Rhodiasolv® Range – New Eco-friendly solvents as an alternative for toxic solvents

Dr. David LANSON
Technical support and Account Manager Europe

Novecare
WE ARE AN ADVANCED MATERIALS AND SPECIALTY CHEMICALS COMPANY

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017 underlying results</td>
<td></td>
</tr>
<tr>
<td>MTAR: Medical Treatment Accident Rate</td>
<td></td>
</tr>
<tr>
<td>Employees</td>
<td>24,500</td>
</tr>
<tr>
<td>Countries</td>
<td>61</td>
</tr>
<tr>
<td>Industrial sites</td>
<td>124</td>
</tr>
<tr>
<td>Major R&amp;I centers</td>
<td>21</td>
</tr>
<tr>
<td>Greenhouse gas intensity</td>
<td>5.53</td>
</tr>
<tr>
<td>Occupational accidents at Group sites</td>
<td>0.65</td>
</tr>
<tr>
<td>Sustainable solutions</td>
<td>49%</td>
</tr>
<tr>
<td>Billion of net sales</td>
<td>€ 10.1</td>
</tr>
<tr>
<td>EBITDA kg CO₂ eq. per €</td>
<td></td>
</tr>
</tbody>
</table>

1. 2017 underlying results
2. MTAR: Medical Treatment Accident Rate
NOVECARE
DELIVERING SUSTAINABLE SOLUTIONS FOR SURFACE CHEMISTRY

Focused on key markets

- Oil & Gas: 28%
- Agro: 14%
- Coatings: 12%
- Industrial: 23%

North America
- 11 production sites
- 12 R&I & tech centers
- 23% Net sales 2017

Europe
- 6 production sites
- 4 R&I & tech centers
- 47% Net sales 2017

Latin America
- 2 production sites
- 1 R&I center
- 23% Net sales 2017

Asia & RoW
- 8 production sites
- 5 R&I & tech centers
- 21% Net sales 2017

Net sales 2017:
- 1.9 B€

Employees:
- ~3,100 employees

Production sites:
- 27 production sites

R&I & tech centers:
- 22 R&I & tech centers

Net sales
- 2017

SOLVAY
asking more from chemistry®
Contents

• Introduction to Rhodiasolv® IRIS

• Introduction to Rhodiasolv® Polarclean HSP

• Introduction to Rhodiasolv® Infinity
  • Overview of Performance Benefits
  • Applications
Rhodiasolv® IRIS
New Eco-friendly solvent
Rhodiasolv® IRIS: Green Solvents

New branched diester solvent

Cas Number [14035-94-0]

Dimethyl-2-methyl glutarate

<table>
<thead>
<tr>
<th>Boiling Point (°C)</th>
<th>Flash Point (°C)</th>
<th>Vapour Pressure 20°C (Pa)</th>
<th>Evaporation Rate 25°C (n-Bu.Ac.=1)</th>
<th>Hazard Statements</th>
<th>Signal Words</th>
<th>Symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td>760 mm Hg</td>
<td></td>
<td></td>
<td></td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>222-224</td>
<td>98</td>
<td>6.1</td>
<td>0.006</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

⇒ Valorization of a by-product of Polyamide 6,6 by avoiding incineration
2. Excellent Health and Safety Environmental Profile

✓ No labelling, No risk phrases

• Non flammable (FP=98°C)
• Non Toxic, non Carcinogenic, non irritant
• Non VOC (directive 1999/13/EC)
• Readily Biodegradable

• Safety of workers
• Reducing flammability risks in workshops
• Protection of the environment
Rhodiasolv® IRIS is safer and Eco-friendly

3. Cost saving

☑ **Volumes consumed are reduced** due to low rate of evaporation (example: 3-4 times less than acetone/methylene chloride)

☑ **Potential insurance cost reduction** due to non-flammable classification (storage and lower requirement on-fire proofed equipment)

☑ **Easy-to-recycle by distillation** (internal recycling machine or outsourcing recycling)
Rhodiasol® IRIS and Hansen solubility parameters

Making it a suitable replacement for a wide range of solvents:

