

Marine biofouling protection: design of controlled release antifouling paints

Søren Kiil,^a Claus E. Weinell,^b Diego M. Yebra,^b Kim Dam-Johansen^a

^a*Department of Chemical Engineering, Technical University of Denmark, Building 229, DK-2800 Kgs. Lyngby, Denmark*

^b*Hempel A/S, Lundtoftevej 150, DK-2800 Kgs. Lyngby, Denmark*

Corresponding author: S. Kiil, sk@kt.dtu.dk, tel. +45-4525-2827, Fax: +45-4588-2258.

Introduction

This chapter is concerned with the design and improvement of chemically-active ship bottom paints known as antifouling paints. The aims have been to illustrate the challenges involved in working with such multi-component, functional products and to show which scientific and engineering tools are available. The research in this field includes both purely empirical formulation and test methods and advanced tools including mathematical modelling of paint behaviour.

First, the background of and problems associated with marine biofouling are presented. This is followed by a concise historical review showing the diverse ideas of biofouling control that have been tried over the years. The next section deals with the characterisation and working mechanisms of antifouling paints, detailing the various components and their function. Practical laboratory and field tests of antifouling paints are subsequently discussed. Then follows a section on mathematical modelling of antifouling paint behaviour illustrating how such quantitative tools can be used in the design and understanding of new and improved paint systems. The final issue raised is the approval of paint products, which is of great importance because antifouling paints contain active ingredients. The chapter ends with conclusions and a look ahead for new solutions to the marine biofouling challenge.

List of contents

INTRODUCTION	1
LIST OF CONTENTS	1
MARINE BIOFOULING	ERROR! BOOKMARK NOT DEFINED.
CHARACTERISATION OF MARINE BIOFOULING	ERROR! BOOKMARK NOT DEFINED.
THE CONSEQUENCES OF BIOFOULING	ERROR! BOOKMARK NOT DEFINED.
HISTORICAL ASPECTS OF ANTIFOULING	ERROR! BOOKMARK NOT DEFINED.
CHARACTERIZATION OF ANTIFOULING PAINT	ERROR! BOOKMARK NOT DEFINED.
PAINT COMPONENTS	ERROR! BOOKMARK NOT DEFINED.
PRODUCT DESIGN CRITERIA OF AN ANTIFOULING PAINT	ERROR! BOOKMARK NOT DEFINED.
FULL PAINT SYSTEM ON A SHIP	ERROR! BOOKMARK NOT DEFINED.
WORKING MECHANISMS OF ANTIFOULING PAINTS	ERROR! BOOKMARK NOT DEFINED.
FORMULATION AND PAINT PRODUCTION	ERROR! BOOKMARK NOT DEFINED.

<i>Binder system</i>	<i>Error! Bookmark not defined.</i>
<i>Biocides</i>	<i>Error! Bookmark not defined.</i>
<i>Solvents</i>	<i>Error! Bookmark not defined.</i>
<i>Pigment Volume Concentration (PVC)</i>	<i>Error! Bookmark not defined.</i>
<i>Wetting agents</i>	<i>Error! Bookmark not defined.</i>
<i>Thixotropic agents</i>	<i>Error! Bookmark not defined.</i>
<i>Paint production</i>	<i>Error! Bookmark not defined.</i>
PAINTING SHIP HULLS	ERROR! BOOKMARK NOT DEFINED.
PAINT TESTING	ERROR! BOOKMARK NOT DEFINED.
MECHANICAL TESTING	ERROR! BOOKMARK NOT DEFINED.
<i>Adhesion test</i>	<i>Error! Bookmark not defined.</i>
<i>Impact</i>	<i>Error! Bookmark not defined.</i>
<i>Mandrel Bending Test</i>	<i>Error! Bookmark not defined.</i>
<i>MAN-H - Hydraulic Mandrel Bending Test</i>	<i>Error! Bookmark not defined.</i>
<i>Wooden Block Settings</i>	<i>Error! Bookmark not defined.</i>
ACCELERATED EXPOSURE TESTING	ERROR! BOOKMARK NOT DEFINED.
<i>Blister Box Test</i>	<i>Error! Bookmark not defined.</i>
<i>Cyclic Blister Box Test</i>	<i>Error! Bookmark not defined.</i>
<i>Immersion</i>	<i>Error! Bookmark not defined.</i>
DYNAMIC TESTING USING ROTARY SET-UP	ERROR! BOOKMARK NOT DEFINED.
DRAG RESISTANCE	ERROR! BOOKMARK NOT DEFINED.
STATIC PERFORMANCE TESTING	ERROR! BOOKMARK NOT DEFINED.
FULL SHIP TESTING	ERROR! BOOKMARK NOT DEFINED.
BIOCIDE RELEASE MEASUREMENTS	ERROR! BOOKMARK NOT DEFINED.
OPTICAL AND SCANNING ELECTRON MICROSCOPICAL EXAMINATION OF PAINT	ERROR! BOOKMARK NOT
DEFINED.	
<i>Microscopical examination of paint (MEP)</i>	<i>Error! Bookmark not defined.</i>
<i>Scanning electron microscopy coupled with energy-dispersive X-ray analysis (SEM-EDX)</i>	<i>Error!</i>
<i>Bookmark not defined.</i>	
MATHEMATICAL PAINT MODELS	ERROR! BOOKMARK NOT DEFINED.
SIMULATION TOOLS.....	ERROR! BOOKMARK NOT DEFINED.
SIMULATIONS OF THE EFFECT OF PAINT FORMULATION PARAMETERS ON THE ANTIFOULING PAINT BEHAVIOUR	ERROR! BOOKMARK NOT DEFINED.
DYNAMIC SIMULATIONS OF PAINT BEHAVIOUR	ERROR! BOOKMARK NOT DEFINED.
SEAWATER-SOLUBLE PIGMENTS AND THEIR POTENTIAL USE IN ANTIFOULING PAINTS	ERROR! BOOKMARK
NOT DEFINED.	
TIN-FREE SYSTEMS	ERROR! BOOKMARK NOT DEFINED.
EXPERIMENTAL MODEL INPUTS	ERROR! BOOKMARK NOT DEFINED.
APPROVAL OF PAINT PRODUCTS	ERROR! BOOKMARK NOT DEFINED.
AF PAINT REGISTRATION/REGULATION SCHEMES .	ERROR! BOOKMARK NOT DEFINED.
REGIONAL AND LOCAL SCHEMES	ERROR! BOOKMARK NOT DEFINED.
GLOBAL ANTIFOULING PAINT LEGISLATION.....	ERROR! BOOKMARK NOT DEFINED.
OTHER LEGISLATION COVERING PAINT PRODUCTS	ERROR! BOOKMARK NOT DEFINED.
CONCLUSIONS AND FUTURE SOLUTIONS	ERROR! BOOKMARK NOT DEFINED.
ACKNOWLEDGEMENTS	ERROR! BOOKMARK NOT DEFINED.
REFERENCES	ERROR! BOOKMARK NOT DEFINED.