

2nd “MUST” WORKSHOP

Self-healing Coatings: Effectiveness and Implementation

REPORT

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2nd MUST WORKSHOP

VENUE: 28th June, Hotels von Orange, Noordwijk, Netherlands

1. Programme:

ROOM - Koninginnezaal	
08:15-08:45	Registration
08:45-09:00	Welcome Theo Hack, MUST Project coordinator
SCIENTIFIC SESSIONS	
Chairperson: M.F. Montemor	
09:00-09:30	<i>Self-healing protective coatings: nightmare or reality? Promises versus limitations</i> M. Zheludkevich, University of Aveiro, Portugal
09:30-10:00	<i>A critical comparison of routes towards self healing materials and coatings</i> S. Zwaag, Technical University Delft, the Netherlands
10:00-10:30	<i>Needs, perspectives and challenges for application of self-healing protective coatings in aerospace industry</i> Theo Hack, EADS IW, Munich, Germany.
10:30-11:00	Coffee Break
11:00-11:30	<i>A coating combination of self-healing polymers and corrosion inhibitors for active corrosion protection of metals</i> I.De Graeve, Vrije Universiteit Brussel, Belgium
11:30-12:00	<i>Fundamental understanding of self-repair processes: Aspects of de-adhesion and corrosion</i> G. Grundmeier, University of Paderborn, Germany
12:00-12:30	<i>Development and characterization of self-healing anticorrosive organic coatings</i> S.J. Garcia, Delft University of Technology, The Netherlands
12:30-13:30	LUNCH
Chairperson: C. Simon	
13:30-14:00	<i>Modelling of multifunctional anticorrosion coatings</i> Zbistaw Tabor, Piotr Warszawski
14:00-14:30	<i>Inhibition of Underfilm Corrosion on Aluminium and Zinc surfaces by in-coating Smart Release Pigments</i> G. Williams, Swansea University, United kingdom
14:30-15:00	<i>Production of nanomaterials at industrial scale – from nanoparticles to nanocontainers</i> S. Eiden, Bayer Technology Services GmbH
15:30-16:00	Coffee Break & Poster session
15:30-16:00	<i>Self-healing coatings for the corrosion protection of magnesium alloys: embedding encapsulated corrosion inhibitors into anodizing layers</i> D. Tabatabai, Dechema, Frankfurt, Germany
16:00-16:30	<i>Mathematical Model for Bacterial Self Healing of Cracks in Concrete</i> S.V.Zemskov; Delft University of Technology
16:30-17:00	<i>Development of flexible LEO resistant PI films for space applications using a self-healing mechanism by surface directed phase separation of block copolymers</i> H. R. Fischer, TNO Science and Technology, Eindhoven, The Netherlands
17:30-18:30	Industrial Reference meeting (round table) Moderator: M. Zheludkevich

2. TOPICS ADDRESSED & STATE-OF-ART

Implementation of self healing coatings advantages & limitations: New self healing coatings are becoming more and more important in the coatings industry. Actually, the concept is already applied at the market level in some industries as is the case of Nissan and Akzo.

The development of strategies for extending the lifetime of structural painted materials is of enormous importance. Many attempts have been proved at laboratory scale, but transfer for industry is still very scarce. Moreover, the benefit of self healing coatings has to be analysed in a complete LCA and compared with conventional systems.

The strategies for improved corrosion protection and durability have a huge impact on the economic sustainability of major components in a number of applications. Despite the strong research activity that is currently developed there is a lack of knowledge and it is not clear how self healing materials can be implemented in the market. Several questions remain to answer:

- What are the typical defects to be healed?
- How to quantify kinetics of self-healing processes?
- How to predict and characterise performance of self-healing coatings?
- Can the production of nanocontainers be up-scaled?
- How far are the self-healing coatings based on nanocontainers from industrial applications?
- Can self healing coatings be offered at reasonable costs?

Self healing has impact on various applications. Self-healing of coatings by microcapsules filled with active polymerising agents has been tested in organic matrixes and has potential for upscaling. Moreover, smart particles, which are sensitive to external triggers have demonstrated beneficial results in many applications.

The potential of upscale has been discussed and it was shown that it is possible to produce significant amounts of various containers for diverse applications.

New strategies to develop surfaces less prone to environmental aggressiveness have been proposed in different types of materials for several applications. One example of successful self healing in non-organic materials is concrete and mortars. Here it is possible to heal microscopic cracks by promoting the formation of calcium carbonates. Furthermore, the strategy opens the possibility for CO₂ sequestration.

Needs of aerospace industry: Self-healing materials can minimize maintenance efforts and must enable development of greener, cleaner and smarter materials”.

Needs for coatings are dependent on the application:

- Type of component (primary/secondary aircraft structure)
- Exterior Surface
- Interior Surface

For aerospace industry, a self healing system must strengthen the protection functionality of the coating, be attractive for long term application, present potential for life time increase and promote replacement of hazardous compounds. Other potential applications could be related to healing of surface damages caused by sand erosion or rain erosion. The potential of self healing coatings for application to aircraft structure has been analysed in connection with future inspection and maintenance concepts. At laboratory scale, many systems show potential self healing ability. Cerium-modified systems have been tested in several coatings, especially thin hybrid coatings, on steel and Al alloys with interesting results.

