table>
<thead>
<tr>
<th>Factor</th>
<th>SF</th>
<th>MeBr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect on Ozone</td>
<td>No</td>
<td>Yes (?)</td>
</tr>
<tr>
<td>Penetration</td>
<td>Rapid</td>
<td>Slow</td>
</tr>
<tr>
<td>Sorption</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Desorption</td>
<td>Rapid</td>
<td>Slow</td>
</tr>
<tr>
<td>Aeration</td>
<td>Rapid</td>
<td>Slow</td>
</tr>
<tr>
<td>Odor Potential</td>
<td>None</td>
<td>Sulfurous</td>
</tr>
</tbody>
</table>
**Key Differences: Biological Activity**

- **Relative Insect Control**

<table>
<thead>
<tr>
<th>Stage</th>
<th>SF</th>
<th>MeBr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Pupal</td>
<td>X</td>
<td>X*</td>
</tr>
<tr>
<td>Larval</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Egg</td>
<td>X*</td>
<td>X</td>
</tr>
</tbody>
</table>

* May Require Higher Dosages
### Key Differences: Packaging and Use

<table>
<thead>
<tr>
<th>Factor</th>
<th>SF</th>
<th>MeBr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder wt</td>
<td>90 kg</td>
<td>20-90 kg</td>
</tr>
<tr>
<td>Pressure (kPa)</td>
<td>2078</td>
<td>172</td>
</tr>
<tr>
<td>Heat Exchanger</td>
<td>No*</td>
<td>Depends</td>
</tr>
<tr>
<td>Vol. Contrl.</td>
<td>Hose len/dia.</td>
<td>None</td>
</tr>
<tr>
<td>Shooting</td>
<td>Outside</td>
<td>Depends</td>
</tr>
</tbody>
</table>

*Shooting fans necessary as internal heat exchanger and for improved fumigant equilibrium.*
ProFume* Gas Fumigant Development

- Biology efforts to define effective dosages
  - Laboratory efficacy trials (1995-2001)
  - Target six key SPIP (IMM, MFM, CFB, RFB, WB, STGB)
    - CSL in UK
    - DFA in CA
    - BBA in Germany
    - USDA-ARS in CA
  - Validate CT concept for SPIP
  - Field validation of laboratory results
    - Germany
    - UK
    - US
  - Translation of data into label rates based on targeted level of control
  - Development of ProFume* Fumiguide Calculator

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ProFume is not available for sale. EPA registration pending.
ProFume* Gas Fumigant Development

- Development of “Best Practices” to optimize efficient use of sulfuryl fluoride
  - Improved structure sealing techniques
  - Optimizing gas retention
  - Increased HLT
  - Shorter time to reach equilibrium
  - Maintenance of fumigant equilibrium
  - Improved monitoring techniques

- Goal: Use of less fumigant to reach desired level of insect control
  - Minimize downtime
  - Ensure safety
  - Avoid damage

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Taste and Quality Effects

- Validate that fumigation of DF & TN and Cereal Grains does not affect taste and quality
  - Completed two DF & TN trails
    - 9 commodities
    - In cooperation with DFA and USDA-ARS
  - Coordinating taste and quality tests on wheat, rice and corn with:
    - Kansas State University
    - HGCA / CSL
  - Fumigating kernels, processed products (flour) and finished products
ProFume* Gas Fumigant Development

- Population Modeling
  - Better understanding of economic thresholds and action levels
  - Population rebound rates
  - Potential for development of resistance
  - Determination of economical dosages
  - Help determine success of previous fumigations
  - Predict when future fumigations will be required

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Profume* Gas Fumigant Development

- Residue Research
  - DF & TN
    - Commodity Fumigation / Analysis - Completed 1999
  - Cereal Grains (Wheat, Rice, Corn)
    - Fumigation of grain and process functions currently underway
    - Residue analysis/risk assessment

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ProFume* Gas Fumigant Development

Regulatory Timeline

* 2001
  - Dried Fruit and Tree Nut EUP (Walnuts, Raisins)

* 2002
  - Section 3 Registration Approval DF&TN
  - Product Launch DF&TN

* 2003
  - Section 3 Registration Approval Cereal Grains (US)
  - Product Launch Cereal Grains (US)

* 2004
  - Product Launch Cereal Grains (Europe)
  - Section 3 Approval Food Processing (US)
  - Product Launch Food Processing (US)

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Product Stewardship

It is a Dow AgroSciences expectation that an effective Product Stewardship Program will be a primary requirement in any area where sulfuryl fluoride business currently exists or where new uses are being developed.
Conclusions

- Dow AgroSciences is committed to supporting sulfuryl fluoride in the existing Vikane* markets as well as new use patterns.
- Sulfuryl fluoride (ProFume*) will be a viable alternative for methyl bromide in many commodity fumigation markets.
- Dow AgroSciences is demonstrating confidence and commitment in ProFume* through our investments in product development.
- Developing technical foundation for long term use of sulfuryl fluoride.
- Cooperating with researchers, fumigators and the food industry to development practical sulfuryl fluoride fumigation options.

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Thank You

Questions?