Solução definitiva em agente de expansão ecologicamente correto

FEIPUR - BRAZIL 2006
**ecomate® advantages**

- A LIQUID Physical Blowing Agent
- Patented: US, Australia, Singapore w others Pending
- Thermally Efficient Insulation
- To Replace HCFC’s, HFC’s, HC’s
- **ENVIRONMENTALLY BENIGN**
  - ZERO ODP, ZERO GWP, VOC Exempt [US EPA]
- Economically Advantageous – Use less!
- Excellent Solubility
- Low Volatility – Non-flammable Mixes
- Good Foam Properties
- Good Foam Flammability Resistance
### ecomate® Blowing Agent Properties

- **Clear, Colorless, Flammable Liquid**
- **Boiling Pt**: 88.7 F / 31.5°C
- **Flash Point**: -26 F / -32°C
- **LEL \ UEL**: 5 - 23%
- **LAMBDA, gas (25°C)**: 0.074 / 10.7
- **Vapor Pressure (25°C)**: 11.4 psia / 586 mm
- **Auto Ignition Temp**: >840 F / >450°C
- **Specific Gravity**: 0.982 / 0.982
- **Molecular Weight**: 60 / 60
# BA COMPARISON

<table>
<thead>
<tr>
<th></th>
<th>ecomate</th>
<th>141b</th>
<th>245fa</th>
<th>365mfc</th>
<th>365/227 93 / 7</th>
<th>n-C5</th>
<th>cC5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mol wt</td>
<td>60</td>
<td>117</td>
<td>134</td>
<td>148</td>
<td>149,6</td>
<td>72</td>
<td>70</td>
</tr>
<tr>
<td>Bpt, C</td>
<td>31,5</td>
<td>32</td>
<td>15,3</td>
<td>40,2</td>
<td>30</td>
<td>36</td>
<td>49</td>
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<tr>
<td>Sp Gr</td>
<td>0,982</td>
<td>1,24</td>
<td>1,32</td>
<td>1,25</td>
<td>1,28</td>
<td>0,62</td>
<td>0,75</td>
</tr>
<tr>
<td>Lambda</td>
<td>10,7</td>
<td>10</td>
<td>12,2</td>
<td>10,6</td>
<td>10,7</td>
<td>14*</td>
<td>11*</td>
</tr>
<tr>
<td>LEL/UEL</td>
<td>5,0 – 23,0</td>
<td>7,6 – 17,7</td>
<td>n/a</td>
<td>3,5 – 9,0</td>
<td>3,8 – 13,3</td>
<td>1,4 – 17,8</td>
<td>1,4 – 8,0</td>
</tr>
</tbody>
</table>
GAS LAMBDA VALUES

Lambda @ 25C [mW/m.k]

HCFC-141b: 10.1
HFC-365mfc: 10.6
ecomate: 10.7
HFC-245fa: 12.2
HFC-134a: 13.7
n-pentane: 15.0
CO2: 16.3
ecomate® Blowing Agent
- Environmental Characteristics

- ecomate blowing agent is an attractive long term environmental option

<table>
<thead>
<tr>
<th></th>
<th>ODP</th>
<th>GWP</th>
<th>VOC</th>
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<tbody>
<tr>
<td>CFC 11</td>
<td>1</td>
<td>4000</td>
<td>NO</td>
</tr>
<tr>
<td>CFC 12</td>
<td>1</td>
<td>8500</td>
<td>NO</td>
</tr>
<tr>
<td>HCFC 141b</td>
<td>0.1</td>
<td>630</td>
<td>NO</td>
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<tr>
<td>HCFC 22</td>
<td>0.05</td>
<td>1700</td>
<td>NO</td>
</tr>
<tr>
<td>HCFC 142b</td>
<td>0.06</td>
<td>2000</td>
<td>NO</td>
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<tr>
<td>HFC 365</td>
<td>0</td>
<td>840</td>
<td>NO</td>
</tr>
<tr>
<td>HFC 134a</td>
<td>0</td>
<td>1300</td>
<td>NO</td>
</tr>
<tr>
<td>HFC 245fa</td>
<td>0</td>
<td>790 -1040</td>
<td>NO</td>
</tr>
<tr>
<td>Cyclopentane</td>
<td>0</td>
<td>11</td>
<td>YES</td>
</tr>
<tr>
<td>ecomate</td>
<td>0</td>
<td>0</td>
<td>NO</td>
</tr>
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## Cost Efficiency