Smart pigments released from the coatings can lead to significant inhibition of the corrosion processes, but the triggering mechanisms have to be understood in more detail.

The assessment of the self healing ability and the understanding of its fundamentals need new approaches and new combinations of tools with special emphasis on localised electrochemical and analytical techniques. Up to now, fundamental studies reveal mainly delays in the anodic activity, continuous inhibition of cathodic delamination leading to slower de-adhesion rates.

The full characterization of self-healing coatings has been widely discussed and techniques such as electrochemical impedance spectroscopy have shown to be very important, especially when combined with localised techniques.

By studying in detail the localised aspects of self healing and the evolution of the coating properties, it is possible to extract significant information. Its modelling can be an adequate strategy to predict the phenomena and the durability of the healed materials.

3. ROUND TABLE

A Round table was organised with all the speakers in order to analyse the latest developments and the challenges of materials with smart properties. A number of questions were raised and addressed to representatives from industry and academia:

- ✓ What potential industrial applications can be predicted for the self-healing coatings?

Nowadays automotive, aeronautical, maritime coatings and concrete and bituminous materials related industries are the ones exploiting the concept of smart materials and self healing. Other potential industries may appear: medical and biomedical, electronics and energy related. The industry of medical instruments is looking for new protective

coatings with self-healing ability. The coatings should withstand high temperatures up to 140°C during the sterilization process. At the same time the thermo cycling can be an effective trigger for the thermo-activated healing processes. New self-healing coatings present also a potential in wind energy applications, especially for highly erosion resistant coatings which represent a challenge in the field of offshore wind.

There are already two self-healing clear coat systems for automotive applications available on the market. The NISSAN's "SCRATCH SHIELD" was the first one which appeared on the market since several years. This paint now is also to be applied to mobile phones. The other product was recently announced by Akzo offering self-healing clear coating.

- ✓ What typical defects are relevant for different applications?

The shape and size of defects provoked by mechanical damage, erosion, fatigue and corrosion are of paramount importance to design and to develop smart materials. More studies are due on these issues for developing successful materials able to fulfill the requirements. It is always important to consider types and size of the defects to be healed. The macroscopic defects are not probable to be healed by the thin protective coatings.

- ✓ What healing mechanisms are relevant for these types of defects?

Depending on the material and defect to be protected, several strategies can be applied. Most of them are to be compatible with the facilities existing at industry and standard tests, which may have to be discussed.

- ✓ Can performance of the self-healing coatings be extrapolated to the long time frame and can self-healing properties be simulated?

The quantification of self healing ability and the performance of smart materials, at the actual stage, cannot be predicted with accuracy for long term. More efforts have to be engaged on the fundamental aspects, a complete characterization and modeling strategies. Another important issue is specification tests for the self-healing materials. The current standard tests used by industry are not always appropriate for the testing of self-healing materials.

- ✓ What is an acceptable price of the nanocontainers and self-healing coatings?

The system must be economically competitive during its entire life cycle. The development of greener, cleaner and smarter materials has to be balanced with the design and production of containers. Still there is no clear definition of the final materials prices due to the various parameters that need to be taken into account. The most important point here is that full life cycle of the product should be taken into account. Higher initial price of the new self-

healing materials can be compensated during their life time by lower maintenance costs and higher durability.

4. PROFILE OF THE ATTENDANTS

The number of attendants from MUST was 26 and the external ones were 54. Among these it was possible to define the profiles depicted in Figure 1.

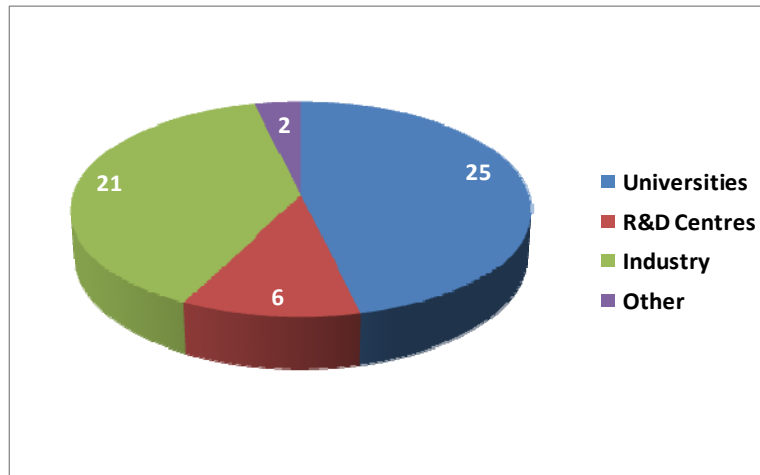


Figure 1 – Profile of the workshop attendants