- **Ester**
  - Rhodiasol IRIS

- **Chlorinated**
  - Dichloromethane

- **Amides**
  - NMP

- **Ketone**
  - Acetone
  - MEK

### Hansen solubility parameters and Rhodiasol® IRIS

- **Green solvents**
- **Harmful solvents**

<table>
<thead>
<tr>
<th>Solvent</th>
<th>Flammability (Flash point)</th>
<th>Evaporation lose</th>
<th>Health and safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhodiasol IRIS</td>
<td>Non flammable</td>
<td>Very low</td>
<td>Non toxic Non irritant</td>
</tr>
<tr>
<td>Acetone</td>
<td>Flammable</td>
<td>Very high</td>
<td>Flammable Irritant</td>
</tr>
<tr>
<td>DCM</td>
<td>Non flammable</td>
<td>Very high</td>
<td>Reprotoxic CMR 2</td>
</tr>
<tr>
<td>NMP</td>
<td>86°C</td>
<td>Low</td>
<td>Reprotoxic CMR 1B</td>
</tr>
</tbody>
</table>
Performance testing of Rhodiasolv® IRIS in Resin Clean-up

**Time to dissolve Unsaturated Polyester**

- **Acetone**
- **Rhodiasolv® IRIS**
- **Rhodiasolv® IRIS (T=40°C)**

Protocol:
- Resin without MEKP
- Blend solvent/resin 50/50 agitation in a reactor

- **Equivalent cleaning performance** compared to acetone at RT
- **Quicker cleaning speed** with Rhodiasolv® IRIS at 40°C. Heating possible because Rhodiasolv® IRIS is non-flammable and has a very low evaporation rate

![Graph showing solubilization time for different resins with Acetone, Rhodiasolv® IRIS, and Rhodiasolv® IRIS (T=40°C)]
Performance testing of Rhodiasolv® IRIS in Resin Clean-up

- Good cleaning performance with Rhodiasolv® IRIS compared to other toxic solvents.
- Better performance with Rhodiasolv IRIS at 40°C
Tool Cleaning with Rhodiasolv® IRIS

Do not use Rhodiasolv® IRIS as Acetone

Resin with carbon powder → Dipped for 10 minutes in Acetone → After 30 s drying

How using Rhodiasolv IRIS?

It does not work

It works

Need to change the way to use it. For instance:
- Longer stirring
- Let soaked in a bucket
- To heat
- ...

To speed the drying process, wipe the surface with a dry cloth, use compressed air, or heating...
SINNER’S CIRCLE: 4 INTERDEPENDENT PARAMETERS CONTRIBUTING TO CLEANING PERFORMANCE

Chemistry
(composition, concentration, contamination)

Mechanics
(agitation, spray pressure)

Temperature
(reaction rate, viscosity)

Time
Cleaning Gel Coat Machines with Rhodiasolv® IRIS

☑ Improving cleaning performance on gelcoat machines

Trials carried out to demonstrate successful cleaning of gel coat machines

Set-up

- BÜFA standard Gelcoat non dried used
- Same process and time used than acetone
- Rhodiasolv IRIS heated by oven at 35°C
- First cleaning to remove big residuals
- Second cleaning with fresh solvent for finishing touches
Results

Acetone

Rhodiasolv IRIS at room temperature

Rhodiasolv IRIS at 35°C

Gelcoat can be removed with hot Rhodiasolv IRIS
Results

Acetone

Rhodiasolv IRIS at room temperature

Rhodiasolv IRIS at 35°C
Additional applications for Rhodiasolv® IRIS

- Resin clean-up (Polyesters, Epoxy, Isocyanate…)
- Cleaner for Textiles
- Cleaner for Windmill
- Cleaners for semi-conductors/electronics
- Detergence & cleaner (Inks, Strippers, Homecare…)
- Industrial wet wipes
- Coatings
- Inks
- Nail polish removers
- Toluene replacement applications
Rhodiasolv® Polarclean HSP
New Eco-friendly solvent
Rhodiasolv® PolarClean HSP is part of a new range of sustainable solvent technologies and solvent formulations from Solvay

