Breakthrough Innovative and Sustainable Solution for Herbicide

CAC Conference Shanghai 2017
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Summary

Glyphosate Weed resistance and Regulation, e.g. Tallow Amine Ethoxylate (TAE) ban in Europe and Paraquat ban in China, are shifting the Herbicide market from Glyphosate solo to multiple a.i. combinations

3 herbicides will see their volumes quadruple over the next decades

- 2,4-D for pre-emergence and DOW Enlist system
- Dicamba for Monsanto’s XTEND system (launch 2017 USA)
- Glufosinate as an alternative weed control solution to Glyphosate and to replace Paraquat

This new market evolution creates new challenges for formulators

- Regulation – develop safe, eco-friendly alternative to Tallow Amine Ethoxylate (TAE)
- Regulation – develop activators for Glyphosate/Glufosinate combos to match Paraquat performance
- Vapor drift and off-target movement control – to fight off 2,4D and Dicamba volatilization
Market Context driven by Weed resistance and regulation

3 herbicides will see their volumes quadruple over the next decades

- 2,4-D for pre-emergence and DOW Enlist system
- Dicamba for Monsanto’s XTEND system (launch 2017 USA)
- Glufosinate as growing answer to Glyphosate resistance and to replace Paraquat
# Market and Technical Trends

<table>
<thead>
<tr>
<th>Trends</th>
<th>Drivers</th>
<th>Projected market size in 10 years</th>
<th>Technical &amp; formulation challenges</th>
</tr>
</thead>
</table>
| Glyphosate | →↘ | - Weed resistance (US)  
- Regulation (EU) | 5 B$  
(Stable) | • Replace TAE  
• Combo Formulations  
• High Load (cost and supply chain) |
| 2,4D | ↑ | - DOW  
- Pre-emergence | 2.0 B$  
(15% CAGR) | • Volatilization Control  
• Combo Formulations |
| DICAMBA | ↑↑ | - MONSANTO  
| | 2.5 B$  
(40% CAGR) | • Volatilization Control  
• Combo Formulations |
| Glufosinate | ↑↑ | - Regulation (Paraquat ban)  
- BAYER | 2.5 B$  
(20% CAGR) | • GLU/GLY (alt. Paraquat)  
• Better efficacy  
• Reduce Treatment Cost |

SOLVAY Agro R&D Teams are developing solutions to meet this new challenges

- Glyphosate TAE Replacement AGRHO & GERONOL FKC
- Glyphosate High Load and Compatibility Solution GERONOL CF
- Glufosinate Efficacy Booster GERONOL N series
- VOLTIGO R&D Platform for Drift and Volatilization Control 2,4-D and Dicamba
Solvay Glyphosate Solutions

Glyphosate bio-activators

Leading worldwide market share among generic Glyphosate

- Agrho® FKC 1500
- Geranol® CF/AR E

Novel Class bioactivators

- Geranol® CF K10
- Geranol® CF 82CC
- Geranol® NV37

Alternative technology to tallow amine

- Geranol® FKC 2080
- Geranol® CF/AS 30HL
- Agrho® FKC 1500
**AG-RHO® FKC 1500**

*Industry standard for efficacy*

- Ideal for Glyphosate IPA recipes at 360g/L and 480g/L, stable in 540g/L
- Low viscosity vs. TAE, loading up to 15%
- Excellent Regulatory Profile
- Compatible tank mixtures with 2,4-D and Dicamba

**Greenhouse Trials, CSU**

- 360g/L Gly IPA + 120g/L surfactant
- Sprayed at 1/4lb per acre
- Control reported as average control on 9 weed species

**Field Trials, Illinois**

- 360g/L Gly IPA + 120g/L surfactant
- Sprayed at 1/3lb per acre on 5ft x 20ft plots.
- Control reported as average control on 7 weed species
GERONOL® CF/AR E
The safest choice

