G-Polymer™ – Option for Sustainable Multilayer Barrier Packaging

Presented by:

Gerd Weyers
Senior Technical Manager
&
Technical Project Management

NIPPON GOHSEI
Europe GmbH

Solution by Chemistry
Solution by Chemistry

Content

• Short Company Introduction

• G-Polymer Characteristics & Market Requirements

• G-Polymer Applications & Production Technologies

• Circular Economy: Recyclability, Compostability

• G-Polymer for Packaging - Easy Recycling

• Summary & Conclusion
Mitsubishi Chemical Group - KAITEKI

Mitsubishi Chemical Holdings

Net sales: $34.2 billion
Employees: ~ 69000

MITSUBISHI CHEMICAL

Net sales: $24.8 billion
Employees: ~ 41600

NIPPON GOHSEI

Net sales: ~ $1 billion
Employees: ~ 1700
NIPPON GOHSEI Production Sites

G-Polymer™
Production Plant, JP

Kumamoto Plant

SOARNOL™ (EVOH)
& G-Polymer™, JP

Mizushima Plant

SOARNOL™ (EVOH)
Production Plants

NIPPON GOHSEI UK Ltd.

NOLTEX L.L.C., TX
Solution by Chemistry

Products for your daily life

Everyday, everywhere, creative products generated from NIPPON

GOHSEI’s technology support comfortable life and society.

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**Products for your daily life**

- **Liquid detergent individual packaging** Hi-Selon™
- **Lamination adhesives** Gohsenol™, Mowiny™
- **Gas barrier film** Soarnol™
- **Floor heating pipes** Soarnol™
- **Laminated glass interior film** Gohsenol™
- **Coating for thermal recording paper**
- **Information equipment coating material** Shikoh™
- **Highly durable adhesives** COPONYL™
- **Coating for LCD display materials**
- **Packaging agricultural chemicals, seed tape** Hi-Selon™
- **Material for solar panel** Vinyl Acetate Monomer
- **Binder for papers** Gohsenol™, Mowiny™
- **Film for transfer printing to curved surface** Hi-Selon™
- **Excipient for medicine/Coating material** Gohsenol EG
- **LCD Display material**

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**Everyday, everywhere, creative products generated from NIPPON**

- **UV curable resin** Shikoh™
- **Ethylene-vinyl alcohol copolymer** Soarnol™
- **Polyvinyl alcohol** Gohsenol™
- **Specialty modified polyvinyl alcohol**
- **High purity polyvinyl alcohol**
- **Polarizing film indispensable for LCDs**
- **Anisotropic vinyl alcohol isochroman® G-Polymer™**
- **Synthetic resin emulsion** Mowiny™
- **UV-curable synthetic resin**

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**GOHSEI’s technology support comfortable life and society**

- **Polarizing film** OPL-Film™
- **Adhesive widely usable for labels, seals, tapes, etc.**
- **Vinyl alcohol resin with melting reactivity and superior for use as a packaging**
- **Film with high heat sealing and printing performance and superior for use as a packaging**
- **Water-dispersible polyvinyl alcohol film**
- **Synthetic resin emulsion**

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**Solution by Chemistry**

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Global Megatrends – Innovation Challenges

Digital Technologies will transform the manufacturing sector

The 4th Industrial Revolution – Operational effectiveness

World population, growing and ageing

Regulation, politics & environment

(Waste) - Water management

Circular Economy – New packaging design
Nichigo G-Polymer™ is the next generation of vinyl alcohol resins based on proprietary “G-Technology”, providing superior gas barrier properties, compostability & easy processability by all production techniques
Requests from the food packaging market

- Barrier
- Aroma
- Safety
- Design
- Sustainability
- Environmental
- Friendly
- Convenience
- Customisation
- Lifestyle
Compatibility with Market Requirements

Environmental Friendly

Compostability

Sustainability

Recyclability

Good Taste

Gas Barrier Properties

Aroma Barrier Properties

Safety Material

Processability

Extrudability

Orientability

Reprocessability

meets market requirements
Biodegradable and Compostable High Gas Barrier resin:

