SYNERGISTIC ADVANCEMENTS IN SUSTAINABLE COATING TECHNOLOGIES: POLYURETHANE MICROENCAPSULATION OF SOYBEAN OIL FOR AUTONOMOUS SELF-HEALING AND ANTICORROSIVE PAINTS

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M. Sc. in Materials Science

Department of Material Science & Engineering

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Thesis/Dissertation submitted in partial fulfillment of the requirements for the degree
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Declaration of supervisor

I declare that this is my own work and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

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The above candidate has carried out research for the Masters thesis/dissertation under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of the supervisor: Mr. S.V. Udayakumara

Signature of the supervisor: Date:

Dedication

To my academic teachers for their guidance and inspiration and to my colleagues in industry, for their invaluable insights and collaboration.
To my parents, and spouse for their unwavering support and encouragement,
Thank you for helping me reaches this milestone.

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Abstract

The objective of this thesis was to develop and characterize a sustainable, self-healing polyurethane (PU) coating containing microencapsulated soybean oil for improved anti-corrosion performance applicable particularly in automotive topcoats. Soyabean oil microcapsules were synthesized with phases of 100 µm to 7000 µm based on the interfacial polymerization and particle size was confirmed via scanning electron microscopy (SEM). Microencapsulation technique was successfully able to generate spherical microcapsules however the particle size was difficult to control. The largest of the microcapsules exceeded the required final dry film thickness of >250 µm, resulting in an uneven coating appearance. This made it visually unappealing and compromised the need for a smooth finish, which is critical in automotive applications.

The self-healing capacity was tested by introducing microcapsules into PU-based paint at the content of 3, 5 and 7% wt of base pigmented PU composite on steel substrate. Optical microscopy assessments of X-shaped scratches at 1 and 7 days revealed that healing efficacy enhanced with higher concentration of microcapsules while excessive dosages caused surface roughness. The self-healing function and the surface properties of the coating were at odds with each other, showing that these properties need to be optimally dosed for high-finish applications.

Corrosion resistance was assessed in a Neutral Salt Spray (NSS) test (ISO 9227) for 72, 168 and 240 hours, showing that increasing the dosage of microcapsules resulted in a significant decrease in the formation of rust and improved the corrosion resistance. Cross-hatch cross cut tape adhesion testing demonstrated consistent adhesion performance between all samples regardless of content, showing that incorporation of microcapsules does not appear to negatively impact adhesion.

The results from this investigation highlight the utility of microencapsulated soybean oil for sustainable mitigation in PU coatings, which could lead to future self-healing automotive topcoats with potential corrosion protection properties. The results pave way for future efforts to focus on controlling the particle size and optimizing loading, which shall target simultaneous improvements in functional properties as well as aesthetic quality of protective coatings.

Keywords: Self-healing coatings, Polyurethane (PU) coatings, Microencapsulation, Soybean oil, Corrosion resistance, Auto-motive topcoats.

Table of contents

List of figures

List of tables

List of abbreviations

PU : Polyurethane
DCPD : dicyclopentadiene
UF : urea-formaldehyde
PUF : polyurea-formaldehyde
POTS : perfluorooctyl triethoxysilane
IPDI : isophorone diisocyanate
SEM : Scanning Electron Microscopy
GNP : Gross National Product
GDP : Gross Domestic Product
UV : Ultra Violet
SDBS : sodium dodecyl benzene sulfonate
TO : Tung oil
LO : Linseed Oil
SBO : Soya bean Oil
GA : Gum Arabic
TMMP-TMTGE :Trimethylolpropanetris3-mercaptopropionate-trimethylolpropane triglycidyl ether
DETA : diethylenetriamine
TMP : trimethylolpropane
TDS : Technical Data Sheet
CMC : Carboxymethyl Cellulose
EtOAc : Ethyl Acetate
NSS : Neutral Salt Spray
IPDI : isophorone diisocyanate
ASTM : American Standard for Testing Materials
WFT : Wet Film Thickness
DFT : Dry Film Thickness

List of appendices