ABSTRACT

Coatings are often used as a means of protecting steel structures in marine and offshore environments. While the use of coatings is extensive, the assessment of the performance of these coatings can be complicated, particularly if and when the coated steel suffers corrosion damage. Several types of smart coatings have been shown to exhibit properties that allow corrosion to be identified before it can be seen with the naked eye. This would be very advantageous and could potentially result in tremendous savings in time and money when structures undergo routine maintenance.

The investigators have examined coatings that incorporate corrosion indicators that change their fluorescent state in the presence of corrosion as a result of changes in pH. The particular corrosion indicators are positive indicators for steel in that they are initially non-fluorescent upon application, but glow over areas of corrosion.

In this paper, fluorescence behavior, electrochemical behavior, microscopic evidence, and visual observations of coated steel specimens will be compared based on exposure to saltwater conditions. Some of the challenges associated with the use of these types of coatings will be presented. All of this information is aimed at the development of smart coatings that can reveal the coating and metal condition before it is visible to the naked eye.

KEY WORDS: Coatings; fluorescence; corrosion; EIS, steel

INTRODUCTION

The use of smart coatings for corrosion detection in marine and offshore structures would be very desirable. These would be coatings that could somehow reveal damage before it could be seen with the naked eye.

To that end, fluorescent coatings have been studied for quite some time, especially for aluminum alloys (Agarwala and Fabiszewski, 1994; Johnson and Agarwala, 1997; Agarwala, 1997, Frankel and Zhang, 1999; Agarwala and Ahmad, 2000; Saidarasamoot et al., 2003). In one of those studies, paints detected changes in acidity and alkalinity by responding when water and air attacked certain metals (Frankel and Zhang, 1999). The result was that electrochemical reactions produced ions that increased the pH.

In addition to work on aluminum alloys, there is also work on other alloys (Kumar and Stephenson, 2008; Li and Calle, 2008).

There has also been success in identifying and using fluorescent coatings commercially for holiday detection in steel structures (Doyle and Gossen, 2004). The use of these types of coatings for corrosion detection, however, is not as mature. Some of the challenges include identifying the types and amounts of fluorescent indicators that need to be added to the coating system; ensuring that the coating system is stable for long periods of time; ensuring that the indicator response can be seen through the coating system; and ensuring that the indicator responds to changes in corrosion behavior.

The present investigation grew out of an earlier investigation in which the authors examined coatings containing corrosion indicators that change their fluorescent state in the presence of corrosion; positive indicators for steel and negative indicators for aluminum. This paper will focus on steel alloys and one indicator. The indicator is a positive indicator and is expected to be non-fluorescent when applied initially and then to glow over areas of corrosion as a function of time and exposure to a corrosive environment. This is due to the nature of the indicator such that its fluorescence is high at pH values between 8 and 12 when corrosion products are formed.

In the earlier part of this investigation, a Fluorescent Corrosion Indicator (FCI) system was used for paint primer and overcoat coatings on steel and aluminum alloys. Systems & Processes Engineering Corporation (SPEC) developed the prototype scanner system and paint additives to provide an early warning corrosion system based on the use of fluorescent indicators distributed throughout the paint (SPEC, 2005).

One of the techniques that was used along with the scanner system was electrochemical impedance spectroscopy (EIS). This technique is often used to assess the effectiveness of coated metals and it involves determining and analyzing the response of corroding electrodes to small-amplitude alternating potential signals of a wide frequency range.