- **Polar and water soluble** solvent
- **Solvency Profile similar to N-Methylpyrrolidone (NMP), N-Ethylpyrrolidone (NEP).** Able to replace Glycols, DMSO.
- **Excellent** toxicological & ecotoxicological **profiles**
- **Non-VOC** (regulation 1999/13/EC and 2004/42/EC)
- **Non-flammable**
- **REACH compliant**
Hansen parameters
<table>
<thead>
<tr>
<th></th>
<th>N-methylpyrrolidinone NMP</th>
<th>Rhodiasolv® Polarclean HSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>IUPAC Name</td>
<td>N-methylpyrrolidinone</td>
<td>Pentanoic acid, 5-(dimethylamino)-2-methyl-5-oxo-,methyl ester</td>
</tr>
<tr>
<td>Appearance</td>
<td>Clear, colorless to slightly yellow liquid</td>
<td>Clear, colorless to yellow liquid</td>
</tr>
<tr>
<td>Odor</td>
<td>Slight amine odor</td>
<td>Slight odor</td>
</tr>
<tr>
<td>Solubility</td>
<td>Soluble in water</td>
<td>Soluble in water</td>
</tr>
<tr>
<td>Boiling Point</td>
<td>202°C</td>
<td>280°C</td>
</tr>
<tr>
<td>Melting Point</td>
<td>-24°C</td>
<td>&lt;-60°C</td>
</tr>
<tr>
<td>Flash Point</td>
<td>86°C</td>
<td>146°C</td>
</tr>
<tr>
<td>Vapour Pressure</td>
<td>40 Pa @ 25°C</td>
<td>1 Pa @ 25°C</td>
</tr>
<tr>
<td>Evaporation rate</td>
<td>0.06 (BuAc=1)</td>
<td>0.002 (BuAc=1)</td>
</tr>
<tr>
<td>Density</td>
<td>1.028 at 20°C</td>
<td>1.043 at 20°C</td>
</tr>
<tr>
<td>GHS</td>
<td>Danger</td>
<td>Warning</td>
</tr>
<tr>
<td>OSHA Hazards</td>
<td>CMR 1B, May damage the unborn child, May cause respiratory irritation, skin irritation, serious eyes irritation.</td>
<td>H319 Serious eyes irritation,</td>
</tr>
<tr>
<td>VOC 2004/42/EC</td>
<td>VOC</td>
<td>Non-VOC</td>
</tr>
<tr>
<td>Biodegradability</td>
<td>Readily Biodegradable (301F)</td>
<td>Inherent Biodegradable (302B)</td>
</tr>
</tbody>
</table>
Applications of Rhodiasolv® Polarclean HSP

- DMPA-based polyurethane Dispersion (PUD)
- Resin clean-up (Polyester, epoxy, Polyurethane, polyimide…)
- Solvent casting of membranes
- Industrial cleaning applications
- General Polymer processing (Poly(ether)sulfone, polyamide-imide, polyimide…)
- Stabilizers in organic peroxydes synthesis
- Lubricants
Rhodiasolv® Infinity
New Eco-friendly formulation
Rhodiasolv® Infinity is a novel microemulsion concentrate based on Rhodiasolv® IRIS

**Benefits:**

- **High Performance**
  - Efficient at neutral pH
  - Unique structure results in improved solubility and performance
  - Multi-purpose applications

- **Safe**
  - Biodegradable, non toxic, non mutagenic, non flammable

**Typical characteristics:**

- Clear, Transparent Liquid
- High flash point, low vapor pressure
- Infinitely dilutable concentrate
- 100% soluble in water
- Efficient in a pH window from 4 to 9
Rhodiasolv® Infinity

Simplicity and Speed in the Pursuit of Environmentally Preferable Alternatives

- Robust concentrate based on Rhodiasolv® Iris and surfactants
- Flexibility remains with the formulator
  - Readily accepts water soluble glycols, alcohols surfactants
- Capable of infinite dilution
  - Able to “dial in” performance, cost, actives