Packaging Application
Below 60% RH, Nichigo’s G-Polymer™ has the highest oxygen gas barrier property of all extrudable polymers!
G-Polymer for all Conventional Production Technologies

High Gas Barrier Packaging
- Blown Film, Melt cast extrusion
  - PE, PP or PET
  - Tie resin
  - Nichigo G-Polymer™
  - Tie resin
  - PE, PP or PET

Lamination, Solution Coating
- PE, PP or PET
- Anchor coating agent
- Nichigo G-Polymer™
- Ink receiving layer
- Adhesive
- PE, PP or PET

Fully Compostable Packaging
- TF, Blown Film, Melt cast extrusion
  - Biopolyester
  - Biodegradable tie resin*
  - Nichigo G-Polymer™
  - Biodegradable tie resin*
  - Biopolyester

- Co-injection
  - Biopolyester
  - Nichigo G-Polymer™
  - Biopolyester

- Paper coating
  - Paper
  - Biopolyester
  - Biodegradable tie resin*
  - Nichigo G-Polymer™
  - Biodegradable tie resin*
  - Biopolyester
Compostable Certification Status

ASTM D 6400

Compliance with compostability standards for each region

Certified
On going

* : Nichigo G-Polymer (standard)

EN13432 coming soon.
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Nichigo G-Polymer - Applications

Nichigo G-Polymer’s unique properties according to market requirements:

- **Excellent gas barrier properties**
  - Gas barrier properties at dry condition
  - Gas barrier properties at different humidity condition
  - Aroma barrier, chemical resistance
- **Excellent water solubility**
- **Extrudability**
- **Biodegradability & Compostability**
Ultra-High Barrier Flexible Packaging Case

**Conventional Packaging**

PO//AL//BO-PET
100// 6 // 12 µm (TTL 120µm)

**Recyclable, AL-free packaging**

BO-PP//PO//SOARMOL-27 //PO
TTL 120µm, EVOH ➔ 6µm to achieve MPOI*

BO-PP//PO//Nichigo G-Polymer™ //PO
TTL 120µm, ➔ 1.5µm to achieve MPOI*

**Fully Compostable Packaging**

BO-PLA//Bio-Polyester//Nichigo G-Polymer™ // Bio-Polyester

TTL Thickness** ➔ 1.5µm to achieve MPOI*

**The lower WVTR of Bio-polyesters might have impact on the shelf-life and needs to be considered to support OTR**

* MPOI = maximum permissable oxygen ingress

**Downgauging Potential:** Nichigo G-Polymer™ shows about 4 times better OTR vs EVOH
Ultra-High Barrier of Rigid Compostable Packaging

Average Thicknesses of Tray

| PLA / tie / | Nichigo G-Polymer / tie / | PLA |
| 140 / 5 / | 8 / 5 / 140µm |

Structure of Lid-Film

| PLA / tie / | Nichigo G-Polymer / tie / | PLA |
| 16 / 5 / | 12 / 5 / 16µm |

Tray and lid made in cooperation with NatureWorks LLC, Eurotech Extrusion Machinery, SRL and Sukano AG

PLA (tray) : Ingeo 4032D
PLA (lid): Ingeo 4043D

<table>
<thead>
<tr>
<th>OTR Tray</th>
<th>OTR Lid</th>
</tr>
</thead>
<tbody>
<tr>
<td>23°C, inner 80%, outer 50%RH</td>
<td>23°C, inner dry, outer 50% RH</td>
</tr>
<tr>
<td>0.0017 cm³/tray day atm</td>
<td>0.06 cm³/m² day atm</td>
</tr>
</tbody>
</table>
High Barrier Solution Coating on PLA Film

**Structure**

<table>
<thead>
<tr>
<th>BO-PLA /primer/</th>
<th>Primer @RT</th>
<th>G-Polymer-Solution* @RT</th>
<th>Coated BO-PLA film</th>
</tr>
</thead>
</table>

**OTR [cm³/m² day atm]**

| 25 / 0.2 / 1µm | 0.3 |

*Dissolving*  
*Dispersing*  
*Coating*  
*Drying*

*23°C 50%RH*

*BVE-8049Q in 10 wt% aqueous solution*
### Ultra-High Barrier Bio-Compostable Capsule