- Ideal for IPA recipes up to 450 g/L
- Best Regulatory Profile recommended for
  - EU markets
  - Home & Garden and Industrial markets
- Suitable for combo Formulations

Green house and open field test (Bologna/Italy)
Sprayed at 3 litres/Ha 360g/L
The results are the average of 4 trials

Test on Dicotyledon: (Amaranthus R, Abutilon T, Solanum N, Chenopodium A)
development stage 30/40 cm
GERONOL® FKC 2080
Designed for premium market to substitute TAE

- Specifically engineered for very high load IPA formulations competitive for export markets
- Best efficacy and cost-effective alternative to TAE
- Excellent Regulatory Profile

540g/L Gly IPA + 160g/L Bio-activator

Efficacy
Cost in use

TAE
FKC2080
GERONOL® CF K10
Innovation for K salt formulation

- Unique Bioactivator Solution for K recipes up to 540g/L
- Excellent low temperature stability
- Low viscosity

![Comparison chart between Conventional and CFK10](chart.png)
GERONOL CF 82CC
Innovation for future herbicide combos

- Unique Patent-Pending Bioactivator Solution
- Excellent compatibility
- Good tox/ecotox profile
- Non-foaming
- Flexibility for use in multiple salts, ideal candidate for 2,4-D and Dicamba combos

Greenhouse Trials, IL

Test on ABUTH, IPOHE, SETVI, SETFA, CYPES
GERONOL CF NV37
Innovation for future Glyphosate ammonium

- Unique Patent-Pending Bioactivator Solution
- Excellent compatibility
- Good tox/ecotox profile
- Unbeatable cost leadership
- Flexibility for use in Glyphosate ammonium salts

**Glyphosate-NH4 30% ae SL**

- Glyphosate Acid, 95% 31.6%
- Geronol CF NV37 10%
- Ammonia, 25% 22%
- DI Water Balance to 100%
# Solvay Glyphosate Bioactivator regulatory profile

<table>
<thead>
<tr>
<th></th>
<th>AgRHO FKC 1500</th>
<th>Geronol CF/AR-E</th>
<th>Geronol CF 82 CC</th>
<th>TAE 15 Tallow amine ethoxylate 15</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Label</strong></td>
<td>H319: eye irritant</td>
<td>Not hazardous under OSHA HCS 2012</td>
<td>Not hazardous under OSHA HCS 2012</td>
<td>H302: Harmful if swallowed. H330: Fatal if inhaled H318: Causes serious eye irritation</td>
</tr>
<tr>
<td><strong>Signal Word</strong></td>
<td>Warning</td>
<td>None</td>
<td>None</td>
<td>Danger</td>
</tr>
<tr>
<td><strong>Acute toxicity</strong></td>
<td>&gt;2000 mg/kg (oral LD50)</td>
<td>&gt;2000 mg/kg (oral LD50)</td>
<td>&gt;2000 mg/kg (oral LD50)</td>
<td>558 mg/kg (oral LD50) 0.51 mg/L (vapor LC50: 4hr)</td>
</tr>
<tr>
<td><strong>Skin irritation</strong></td>
<td>Not classified</td>
<td>Not classified</td>
<td>Not classified</td>
<td>Not classified</td>
</tr>
<tr>
<td><strong>Eye irritation</strong></td>
<td>Eye Irritant (2A)</td>
<td>Not classified</td>
<td>Not classified</td>
<td>Severe Eye Irritant (1)</td>
</tr>
<tr>
<td><strong>DOT (Transport)</strong></td>
<td>Not regulated</td>
<td>Not regulated</td>
<td>Not regulated</td>
<td>UN2810 Class 6.1 Toxic</td>
</tr>
<tr>
<td><strong>Environmental classification (GHS)</strong></td>
<td>Acute aquatic toxicity Category 2 Chronic aquatic toxicity Category 3 H401, H412</td>
<td>Not classified</td>
<td>Not classified</td>
<td>Acute aquatic toxicity Category 2 Chronic aquatic toxicity Category 2 H401, H411</td>
</tr>
<tr>
<td><strong>Acute Fish</strong></td>
<td>LC50 (96h) = 4.4 mg/L (active ingredient)</td>
<td>LC50 (96h) &gt; 100 mg/L</td>
<td>LC50 (96h) &gt; 100 mg/L</td>
<td>LC50 (96h) = 1.3mg/L</td>
</tr>
<tr>
<td><strong>Acute Daphnia</strong></td>
<td>EC50 (48h) = 7.7 mg/L (active ingredient)</td>
<td>EC50 (48h) &gt; 100 mg/L test on one ingredient</td>
<td>EC50 (48h) &gt; 100 mg/L</td>
<td>EC50 (48h) = 1.7 mg/L</td>
</tr>
<tr>
<td><strong>Biodegradability</strong></td>
<td>Readily biodegradable</td>
<td>Ultimately biodegradable</td>
<td>Readily biodegradable</td>
<td>Inherently biodegradable</td>
</tr>
</tbody>
</table>
Solutions for Glufosinate formulations

