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Corrosion protection using conducting polymers

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CORROSION PROTECTION USING CONDUCTING POLYMERS

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CERTIFICATION

I, Magnus Gustavsson, declare that this thesis, submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Department of Chemistry, University of Wollongong, is wholly my own work unless otherwise referenced or acknowledged. The document has not been submitted for qualifications at any other university or institution.

Magnus Gustavsson

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Concern over the toxicity and environmental impact by use of chromate containing coating coatings has fuelled efforts to find suitable replacements. One class of materials considered as a potential replacement for chromate coatings are the intrinsically conducting polymers (ICP's). This thesis describes the synthesis and characterization of a range of ICP materials with emphasis on producing processable ICP and their use as corrosion protection coatings for aluminium alloy 2024-T3 and Zn-55%Al- hot dipped coated steel, two substrates that commonly employ chromate coatings for adequate protection. A general introduction to corrosion and ICP's are given in Chapter 1 with techniques employed to study corrosion inhibition detailed in Chapter 2.

Processability of Polyaniline was afforded by making of composite material to produce Polyaniline-HCSA/Poly(butyl acrylate-vinyl acetate) copolymer (PAn/co-poly) possessing moderate conductivity and electroactivity (Chapter 3). PAn/co-poly was highly soluble and could be applied as a coating to AA2024-T3 by airbrushing. Polypyrrole was afforded processability by monomer substitution to produce soluble Poly(3-octylpyrrole). Material synthesis was optimised to produce a maximum conductivity for the soluble ICP that could be applied to a metal surface by airbrushing or evaporative casting. Conductive, soluble P3OP was synthesised both through electrochemical and chemical synthesis P3OP route

Corrosion inhibition offered by ICP evaluated using Potentiodynamic polarisation and Electrochemical Impedance spectroscopy (EIS) (Chapter 4) suggests an interaction between the ICP coating and the underlying substrate. PAn/co-poly was observed to provide an anodic shift to the OCP of coated AA2024-T3. Increasing R_c and R_{ct} during exposure suggested that the coating converted towards a less conductive form. Exposure of conductive P3OP-ClO_4 coated AA2024-T3 also resulted in increasing R_{ct} overtime, ascribed to the formation of protective oxide.

Local corrosion behaviour within a coating defect was studied by SVET (Chapter 5). SVET demonstrated that PAn/co-poly accelerated corrosion within a defect without formation of protective oxide. Conductive fractions of P3OP exhibited decreasing oxidation within coating defect overtime suggesting the formation of an oxidation product that hinders further corrosion. Raman spectroscopy (Chapter 6) as well as visual observations (Chapter 4 and 5) suggest that oxidation of the substrate was promoted by the ICP that undergoes reduction. For P3OP this leads to lower corrosion current density within surface a defect suggesting that P3OP does protect against corrosion through anodic protection.

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