Blistering of FRP boat hull due to osmosis
Marine Application - Osmosis

Osmosis phenomenon starts with water diffusion into FRP

- Polarity matrix
- Amount and type of ester linkages
- Tg of cured matrix (cross link density)
Marine Application - Osmosis

**Diffusion**
Water will fill voids in FRP and low molecular weight materials will dissolve in water phase

**Osmosis**
Due to difference in concentration in water of soluble materials, extra water will move from outside to the void resulting in build up of osmotic pressure.

**Flexilibity**
When osmotic pressure exceeds flexibility properties of resin matrix a crack is initiated and blister will start to grow.
Marine market - Hydrolysis resistance - the Ester Linkage

\[
R - \overset{\text{C}}{-\overset{\text{C}}{\text{O}}} - \overset{\text{C}}{-\overset{\text{O}}{\text{C}} - \overset{\text{C}}{\text{O}}} \quad \text{H}_2\text{O}
\]

\[
\overset{\text{CH}_3}{-\overset{\text{C}}{-\overset{\text{C}}{\text{O}}} - \overset{\text{C}}{-\overset{\text{O}}{\text{C}} - \overset{\text{C}}{\text{O}}} \quad \text{H}_2\text{O}
\]

\[
\overset{\text{H}}{-\overset{\text{C}}{-\overset{\text{C}}{\text{O}}} - \overset{\text{C}}{-\overset{\text{O}}{\text{C}} - \overset{\text{C}}{\text{O}}} \quad \text{H}_2\text{O}
\]

\[
\overset{\text{H}}{-\overset{\text{C}}{-\overset{\text{C}}{\text{O}}} - \overset{\text{C}}{-\overset{\text{O}}{\text{C}} - \overset{\text{C}}{\text{O}}} \quad \text{H}_2\text{O}
\]

DSM Composite Resins
Marine Application – How to prevent blistering

- Parameters osmosis
  - Gelcoat
  - tiecoat
  - Resin matrix
  - Glass fibres
  - Cure system
  - Cure temperature
  - Processing
**Gel coat**

- **Good hydrolysis resistance:**
  
  \[ \text{VE} > \text{ISO/NPG} > \text{ISO/PG} > \text{ISO/Standard glycols} > \text{OPA/Standard glycols} \]

- No / low fillers / type of fillers

- Special types of pigments:
  
  - No influence of hydrolysis resin matrix
  - No influence on cure
  - Only based on unsaturated polyester paste resins

- **Processing**
  
  - Layer thickness between 0.4 - 0.75 mm
  - Geltime on mould ± 20 minutes
  - Void free
  - Prevent styrene inhibition (ventilate!)
# DSM Gelcoat range for Marine

<table>
<thead>
<tr>
<th>Resin type</th>
<th>processing</th>
<th>colour</th>
<th>application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neogel NPG 8373</td>
<td>ISO-NPG</td>
<td>Spray</td>
<td>unlimited</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Boat, swimming pools</td>
</tr>
<tr>
<td>Neogel NPG 8375</td>
<td>ISO-NPG</td>
<td>Brush / roller</td>
<td>unlimited</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Boat, swimming pools</td>
</tr>
<tr>
<td>Neogel <strong>ECO</strong> NPG 9373</td>
<td>ISO-NPG</td>
<td>Spray</td>
<td>Light colours</td>
</tr>
<tr>
<td></td>
<td>low VOC</td>
<td></td>
<td>Low emission for marine</td>
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<tr>
<td>Neogel <strong>ECO</strong> NPG 9375</td>
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<td></td>
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<td></td>
<td>Low emission for marine</td>
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</tbody>
</table>
Tiecoat

- Additional resin rich layer, acting as water barrier and adhesion layer between gelcoat and structural layer

- Properties
  - Glass content: Low
  - Fast wetting characteristic
  - Low water absorption value
  - High mechanical performance

- State of the art: Atlac 580 ACT
  - Vinyl ester urethane resin
  - Maximum water absorption: 0.6%
  - High mechanics
    - Tensile strength: 85 MPa
    - Elongation at break at full post cure: 4.2%

Excellent osmosis and water resistance
Comparison of resin systems to resist osmotic blistering
(time to onset of blistering using accelerated test QCT at 60°C)

System 1:
- Iso/npg gelcoat, cured thickness 0.4 mm
- **Ortho-resin** in buffer-laminate 1x450 g/m²
- Ortho-resin in structural laminate 2x450 g/m²

System 2:
- Iso/npg gelcoat, cured thickness 0.4 mm
- **Iso-resin** in buffer-laminate 1x450 g/m²
- Ortho-resin in structural laminate 2x450 g/m²

System 3:
- Iso/npg gelcoat, cured thickness 0.4 mm
- **Atlac 580 ACT** buffer-laminate 1x450 g/m²
- Ortho-resin structural laminate 2x450 g/m²
# DSM tiecoat resins

