Encapsulation Technologies for Stabilisation of Actives in Consumer Cleaning Products

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RSC Right On Target Symposium, 25th June 2015
OVERVIEW

Introduction to Revolymer

The formulation challenge

Revolymer’s technical solution - Active encapsulation

Oxygen bleach for unit-dose liquids and bulk powders

RevPerox™ SPC - encapsulated Sodium Percarbonate particle

Oxygen bleach for multi-compartment unit-dose pods

Eureco™ RP103 - stabilised PAP bleach granule

Bleach catalyst for ADW tablets

RevCap™ MnTACN - stabilised Manganese catalyst particle

Summary
REVOLYMER
THE POLYMER TECHNOLOGY COMPANY

Improving the performance of our partners’ products
using innovative polymer and encapsulation systems

Competency
Polymer expertise, QA/QC, Regulatory, cGMP, Food Standards, Supply chain, Licensing

Capability
design, synthesis, optimisation, process, formulation & testing

People
30 Employees, 20 in R&D, 9 PhDs, >20 years average experience
drawn from diverse backgrounds: FMCG, Pharma, Polymer, Colloids, biocides, food, paints...
<table>
<thead>
<tr>
<th>Section</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home &amp; Professional Care</td>
<td>Laundry, Dishwash, Surface cleaners, Active delivery</td>
</tr>
<tr>
<td>Personal Care &amp; Cosmetics</td>
<td>Hair, Skin and Oral Care</td>
</tr>
<tr>
<td>Industrial</td>
<td>Barrier coatings, Adhesives and Sealants</td>
</tr>
<tr>
<td>Medicated Chewing Gum</td>
<td>Nicotine Chewing Gum</td>
</tr>
</tbody>
</table>
The Formulation Challenge

Stabilising Actives in Solid and Liquid Detergent Products
REVOLYMER IN HOME CARE
A GROWING FORMULATION CHALLENGE

The growing formulation challenges associated with stabilisation of active benefit agents in detergent formulations is a consequence of the move to consumer convenient products without compromising performance.

Challenges:

- Shelf life - maintaining stability of the active in the product
- Releasing active quickly in-use
- Effective at low temperatures and short cycles
On the shelf

Product challenges
- Incompatible components
- Reactivity of media
- Protection of actives
- Stability and release of active

Example Actives
- Peroxide/peracid
- Catalysts
- Enzymes
- Activators

In the end use

Triggers
- pH change
- Ionic strength change
- Dilution
Particles containing the active are coated with a responsive material through processes such as spray coating.

Polymer coating protects the active from incompatible media components.
The responsive polymer that is coated onto the active particles provides:

- Impermeable barrier to formulation ingredients
- Tuneable release of active when product is used
  - Triggered by pH, dilution, ionic strength change…

Polymer coating remains intact as a barrier

Coating dissolves in end use application to release the active efficiently into solution
Oxygen Bleach for Unit-dose Liquids

RevPerox™ SPC - Responsive Polymer Coated Sodium Percarbonate
REVPEROX<sup>TM</sup> SPC
SUCCESSFUL INNOVATION - ENCAPSULATED SPC GRANULE

- Responsive polymer coated SPC particle
- Dust free, mechanically stable, robust particles
- Excellent stability in a range of formulations:
  - Laundry and ADW
    - Unit dose liquid capsule
    - Bulk powder
- Rapid dissolution at low temperature
STABILITY OF REVPEROX™ SPC
LIQUID UNIT-DOSE LAUNDRY

✓ Successful incorporation of stabilised SPC particles into liquid laundry pod
✓ Dramatic improvement of SPC stability with responsive polymer coating

Stability of RevPerox™ SPC in commercial unit-dose laundry pod

<table>
<thead>
<tr>
<th></th>
<th>% SPC activity remaining</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Sodium Percarbonate Grade</td>
<td>56.65 (7 days ambient), 53.2 (7 days 32°C), 37.76 (28 days ambient), 17.56 (28 days 32°C)</td>
</tr>
<tr>
<td>RevPerox™ SPC SF8</td>
<td>97.44 (7 days ambient), 92.54 (7 days 32°C), 89.74 (28 days ambient), 76.26 (28 days 32°C)</td>
</tr>
<tr>
<td>RevPerox™ SPC SF8 (modified - reduced water activity)</td>
<td>99.93 (7 days ambient), 98.48 (7 days 32°C), 99.59 (28 days ambient), 93.93 (28 days 32°C)</td>
</tr>
</tbody>
</table>
STABILITY OF REVPEROX™ SPC
LIQUID UNIT-DOSE ADW

