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Evaluation of corrosion resistant coatings derived from microcapsules containing corrosion inhibitors

Feasibility study

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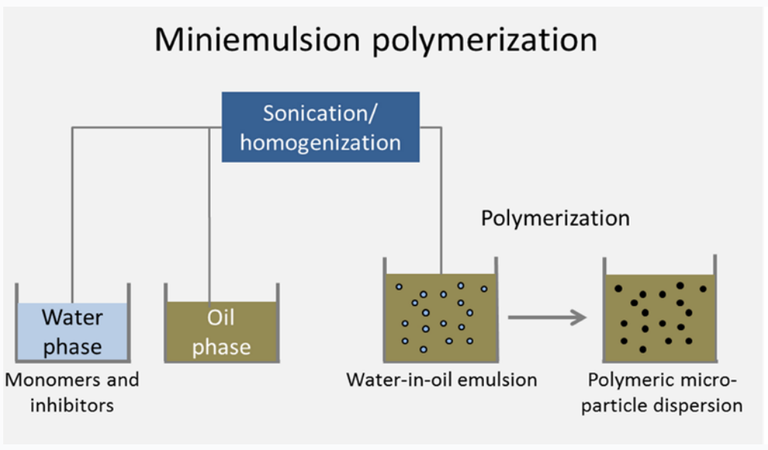
Introduction

The work on protective coatings has been performed within the Norwegian Research Centre for Offshore Wind – NOWITECH. The objectives have been increased lifetime and reduced O & M costs for offshore wind turbines.

Stimuli-responsive corrosion protective coatings can be achieved by incorporating capsules loaded with corrosion inhibitors in the organic coatings. The corrosion inhibitors will be released from the capsules and provide protection against the corrosion. The triggers (or the so called external stimuli) can be moisture, pH or mechanical strength.

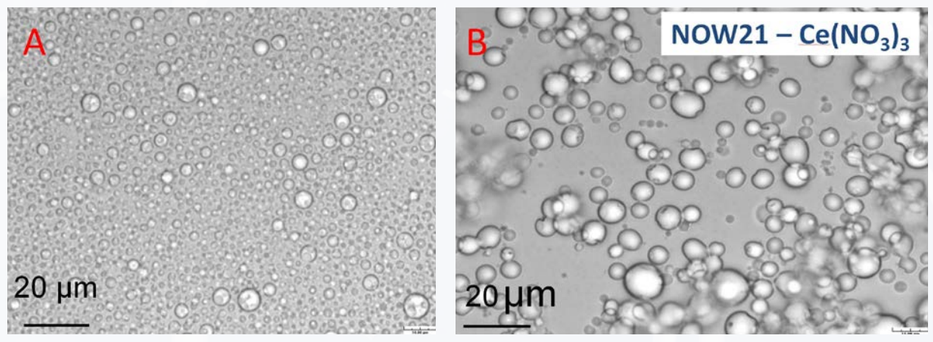
Synthesis of polymeric microcapsules

In the present work, Polyurethane microcapsules were synthesized using a miniemulsion polymerization process.



Cerium nitrate hexahydrate and sodium metasilicate nonahydrate were encapsulated as corrosion inhibitors. Formation of microcapsules in the size range of 1-10 µm could be confirmed.

Capsules produced	Inhibitor	Content in coatings [wt%]	Comments
NOW-12	Cerium nitrate hexahydrat (50%)	2.0	Thinner capsule wall
NOW-14	Cerium nitrate hexahydrat (50%)	0.1 and 1.0	Medimum capsule wall
NOW-15	Cerium nitrate hexahydrat (50%)	0.1 and 1.0	Comparable to NOW-14
NOW-20	Sodium metasilicate nonahydrat (33%)	0.1 and 1.0	Comparable to NOW-14
NOW-21	Cerium nitrate hexahydrat (50%)	2.0	Thicker capsule wall



