Antifouling Coating for Topside Equipment

A presentation of a coating technology for the prevention of crude oil derived fouling
Outline

- Introduction to Sol-Gel technology
- Coating of Plate Heat Exchangers for Crude Oil
- Pilot Plant Coating Facility
- Status of today
The Sol-Gel process

What is the Sol-Gel process?

The term Sol-Gel describes a technology for the synthesis of glass ceramic coatings from liquid reagents.

Traditional Glass ceramics:
Solid components are sintered at a very high T to obtain fully inorganic glass ceramic coatings. High strength, poor flexibility, no ‘specialized’ functions.

Sol-Gel technology:
Liquid reagents form at glass ceramic coating. Cures at low T. Less hard, but more flexible than traditional. Possible to obtain coatings with highly specialized physical/chemical properties.
Why is it called Sol-Gel?

The Sol-Gel technology is founded on colloidal chemistry.

Colloids are ‘stable systems, where one material is evenly distributed in another material’

<table>
<thead>
<tr>
<th>Media/Phase</th>
<th>The dispersed phase (“the solubilized”)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas</td>
<td>Gas</td>
</tr>
<tr>
<td>Liquid</td>
<td>Liquid aerosols</td>
</tr>
<tr>
<td>Solid</td>
<td>Solid aerosols</td>
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</tbody>
</table>

(All gasses can be mixed)

- Foam: whipped cream, etc.
- Emulsion: milk, mayonnaise, etc.
- Sol: ink, blood, etc.

- Solid Foam: PUR, styrofoam, aerogel, etc.
- Gel: agar, gelatin, gelé, etc.
- Cured Sol: ruby glass

The Sol-Gel term is derived from the fact that the two colloidal steps are present in the formation of glass ceramic coatings formed from this particular process.
Introduction to the Sol-Gel technology

Quartz and crystal glass are primarily made up of Si and O atoms arranged in a perfect crystalline structure.

Sol-Gel technology

Naturally occurring quartz crystal

Silicium Oxygene
Amorphous glass
Inorganic
Contains eg. sodium carbonate
Ordinary glass (window panes, etc)

Can be produced by a Sol-Gel process
Superior optical properties
Brittle
Telescope lenses

Obsidian: Naturally occurring amorphous glass

Coated telescope lens

Silicium  Oxygene
**Introduction to the Sol-Gel technology**

Hybrid Sol-Gel glass ceramics
- Amorphous
- Organic and inorganic

Organic component = functionality, e.g.:
- Easy-release
- Hydrophobic/hydrophilic
- Anti-graffiti
- Flexibility

Reaction between Epoxy and Amine:

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\[ \text{Si-O-Si} + \text{H}_2\text{N-Si-O-Si} \rightarrow \text{Si-O-Si-NH} \]  
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Hybrid Sol-Gel glass ceramics
- **Silicium**
- **Oxygene**
Introduction to the Sol-Gel technology

General characteristics of the Sol-Gel based glass ceramic coatings:
- Thin (3-15 µm)
- Transparent
- Flexible
- Good adhesion to different materials

Four ‘handles’ for the formulation of Sol-Gel coatings:
- The in-organic, glass-ceramic matrix
- Surfactant, additives
- ‘Organic modified silanes’ – ORMOSILS
- Solid fillers

Enables the development of coatings with customized features:
- Repellent
- Low surface energy
- Smooth

Application:
- Spray, dipping, spinning, etc.
- Curing at 200 °C
Research and Development of Crude Oil Repellent Coating

CORE Coat 010 was adapted and lab-tested under relevant parameters

Extract from test regiment
• Stability to crude oil (RT and 50 °C)
• Adhesion to ss, Ti og Al
• 1000 hr Salt spray testing, Atlas Cell testing
• Flexibility
• Heat Conductivity (reduction of PHE efficiency)
• Contact point wear
Based on laboratory tests, the two best performing coating systems were chosen for preliminary offshore tests on 30 Alfa Laval M20 plates:

15 x CORE Coat 010
15 x CORE Coat 020

• Operational for seven months in the North Sea
• Surveillance by thermographic camera and laser thermometry
• Disassembly and inspection
Inspection of PHE plates after 7 months of operation

- CORE Coat 010 and 020 provide superior repellent properties towards both organic and inorganic fouling
- CORE Coat 010 exhibits the superior adhesion and integrity
- CORE Coat 020 exhibits slightly inferior properties compared to CORE Coat 010

Since, thousands of plates have been coated with CORE Coat 010 and excellent data have been retrieved.

- Efficiently repels crude oil fouling (organic and inorganic components) – approx. 1000 days offshore
- Is stable in contact with crude oil
- Has proven effect on Ti PHE units for crude oil cooling
**Status Today**

CORE Coat 010 (Crude Oil Repellent Coating 010):

- Pilot production facility established in 2010
- Flexible production – permits new coatings assignments with short notice
- Cooperation with Alfa Laval on PHE application
- Coating of new and old plates possible
- ISO9001 certifiability in process
Status Today

CORE Coat 010 (Crude Oil Repellent Coating 010):

Focus on environmental impact
- ISO14001 certifiability in process
- Documentation available on
  - Environmental Impact
  - HSE

- CORE Coat 010 is not formulated from nano-particles
- CORE Coat 010 does not contain any fluorated compounds

CORE Coat 010 does NOT contain FLUORATED COMPOUNDS

No PFOS, PFOA or any other kind of per-fluorated or poly-fluorated compounds are present in the CORE Coat 010 formulation. Such substances are known to be extremely persistent in the environment. The substances are known to bioaccumulate in marine species and ultimately in polar bears and other predators at the top of the food chain. Toxicological studies on animals indicate potential developmental, reproductive and systemic effects.

The repellent properties of CORE Coat 010 rely on an entirely different technology that is documented safe, and approved for food contact.
Please contact us for further information