✓ Successful incorporation of stabilised SPC particles into liquid ADW pod
✓ Dramatic improvement of SPC stability with responsive polymer coating

Stability of RevPerox™ SPC in modified commercial unit-dose ADW pod

<table>
<thead>
<tr>
<th>Condition</th>
<th>Commercial Sodium Percarbonate Grade</th>
<th>RevPerox™ SPC SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 days ambient</td>
<td>60.73%</td>
<td>94.98%</td>
</tr>
<tr>
<td>7 days 32°C</td>
<td>26.53%</td>
<td>94.75%</td>
</tr>
<tr>
<td>28 days ambient</td>
<td>19.03%</td>
<td>87.94%</td>
</tr>
<tr>
<td>28 days 32°C</td>
<td>1.14%</td>
<td>72.52%</td>
</tr>
</tbody>
</table>
RELEASE PROFILE OF REVPEROX™ SPC
PERFORMED AT LOW TEMPERATURE IN A TERGO

✓ All samples demonstrate >80% release after 4mins

Peroxide release profile at 10°C into wash liquor
5g detergent/L

- 3% coating
- 10% coating
- unmodified percarbonate

% SPC released

0 10 20 30 40 50 60 70 80 90 100

Time (minutes)

0 1 2 3 4 5 6 7 8 9

All samples demonstrate >80% release after 4mins.
Oxygen Bleach for Bulk Laundry Powders

RevPerox™ SPC - Responsive Polymer Coated Sodium Percarbonate
STABILITY OF REVPEROX™ SPC LAUNDRY POWDER

✓ Improved SPC stability for RevPerox™ SPC compared to commercial grades

SPC stability in standard laundry powder

% SPC activity Remaining

- Commercial Sodium Percarbonate Grade B: 65%
- Commercial Sodium Percarbonate Grade A: 78%
- RevPerox™ SPC A: 96%
- RevPerox™ SPC E: 100%

28 days at 32 degC, 60% RH
Oxygen Bleach for Multi-compartment Unit-dose Pods

Eureco™ RP103 - A New Grade of Phthalimido-peroxy-hexanoic acid (PAP) Bleaching Agent
PHTHALIMIDO-PEROXY-HEXANOIC ACID - PAP

BENEFITS VERSUS OTHER BLEACH SYSTEMS

- Pre-formed peracid
- Registered on European Biocides Regulation
- Superior bleach performance against hydrophobic stains
  - pH < 10 and T < 40°C
- Provides an improved performance even at a lower dose level compared to SPC-Activator
**EURECO™ RP103* - PAP**

**SUCCESSFUL INNOVATION - STABILISED PAP GRANULE**

- Novel boron-free PAP composition (64% PAP)
- Dust free, mechanically stable, robust particles
- For use in domestic and professional formulations:
  - Laundry and ADW
    - powder and tablet
    - Unit dose liquid-solid dual compartment
- Excellent compatibility with PVOH film
- Very rapid dissolution at low temperature

*Available from Solvay*
STABILITY OF EUReCO™ RP103 IN DUAL COMPARTMENT POD
PAP IN PVOH POUCH IMMERSED IN LIQUID POD FORMULATION

✓ Eureco RP103 provides improved PAP stability

PAP stability following storage of PVOH pouch of PAP in commercial liquid pod formulation

% PAP Activity Remaining

<table>
<thead>
<tr>
<th></th>
<th>7 days ambient</th>
<th>7 days 32°C</th>
<th>28 days ambient</th>
<th>28 days 32°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loose Eureco™</td>
<td>2.9</td>
<td>2</td>
<td>2</td>
<td>0.6</td>
</tr>
<tr>
<td>Eureco™ RP103</td>
<td>98.7</td>
<td>92</td>
<td>97.5</td>
<td>60.3</td>
</tr>
<tr>
<td>PAP Granules</td>
<td>95.3</td>
<td>87.8</td>
<td>88.6</td>
<td>44.5</td>
</tr>
<tr>
<td>PAP Powder</td>
<td>86.6</td>
<td>60.5</td>
<td>50.4</td>
<td>7.7</td>
</tr>
</tbody>
</table>