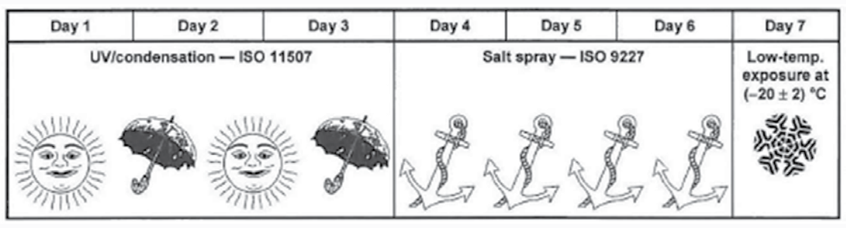
Optical microscopy of (A): emulsion and (B):polyurethane capsules

Coating application

Modified organic coatings were prepared by incorporating the inhibitor containing capsules or the pure inhibitors in a two-component epoxy system. The coating was applied on grit blasted steel panels by bar coating

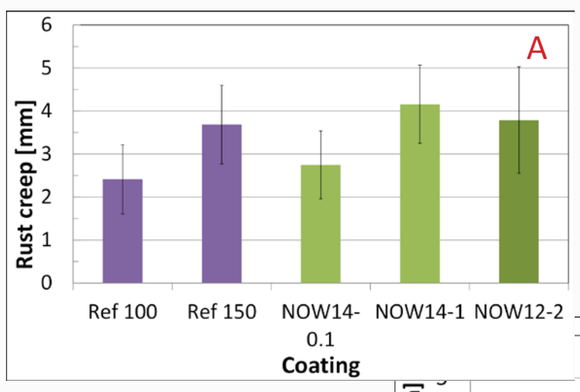
Corrosion testing

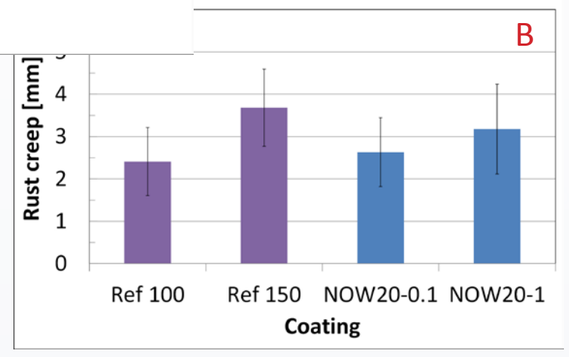
Corrosion performance of the coated panels was investigated by ageing resistance testing according to ISO 20340/NORSOK M-501. The test consist of 25 cycles each one week:



Prior to exposure, the coating was scribed down to bare steel. In this work, the testing lasted for 2000 hours (12 cycles). Samples were evaluated by rust creep and pull-off adhesion testing.

Satisfying adhesion strengths were obtained for all coatings tested. The corrosion results showed that the types and contents of corrosion inhibitor did not affect the corrosion creep significantly:

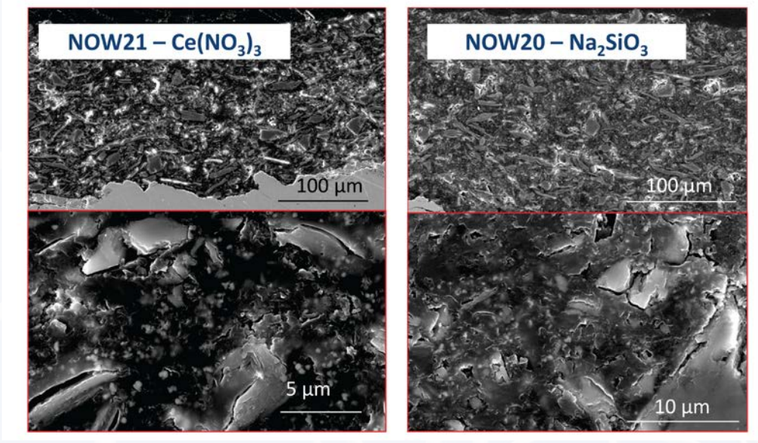




Rust creep for modified coatings containing (A): $Ce(NO_3)_3$ and (B): Na_2SiO_3 compared to the unmodified reference

Characterization

Cross sections prepared of coated samples were investigated by SEM and EDS spectroscopy. The results showed that the capsules broke during coating application. Minor amounts of inhibitor were found in the modified coatings.



SEM images of cross section of modified coatings

Conclusions

The results showed:

- Inhibitor containing capsules were successfully prepared
- Capsules have been broken during coating application
- No improving effect on corrosion performance by inhibitor addition to the specific two-component epoxy coating used

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