<table>
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<tr>
<th>Blowing Agent</th>
<th>Mol Wt</th>
<th>Factor</th>
</tr>
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<tbody>
<tr>
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<td>117</td>
<td>1.00</td>
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<td>134</td>
<td>1.15</td>
</tr>
<tr>
<td>HFC-365/227</td>
<td>149</td>
<td>1.27</td>
</tr>
<tr>
<td>cC5</td>
<td>70</td>
<td>0.60</td>
</tr>
<tr>
<td>nC5</td>
<td>72</td>
<td>0.62</td>
</tr>
<tr>
<td><strong>ecomate®</strong></td>
<td><strong>60</strong></td>
<td><strong>0.51</strong></td>
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<td>**</td>
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<tr>
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<td>1.15</td>
<td>*****</td>
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<tr>
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<td>1.27</td>
<td>****</td>
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<tr>
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<td>70</td>
<td>0.60</td>
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</tr>
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<td>**</td>
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<tr>
<th>Blowing Agent</th>
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<th>Factor</th>
<th>$/LB</th>
<th>$/mole</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCFC-141b</td>
<td>117</td>
<td>1.00</td>
<td>**</td>
<td>Ref</td>
</tr>
<tr>
<td>HFC-245fa</td>
<td>134</td>
<td>1.15</td>
<td>*****</td>
<td>+350%</td>
</tr>
<tr>
<td>HFC-365/227</td>
<td>149</td>
<td>1.27</td>
<td>****</td>
<td>+380%</td>
</tr>
<tr>
<td>cC5</td>
<td>70</td>
<td>0.60</td>
<td>**</td>
<td>- 45%</td>
</tr>
<tr>
<td>nC5</td>
<td>72</td>
<td>0.62</td>
<td>*</td>
<td>- 70%</td>
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<tr>
<td><strong>ecomate®</strong></td>
<td>60</td>
<td>0.51</td>
<td>**</td>
<td>- 65%</td>
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### ecomate® Solubility

<table>
<thead>
<tr>
<th>CHEMICAL</th>
<th>ASPECT w 20% ECOMATE</th>
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<tbody>
<tr>
<td>POLYESTER polyol</td>
<td>CLEAR</td>
</tr>
<tr>
<td>SUCROSE GLYKERIN polyol</td>
<td>CLEAR</td>
</tr>
<tr>
<td>AMINE polyol</td>
<td>CLEAR</td>
</tr>
<tr>
<td>MANNICH polyol</td>
<td>CLEAR</td>
</tr>
<tr>
<td>ISOCYANATE</td>
<td>CLEAR</td>
</tr>
<tr>
<td>DEG</td>
<td>CLEAR</td>
</tr>
<tr>
<td>TCPP</td>
<td>CLEAR</td>
</tr>
<tr>
<td>Br FRA</td>
<td>CLEAR</td>
</tr>
<tr>
<td>PROP CARBONATE</td>
<td>CLEAR</td>
</tr>
<tr>
<td>WATER</td>
<td>CLEAR</td>
</tr>
</tbody>
</table>

- Excellent solubility in all foam ingredients
ecomate® System Emissions – Stored Systems in Drums/Totes

“A” Isocyanate
(ecomate® Blowing Agent)

“B” Polyol Blend
(ecomate® Blowing Agent)

< 0.22% LEL
0-5 cm above bung @ 29-32°C

0.22% LEL within drum headspace
Vapor Pressure of Stored ecomate® Blends

Vapor Pressure (ASTM D2879, typical data)
Blowing Agent/Polyol System
eco3-95-1.7

“A” Polyol Blend with ecomate® Blowing Agent

UN 1A1 Max pressure

TEMP, C

mmHG
Vapor Pressure of Stored ecomate® Blends

Vapor Pressure (ASTM D2879, typical data)
Blowing Agent / Isocyanate System
eco3-95-1.7

“A” ISO Blend with ecomate® Blowing Agent

UN 1A1 Max pressure

TEMP, C

mmHG
Emissions are <100 ppm from the laminator to the warehouse (2-6)
Potential Challenges

- Flash Point
- Hydrolysis
- Toxicity
- Foam Properties
System Flash Point

POLYOL TYPE

ECOMATE PCT

POLYOL 1
POLYOL 2
POLYOL 3
POLYOL 4
POLYOL 5
POLYOL 6
HYDROLYSIS

- ESTER HYDROLYSIS
- PRODUCTS:
  - Formic Acid & Methanol
- YET Very Stabile in Systems: 1+ yrs on shelf
Toxicity

U.S.EPA HPV Chemical Challenge Program
Revised Test Plan for the Formates Category

Formic Acid*          CAS#: 64-18-6
Sodium Formate       CAS#: 141-53-7
Calcium Formate      CAS#: 544-17-2
Methyl Formate       CAS#: 107-31-3