<table>
<thead>
<tr>
<th></th>
<th>STATE OF THE ART</th>
<th>LOW VOC Version</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Atlac 580 ACT</td>
<td>Atlac E-Nova MA6325</td>
</tr>
<tr>
<td></td>
<td>Vinyl ester urethane resin</td>
<td>High solid vinyl ester modified resin</td>
</tr>
<tr>
<td>solid content (%)</td>
<td>50 - 52</td>
<td>65 - 67</td>
</tr>
<tr>
<td>Water absorption (%)</td>
<td>0.6</td>
<td>1.4</td>
</tr>
<tr>
<td>*60 days at 60°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tensile strength (Mpa)</td>
<td>83</td>
<td>70</td>
</tr>
<tr>
<td>Elongation at break (%)</td>
<td>4.2</td>
<td>2 - 3</td>
</tr>
</tbody>
</table>
Marine Application - Processing

• Workshop
  - Temperature > 20°C
  - Relative humidity as low as possible (the lower the better)
  - Resins, glass, equipment, tools and moulds have to be conditioned to workshop temperature.

• Moulds/tools
  - Clean and free from dust and condense

• Lossing agent
  - Wax -> not too thick layers, well polished
  - Polyvinyl alcohol -> well dried
  (in both cases ‘when not’, agent will dissolve in curing resin matrix, resulting in reduction of properties)
Marine Application – Structural resins for hulls and decks

Resins for Open-mold applications:
hand lay up and spray up represent more than 95% of the volume of resin processed in boat building industry.

Resins for Closed-mold applications:
Vacuum injection, Light RTM, RTM represent less than 5% of the volume of resin processed in boat building industry.

➢ Both technologies have their own advantages and limits and consequently require different products and know-how.
Ortho resins

Synolite 0188 series
- Thixo and preaccelerated
- Colour change indicator
- Low exotherme
- Good workability
- Structural parts of boats

Synolite 1408 series
- Thixo and preaccelerated
- Promoted
- Colour change indicator
- Low exotherme
- Good workability
- LSE
ISO resins

Synolite 0280 and 0288 series

- Thixo and preaccelerated.
- Low exotherm.
- Good workability.
- Structural parts of boats.
HLU / SU applications

DCPD resins

- Low styrene content (36% for 44% in ortho resins)
- Low viscosity → low fibre print through
- Low styrene emission in dynamic phase

8388 series

- Thixo and preaccelerated
- Colour change indicator
- Low to medium exotherm
- Good workability
- L.S.E available
- Structural parts of boats
### HLU / SU applications

<table>
<thead>
<tr>
<th>Resin</th>
<th>type</th>
<th>Thix</th>
<th>Peak exo</th>
<th>Approval</th>
<th>Colour Change indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>0188</td>
<td>Ortho</td>
<td>Yes</td>
<td>Low (110)</td>
<td>Lloyds, Rina, DNV</td>
<td>Yes</td>
</tr>
<tr>
<td>1408</td>
<td>Ortho</td>
<td>Yes</td>
<td>Low (80)</td>
<td>DNV</td>
<td>Yes</td>
</tr>
<tr>
<td>8388</td>
<td>DCPD</td>
<td>yes</td>
<td>Medium (130)</td>
<td>Lloyds, Rina</td>
<td>Yes</td>
</tr>
<tr>
<td>0280</td>
<td>Iso</td>
<td>yes</td>
<td>Medium (150)</td>
<td>Rina, DNV</td>
<td>No</td>
</tr>
<tr>
<td>0288</td>
<td>Iso</td>
<td>yes</td>
<td>Low (100)</td>
<td>Lloyds, Rina, DNV</td>
<td>Yes</td>
</tr>
</tbody>
</table>
HLU / SU - System Silver

- Laminate built up for workboats, RIBs, small standard crafts:
  - Iso gel coat (500 micron)
  - Structural layer: Ortho or ISOor Synolite 1573-I-1 or Synolite 1573-P-1

| ECONOMY       | ★★★★★★
|---------------|------------------
| PRODUCTIVITY  | ★★★★★★
| WEATHERING    | ★★★          |
| BLISTER RESISTANCE | ★★★          |
| PRINT THROUGH | ★★★          |

DSM Composite Resins
HLU / SU - System **Gold**

- **Laminate built up for medium sized, medium value boats with white gel coat:**
  - 500 micron NPG gel coat: Neogel NPG 8373/8375
  - Iso Synolite 0280/288 tiecoat – 2x 300 g/m² p.b. CSM
  - Ortho or Iso for structural layer: Synolite 1408-P-1

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<tr>
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HLU / SU - System Platinum  High surface quality

- Laminate built up for large, high value boats, coloured or white gelcoat, permanently afloat and/or in hot humid climates:
  - 500 micron NPG gel coat: Neogel NPG 8373/8375 or Neogel ECO 9373/9375
  - Atlac 580 ACT tiecoat – 2x 300 g/m² p.b. CSM
  - DCPD for structural layer: Synolite 8388-P-1

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</table>
Typical time intervals between layers

- Gel coat – constructive layers: 2-24 hrs
- Gel coat – tie coat: 2-24 hrs
- Gel coat – Barrier (spray) coat: 1-24 hrs
- Tie coat – constructive layers: 16 hrs – 1 week
- Barrier (spray) coat – constructive layers: 16 hrs – 1 week

- In general: Longer time intervals = better surface quality
  (However, risk for bad secondary bonding at some surfaces)