Formulation ease

<table>
<thead>
<tr>
<th>Dilution H₂O</th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhodiasolv® Infinity + 0% Glycol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhodiasolv® Infinity + 30% Glycol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rhodiasolv® Infinity meets the requirements for LVP-VOC exemption per CARB
3 main applications for a innovative sage alternative solvent

- Spot Cleaner
- D-limonene extender
- Multi-purpose decreaser for Hard surface cleaner
Rhodiasolv® Infinity: Multi-purpose Stain Cleaner

Rhodiasolv® Infinity can be used to replace traditional solvents without sacrificing performance

Testing Protocol

- Commercial High Gloss Paint, Cured 7 Days
- Stains Applied, Dried for 1 Day
- Modified Garco Scrub Tester
  - Cotton swab over a foam brush
  - 1mL of solvent applied to panel
  - 60 cycles total, change cotton every 20 cycles
- Control
  - >98% Aromatics + Glycols
- Rhodiasolv Infinity
  - Diluted with 40% water
  - pH neutral
- Formulation easily customized
Rhodiasolv® Infinity: Light Institutional / Consumer Degreaser

Degreaser based on Rhodiasolv® Infinity delivers performance

- **Test**
  - 2 sprays of cleaner on applied grease
  - 2 sprays of water (observe drainage)

Substrate (Tile) prepared with dirty motor oil + carbon black

<table>
<thead>
<tr>
<th>DEGREASER</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>90.00%</td>
</tr>
<tr>
<td>Rhodiasolv® Infinity</td>
<td>5.00%</td>
</tr>
<tr>
<td>Miranol C2S conc NP</td>
<td>5.00%</td>
</tr>
</tbody>
</table>

Equivalent to Benchmark

- **Benchmark 1**
  - pH 9.5
  - Rhodiasolv® Infinity Formulation

- **Benchmark 2**
  - pH 11.5
  - Rhodiasolv® Infinity Formulation

Outperforms Benchmark
Examples of formulation for mineral oil degreasing based on Rhodiasolv® Infinity

<table>
<thead>
<tr>
<th>DEGREASER 1</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhodiasolv® Infinity</td>
<td>24.00%</td>
<td></td>
</tr>
<tr>
<td>Fatty Acid Methyl Ester</td>
<td>37.00%</td>
<td></td>
</tr>
<tr>
<td>Geropon DOS</td>
<td>11.00%</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>28.00%</td>
<td></td>
</tr>
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</table>

DOS = dioctyl sulfosuccinate

<table>
<thead>
<tr>
<th>DEGREASER 2</th>
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</thead>
<tbody>
<tr>
<td>Rhodiasolv® Infinity</td>
<td>25.00%</td>
<td></td>
</tr>
<tr>
<td>Fatty Acid Methyl Ester</td>
<td>35.00%</td>
<td></td>
</tr>
<tr>
<td>Rhodiasolv RPDE</td>
<td>3.00%</td>
<td></td>
</tr>
<tr>
<td>Geropon DOS</td>
<td>11.40%</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>25.60%</td>
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</table>
Rhodiasolv® Infinity:
1. Heavy duty degreaser (oven, barbecue)

- Faster results with Rhodiasolv Infinity
- pH neutral vs basic pH (13.5)

<table>
<thead>
<tr>
<th>Heavy duty degreaser</th>
<th></th>
</tr>
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<tbody>
<tr>
<td>Water</td>
<td>69.00%</td>
</tr>
<tr>
<td>Rhodiasolv® Infinity</td>
<td>30.00%</td>
</tr>
<tr>
<td>Rhodopol 23 (Xanthan Gum)</td>
<td>1.00%</td>
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</table>
Markets using Rhodiasolv® Infinity

- **Degreasing**
  - Home Care: Kitchen degreaser and Oven cleaner
  - I&I: safety kitchen and floor decreaser
  - Dilutions from 5% (Light decreasing) up to 35% (Heavy duty)

- **Adhesive Removal**

- **Floor resin clean-up**
  - Polyester, Epoxy and polyurethane cleaning

- **Leather cleaning**

- **Printing cleaning**

- **Spot Cleaner**