Submitted by: American Chemistry Council
Formic Acid and Formates Panel
Submitted to: U.S. Environmental Protection Agency

Prepared by: Elmer Rauckman, PhD,
DABT Toxicology and Regulatory Affairs
Freeburg IL 62243

May 27, 2003

* Formic Acid is being reviewed as an ICCA chemical and is not formally a HPV chemical.

http://www.epa.gov/chemrtk/formates/c13438rt.pdf#search='methyl%20formate'
Toxicity

- The **acute toxicity** of all Formate materials is **low** with no special hazards
- **Methyl Formate [MF]** is transformed very rapidly into formic acid and methanol in the body
  - with a half-life on the order of several seconds.
- **MF** is present in many foods (18)
  - e.g., fruits (20 -40 ppm),
  - fruit juices (30 -100 ppm),
  - fruit syrups (650 -1630 ppm),
  - honey (20 -2000 ppm),
  - wines (1 -340 ppm),
  - coffee, roasted (1350 -2200 ppm),
  - coffee, extracts (2000 -7700 ppm),
  - evaporated milk (30 -400 ppm), and
  - cheese (20 -200 ppm) (19). (20). (page 14)
- The 4-hour **inhalation LC50** of methyl formate was > 21 mg/L
- All found **negative** in the **Ames test**
- No further testing is recommended. (page 27).
Use in Foams

- Rigid
  - Pour
  - Spray
- Integral Skinned
- Flexible
Rigid Applications

- Moulded Roof Panels
- Pipe-in-Pipe Insulation
- Spray Foam
### Physical Properties

**POUR SYSTEMS**

**Very Good Properties**

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>ecomate 3-95-1.7</th>
<th>ecomate 2-90-1.7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>37 kg/m³</td>
<td>34 kg/m³</td>
</tr>
<tr>
<td>CS(//), kPa</td>
<td>317</td>
<td>283</td>
</tr>
<tr>
<td>CS(<em>|</em>), kPa</td>
<td>214</td>
<td>186</td>
</tr>
<tr>
<td>DIM STABS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COLD, 7d</td>
<td>-0.06 %</td>
<td>-0.06 %</td>
</tr>
<tr>
<td>HUMID, 7d</td>
<td>2.0 %</td>
<td>-0.21 %</td>
</tr>
<tr>
<td>Lambda</td>
<td>20.9</td>
<td>20.1</td>
</tr>
</tbody>
</table>
POUR FOAMS

- **ecomate** system gets HIGHEST Fire Resistance
  - FSI’s **eco1** System
    - **UL 723** – 25 FS / 300 Smoke - 30 – 42 kg/m³ core @ 15 cm
      - 15 FS / 65 Smoke – AL skins [9 - 14 cm]
      - 20 FS / 300 Smoke - Steel skins [9 - 14 cm]
  - **FM 4880** – Lg. Scale Corner Test – Passed

- **ecomate** excellent for PIR Boardstock
  - Laminator approval obtained.

- System shipping possible w/o ‘Flammable’ tags
- Foam recycling / disposal w/o environmental impact.
SPRAY FOAM

- Like other foams – except:
  - Faster Reacting
  - Prolonged Shelf Stability > 3 mos.
  - 1:1 by volume
  - Uncontrolled Application Environment

- Two routes
  - PUR & PIR
SPRAY FOAM

- Blended polyols
  - Ester - Cost & Fire Properties
  - Amine - Reactivity & Can Stability
  - Mannich - Adhesion & Can Stability
  - Sucrose - Strength & Char

- What is the Best Combination?
D-Optimal Mixture
DESIGN EXPERT 6.0

- DMT ESTER, 184 Eqwt
- MANNICH, 178 Eqwt
- SUCROSE, 152 Eqwt
- AMINE, 94 Eqwt

- 20 – 50 Parts
- 20 – 40 Parts
- 0 – 30 Parts
- 0 – 25 Parts
# D-Optimal Mixture

**DESIGN EXPERT 6.0**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Eqwt</th>
<th>Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMT ESTER</td>
<td>184</td>
<td>20 – 50</td>
</tr>
<tr>
<td>MANNICH</td>
<td>178</td>
<td>20 – 40</td>
</tr>
<tr>
<td>SUCROSE</td>
<td>152</td>
<td>0 – 30</td>
</tr>
<tr>
<td>AMINE</td>
<td>94</td>
<td>0 – 25</td>
</tr>
<tr>
<td>FIRE RETARDANT</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>ecomate</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>WATER</td>
<td></td>
<td>2.5</td>
</tr>
<tr>
<td>WATER</td>
<td></td>
<td>2.5</td>
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D-Optimal Mixture
DESIGN EXPERT 6.0