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STABILITY OF EURECO™ RP103 IN DOMESTIC LAUNDRY POWDER

☑ Excellent PAP stability at elevated temperature and humidity for an extended period

Stability of Eureco RP103 in domestic laundry powder at 32°C and 60% RH

<table>
<thead>
<tr>
<th></th>
<th>7 days</th>
<th>42 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAP powder</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>PAP granules</td>
<td>65</td>
<td>16</td>
</tr>
<tr>
<td>Eureco ™ RP103</td>
<td>94</td>
<td>89</td>
</tr>
</tbody>
</table>
EURECO™ RP103 BLEACH PERFORMANCE AT LOW TEMPERATURE
TERGOTOMETER WASH TRIAL

✓ Eureco RP103 out-performs the SPC-TAED bleach system at low temperature

Bleach Performance following a 30 mins wash at 15 °C using Persil Colour powder

Reflectance (%) at 460nm

<table>
<thead>
<tr>
<th></th>
<th>Control Persil Colour powder only</th>
<th>Persil powder + Eureco™ RP103</th>
<th>Persil powder + SPC&amp;TAED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wine</td>
<td>43.5</td>
<td>70.0</td>
<td>59.2</td>
</tr>
<tr>
<td>Tea</td>
<td>27.4</td>
<td>58.5</td>
<td>43.7</td>
</tr>
<tr>
<td>Grass</td>
<td>38.4</td>
<td>54.8</td>
<td>42.3</td>
</tr>
<tr>
<td>Tomato Sauce</td>
<td>39.8</td>
<td>41.8</td>
<td>42.2</td>
</tr>
<tr>
<td>Coffee</td>
<td>50.0</td>
<td>57.6</td>
<td>52.7</td>
</tr>
</tbody>
</table>
DISSOLUTION OF EURECO™ RP103
IN HARD WATER AT 30 °C

✓ Fast dissolution through measurement of PAP in solution at each time point

• Dissolution testing conditions:
  ○ 30°C in hard water conditions (300ppm Na₂CO₃)
  ➢ without surfactants or reducing substances
Manganese Catalyst for Unit-dose Tablets

RevCap™ MnTACN - A stable free-flowing catalyst particle
**RevCap™ MnTACN**

SUCCESSFUL INNOVATION - STABILISED CATALYST GRANULE

- Dust free, mechanically stable, robust particles
  ✓ For uniform dosage during manufacturing
- Excellent stability in ADW tablet formulations
- Excellent bleaching performance
- Rapid dissolution

RevCap™MnTACN in ADW tablet after 7 Days at 30 ℃ 80% RH
REVCAP™ MnTACN BLEACH PERFORMANCE
ADW TABLET FORMULATION

- Catalyst stability is improved following encapsulation with responsive polymer following storage stability

Change in reflectance of tea stained cotton swatches before and after washing at 55°C, 1hr 20mins in European dishwasher

<table>
<thead>
<tr>
<th></th>
<th>Time 0</th>
<th>7 Days at 30°C 80% RH</th>
<th>14 Days at 30°C 80%RH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mn-TACN catalyst unmodified</td>
<td>100.0%</td>
<td>18.8%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Processed particle</td>
<td>100.0%</td>
<td>78.2%</td>
<td>62.7%</td>
</tr>
<tr>
<td>Responsive polymer coated particle</td>
<td>100.0%</td>
<td>100.0%</td>
<td>79.1%</td>
</tr>
</tbody>
</table>

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SUMMARY

5 KEY POINTS

1. The consumer wants convenient products without compromising performance

2. Important active benefit agents are currently unstable in liquid and powder formulations

3. RevPerox™ SPC enables the incorporation of Sodium Percarbonate into unit-dose liquid formulations to provide the bleach performance that the consumer expects

4. Eureco™ RP103 provides efficient bleaching in powders and can be incorporated into multi-compartment PVOH pods

5. RevCap™ MnTACN provides a stable catalyst for uniform dosing into ADW tablets with excellent bleach performance
Thank you for listening!

We are always happy to work with new partners to enhance product performance

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