- A global product to all fast growing Glufosinate markets (China, USA, Brazil)
- Innovation: breakthrough weed control performance vs SLES
- A sustainable solution for Paraquat alternative formulations and reduced Glufosinate surfactant loading
GERONOL® N80S
Cost Driven Innovation for Glufosinate formulation

- High efficacy
- Better usage value
- User friendly at low temperature conditions

18.5% Glufosinate SL

- Glufosinate (50%)
- Geronol N80S
- Water

<table>
<thead>
<tr>
<th>Property</th>
<th>Commercial benchmark</th>
<th>Geronol N80S</th>
<th>Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glufosinate</td>
<td>37%</td>
<td>25%~30%</td>
<td>to 100%</td>
</tr>
<tr>
<td>Density</td>
<td>1.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Viscosity</td>
<td>25 cps</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Appearance: Clear Yellow
VOLTIGO
Volatileization and Drift Control Global Expertise

Additives and solutions for combined control
- Vapor Drift (volatilization) of 2,4D and Dicamba
- Physical Drift (droplet size) of herbicide spray

Offering
- In-can additives to formulators – In development
- Ready-to-use, customizable tank-mix products to distributors or copack – launching STARGUAR™ Control
AgRho® STARGUAR® Control
Tank Mix AntiDrift for Combo Herbicide

- Starguar Control – AMS-free drift control Tank Mix for Glyphosate solo and combo formulations
- Combining spray droplet size control and wetting/retention properties for optimal off-target movement control

Spray conditions: Use rate of Glyphosate-K (RU Powermax): 1.67% v/v; Nozzle: Flat fan Teejet XR11003; spray pressure: 3 bars
VOLTIGO

Volutilization control in-can additives proof of concept

Thermobalance (5h, 75°C, 2g)
DMA Dicamba 485 g/L + 0.65 % w/w VOLTIGO Additive

\[ \Delta m = 1.9\% , \text{slope } \Delta m/ \Delta t = 0.25 \]
\[ \Delta m = 3.7\% , \text{slope } \Delta m/ \Delta t = 0.45 \]

Water Evaporation is reduced
- Humectancy
- Contact time with cuticle
- Kinetics of penetration improve efficacy

Final \( \Delta m\% \) and slope \( \Delta m/ \Delta t \) decreasing highlighting a reduction of Dicamba DMA volatilization.
THANK YOU!

Zhichao Han, China Lab – Glufosinate and Glyphosate formulations
Paul Gioia, Australia Lab – Glyphosate innovation
Zixian Chen, Singapore Lab Manager
Tom Ruch, US Lab – Glyphosate Formulations
Hong Liu, North America Lab Manager
Neal Ryan, US Lab – Drift Control Adjuvants Voltigo Team
Laurianne Moity, France Lab – Volatilization Expert, Voltigo Team
Monique Adamy, Europe Lab Manager
Krish Shanmuga, Global R&D Solvay Agro