- DMT ESTER, 184 Eqwt
- MANNICH, 178 Eqwt
- SUCROSE, 152 Eqwt
- AMINE, 94 Eqwt

- OPTIMIZED [DESIGN EXPERT]
  - ESTER 50
  - MANNICH 21
  - SUCROSE 29
  - AMINE 0

- 45 FS / 400 SMOKE
SPRAY FOAM

- GOOD PROPERTIES
- CLASS 1 & 2 FLAMMABILITY
- 3+ MOs STABILITY
Integral Skin
Integral Skin

- **ecomate** – best alternative to 141b
- Solvates all Raws currently used
- BPt. just above ambient [like 141b]
  - Permits good skin formation
  - Allows fast demold times
- Environmentally Benign
- Economical – Mol Wt **HALF** of 141b
- US EPA SNAP Approved
Flexible Foams
Molded & Slab

- Good Solubility
- Fine Cells
- Safer than MeCl$_2$,
  Acetone
- Non-VOC
- Excellent Hand
- Can use MDI
Toxic Effects

- Long Term Animal Studies - **ACETONE**
  - Kidney Damage
  - Liver Damage
  - Nerve Damage
  - Increased Birth Defects
  - Lowed Reproduction [Males]

- Long Term Animal Studies – **MeCl₂**
  - Cancer of Lungs, Liver, Pancreas
  - Fetal Toxicity [Females]
## Flexible Foams

### Molded & Slab

<table>
<thead>
<tr>
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<th>Acetone</th>
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</tr>
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<tbody>
<tr>
<td>Mol Wt</td>
<td>60</td>
<td>58</td>
<td>85</td>
</tr>
<tr>
<td>B Pt, °C</td>
<td>32.1</td>
<td>56.3</td>
<td>40</td>
</tr>
<tr>
<td>LEL, vol%</td>
<td>5</td>
<td>2.5</td>
<td>12</td>
</tr>
<tr>
<td>UEL, vol%</td>
<td>23</td>
<td>12.8</td>
<td>23</td>
</tr>
<tr>
<td>Heat of Vaporization, cal/g</td>
<td>112.4</td>
<td>130</td>
<td>78.9 <strong>CARCINOGEN</strong></td>
</tr>
<tr>
<td>PEL, ppm</td>
<td>5000</td>
<td>1000</td>
<td>25</td>
</tr>
<tr>
<td>TLV, ppm</td>
<td>100</td>
<td>500</td>
<td>50</td>
</tr>
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# Flexible Foams

**Molded & Slab**

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- **Ecomate**
  - Lower GWP
  - Lower HtVap = Lower Dens
  - Safer to Use
    - MeCl₂ = Carcinogen
    - 2x higher LEL = SAFER
    - 5x higher PEL = SAFER
    - 1/5 lower TLV = SAFER
  - No Baggage – Now or Future!
CONCLUSIONS

- SPRAY
  - GOOD PROPS, CLASS 1 & 2, 3+ MOs STABILITY

- POUR
  - EXCELLENT PROPS, HIGH FIRE RESISTANCE

- INTEGRAL SKIN
  - ecomate - a perfect fit
    - solubility,
    - ideal BPt,
    - Lo MW,
    - environmentally benign

- SLABSTOCK
  - All the above
  - Safer than Acetone, MeCl₂
ecomate® advantages

- A True **LIQUID** Blowing Agent
- Good Solubility
- Low Volatility
- Good Foam Properties
- Good Flammability Resistance
- Cost Competitive
- BENIGN to ENVIRONMENT
- No Future Baggage!
Contacts – S/C America

- PURCOM Quimica Ltda
- Gerson Silva
- Rua Aeroporto n° 83/115
- 06419 260 Barueri, SP, BRAZIL
- TEL:(+55 11) 4168 2829
Contacts - EUROPE

- BOC Specialty Gases
- Zoë Sturdy
- 10 Priestly Rd
- Guildford, Surrey GU2 7XY
- ENGLAND
- TEL: +44 (0)1483 244 088
Contacts – Australia / SE Asia

- Australian Urethane Systems
- Roy Chowdhury
- 25 Garling Rd
- Kings Park NSW 2148
- TEL: (+1300) 304 522
Contacts - ROW

- FOAM SUPPLIES INC
- Todd Keske
- 4387 North Rider Trail
- Earth City, MO 63045
- USA
- TEL: 314-344-3330
The Next Generation Blowing Agent