Fostering friendly bacteria

Professor Robert Akid explains how research into bio-active 'sol-gels' could result in an effective, low-cost and environmentally-friendly means of combating bio-fouling

SUBMERGE ALMOST ANYTHING in a liquid that contains natural bacteria and its surface will start to play host to various forms of life.

Known as 'biofouling', the speed and extent to which it occurs will primarily depend on the environment. Further, the biofouling often leads to highly localised 'microbial-induced corrosion', the extent of which will typically be hidden beneath a biofilm or surface populated with seaweed, barnacles, molluscs and/or other forms of marine life.

The traditional approach to combating biofouling has been to employ antifouling paints containing a 'biocide'. Here, tin (in the form of tributyltin, or TBT) has proved to be an effective biocide ingredient but it was banned in the late 1980s for use in most marine applications because of its harmful effects on shellfish. Post-ban, attention turned to copper-based antifouling paints, but these cannot be used on some metals (such as aluminium) because of potential galvanic corrosion reactions.

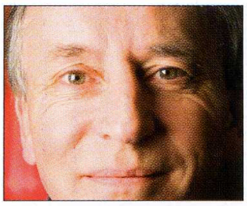
There is therefore a search for 'greener' and more economically viable alternatives to biocides, and one of the strongest contenders at present is to use a 'sol-gel' based coating (or primer). A 'sol-gel' consists of particles (between 0.0001 and 0.001mm in size) dispersed and suspended in a liquid (a 'sol') which when allowed to hydrolyse and condense, forms a 'gel'. Further curing leads to the formation of a dense film.

To date, the vast majority of sol-gels have been a mix of inorganic materials, and coatings based on such formulations require either a long cure time or a high cure temperature (often above 300°C). In addition, they generally have a limited coating thickness (less than 0.001 to 0.01mm for a single-coat system) and are inflexible, so often crack.

In 2005, researchers at the Materials & Engineering Research Institute (MERI) at Sheffield Hallam University made a breakthrough in the development of low-temperature cure 'hybrid sol-gels', which contain both inorganic and organic components. The coatings evaluated so far have proved to be flexible and thicker (up to 0.015mm).

Where marine applications are concerned, the greatest potential comes from the fact that the organic component is typically carbon-based, and can therefore include a 'living' element, namely bacteria. This allows for the production of 'biologically active' coatings which would prevent/limit the colonisation and build up of a biofilm.

A number of field tests have been conducted to evaluate the properties and performance of hybrid sol-gel coatings – the most notable of which so far has been at the Thames Barrier in London. The tests are also establishing if the active component in the



Professor Robert Akid

'... biofouling often leads to highly localised microbial-induced corrosion'

sol-gel is secreting a natural inhibitor or if it leads to formation of its own bio-film (which prevents others taking hold).

The most recent sol-gel development relates to the creation of a solvent-free (100% water-based) system. It also has the added environmental benefit that no volatile organic compounds (VOCs) are released during the curing process. To date this coating has only been used as an anti-corrosion pre-treatment prior to the application of a top coat.

Sol-gel systems have potential applications in numerous areas including pre-treatment and primers. Retrieving and then treating (with bioactive sol-gel coatings) structures which have been submerged for a long time would require suitable surface cleaning prior to coating, however, where new structures are to be submerged in marine environments treatment to ward off biofouling would be a viable proposition. Such surfaces could include polymer/plastics. Watch this space.

Professor Robert Akid is head of the Structural Materials & Integrity Research Centre, of the Materials & Engineering Research Institute at Sheffield Hallam University. He would like to acknowledge the involvement of Dr Heming Wang and Dr Thomas Smith in developing the above-mentioned sol-gel systems. PS

■ *For further information on sol-gel please visit: www.shu.ac.uk/research/meri/cct/coatings*

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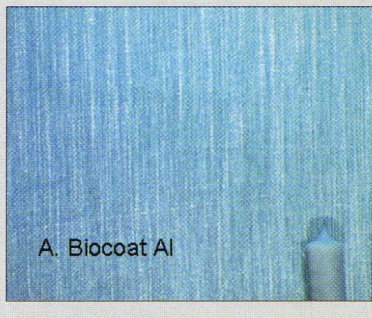
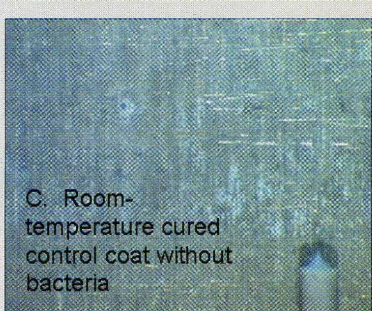
The bio-barrier

ALL THREE PLATES shown here were submerged for six months at the Thames Barrier. The results show clearly corrosion of the bare aluminium sample, some protection with the sol-gel coating without bacteria and no corrosion/biofouling of the biocoat sample. Currently a similar test is being conducted in the warm and highly bio-active waters of Florida.



A. Biocoat Al

B. Bare Al



C. Room-temperature cured control coat without bacteria