**Bio-capsule:** 4-times higher barrier or lower OTR, even with 7-times higher humidity in barrier layer

**Conventional capsule:** 8-times higher moisture barrier

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Bio-BARRIER with Existing Barrier (PP/SOARNOL™/PP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrier Layer [µm]</td>
<td>13</td>
</tr>
<tr>
<td>Humidity in Barrier [%]</td>
<td>26</td>
</tr>
<tr>
<td>WVTR [g / capsule day]</td>
<td>38°C 90%RH</td>
</tr>
<tr>
<td>OTR [cm³ /capsule day Air]</td>
<td>23°C Inner Dry, Outer 50%RH</td>
</tr>
</tbody>
</table>
Circular Economy & Recycling

Conceptual diagram illustrating the Circular Economy in a simplified way.
Recyclability of EVOH in Barrier Multilayer

Barrier Plastic packaging using SOARNOL™ is already commonly recycled together with our SOARESIN™ RG500 for in-house recycling.

Synergy of SOARNOL™ and SOARESIN™ as option for realization of Circular Economy.

Scrap return

PP
Regrind layer
Regrind layer
PP
Distribution of EVOH in Regrind

**PO/Tie/EVOH**

*Without RG500*

**PO/Tie/EVOH + RG500**

Use of SOARESIN™ RG500 allows EVOH excellent distribution into polyolefin matrix
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used as barrier layer with conventional plastics could be easily dissolved and washed-away from the regrind, facilitating recycling of “mono-material”

„Wash-Away“ from Multi-Layer Structure

Re-use „mono-material“ for Recycling
Solution by Chemistry

Separation Technology for easy Recycling

- Pelletising
- Shredding
- Washing
- e.g. Film

**Target:** To obtain „mono-material“ for easy recycling
Highly demanded for flexible Post consumer packaging
Easy Recyclable Packaging - Combination with Conventional Polymers
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**, the world’s first amorphous vinyl alcohol polymer with superior barrier performance and additional benefits at a glance**

**Excellent Gas Barrier**
- 50 times better OTR compared to EVOH under dry condition

**Compostable, Recyclable**
- OK Compost Vincotte - EN13432 (Industrial/Home)
- Compostable cert. BPI - ASTM D6400

**Extrudable**
- Extrudable with a wide processing window

**Excellent Water Solubility**
- Fast and perfect dissolution

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**Ultra High Barrier**
Flexible & Rigid Packaging

**Fully Compostable**
Flexible & Rigid Disposable Packaging or Agricultural Films

**Easy Recycling**
with conventional Polymers

**Water soluble support filament**
3D Printing
## Circular Economy - Recyclability

<table>
<thead>
<tr>
<th></th>
<th>Mono-layer</th>
<th>Al Foil</th>
<th>EVOH SOARNOL™</th>
<th>Nichigo G-Polymer™</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compostability</td>
<td>Maybe</td>
<td>None</td>
<td>None</td>
<td>Excellent</td>
</tr>
<tr>
<td>Recyclability</td>
<td>Excellent</td>
<td>Good</td>
<td>Good</td>
<td>Very Good</td>
</tr>
<tr>
<td>Barrier</td>
<td>Poor</td>
<td>Excellent</td>
<td>Very Good</td>
<td>Excellent</td>
</tr>
<tr>
<td>Taste</td>
<td>Poor</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Processability</td>
<td>Excellent</td>
<td>Not easy</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Environmental Friendly</td>
<td>Good</td>
<td>Not so good</td>
<td>Good</td>
<td>Excellent</td>
</tr>
</tbody>
</table>
Conclusions

Nichigo G-Polymer™ - offers the Option for Sustainable Multilayer Barrier Packaging by providing:

- Ultra-high barrier for Single Serve Capsules and flexible films;
- Fully compostable barrier packaging by conventional production methods, either co-extrusion or solution coating;
- Easy recycling of multilayer structures to “mono-materials” and.....
- Effectiveness for realistic recycling to create a more “Circular Economy”
Thank you very much for your attention