

MASTER'S THESIS

The use of the rock shell, *thais clavigera*, as a biomonitor of tributyltin contamination in Hong Kong and Shenzhen

Chan, Ka Ming

Date of Award:
2008

[Link to publication](#)

General rights

Copyright and intellectual property rights for the publications made accessible in HKBU Scholars are retained by the authors and/or other copyright owners. In addition to the restrictions prescribed by the Copyright Ordinance of Hong Kong, all users and readers must also observe the following terms of use:

- Users may download and print one copy of any publication from HKBU Scholars for the purpose of private study or research
- Users cannot further distribute the material or use it for any profit-making activity or commercial gain
- To share publications in HKBU Scholars with others, users are welcome to freely distribute the permanent URL assigned to the publication

**The Use of the Rock Shell, *Thais clavigera*, as a Biomonitor of
Tributyltin Contamination in Hong Kong and Shenzhen**

CHAN Ka Ming

**A thesis submitted in partial fulfillment of the requirements
for the degree of
Master of Philosophy**

Principal Supervisor: Dr. QIU Jianwen

Hong Kong Baptist University

February 2008

Abstract

Tributyltin (TBT) is widely used as an active ingredient in antifouling paints to prevent the fouling of marine organisms on ship hulls. It is effective, but exerts adverse effects on many non-target organisms, such as imposition of male sexual characteristics (i.e. imposex) in female neogastropods. With busy traffic of shipping and pleasure vessels in Hong Kong and Shenzhen, the coastal water in these regions is seriously contaminated by TBT. This study aims to assess the suitability and problems of applying *Thais clavigera*, a common neogastropod in western Pacific, as a biomonitor of TBT contamination in southern China, including Hong Kong and Shenzhen.

The thesis is organized into six chapters. Chapter 1 is a general introduction of the problems and the objectives of the study. Chapter 2 is a literature survey encompassing the source and fate of TBT, its toxicity to marine animals, as well as the biology of *Thais clavigera*, the experimental animal used in this study. Chapter 3 is a survey of TBT contamination in Mirs Bay, based on seasonal changes in imposex status and tissue butyltin concentrations in different populations of *T. clavigera*. The results are compared with those from previous studies conducted in Hong Kong waters. Taken together, these results provide us a geographic view of TBT contamination in these two regions, their seasonal changes, and factors that may be

Tsang, Ms. Y.M. Lee and Ms. N.C. Wong, for their advice and help on my experiments.

Finally, my deepest appreciation is extended to my family including my parents, my brother for their continuous support, love, patience, encouragement and effort to understand what I was doing.

Table of Contents

Declaration	i
Abstract	ii
Acknowledgments	v
Table of Contents	vii
List of Tables	xii
List of Figures	xv
List of Plates	xvii
Chapter 1. General Introduction	1
1.1. Background	1
1.2. Objective and Outline of the Present Study	2
Chapter 2. Literature Review	6
2.1. Biofouling and Antifouling Paint	6
2.1.1. Biofouling	6
2.1.2. Antifouling Method	7
2.2. Tributyltin Properties	8
2.2.1. Physio-chemical Properties	8
2.2.2. Fate of TBT in the Environment	12
2.2.2.1. Physical Adsorption	12
2.2.2.2. Degradation	13
2.2.2.3. Bioaccumulation	14
2.3. Tributyltin Toxicity	15
2.3.1. Acute Toxicity	16
2.3.2. Chronic Toxicity	17
2.3.3. Endocrine Disruptive Effects	18

2.3.3.1.	Oyster Shell Thickening	18
2.3.3.2.	Imposex in Gastropods	19
2.3.3.2.1.	Characteristics of Imposex	19
2.3.3.2.2.	Relationships between TBT and Imposex in Gastropods	20
2.3.3.2.3.	Hypothesis of Imposex	21
2.4.	TBT Contamination	23
2.4.1.	TBT Profile in Hong Kong	23
2.4.2.	TBT Profile in China	25
2.5.	Tributyltin Regulations	27
2.6.	Biomonitoring of TBT Contamination	31
2.7.	The Use of <i>Thais clavigera</i> as an Indicator of TBT Contamination	34
2.7.1.	Biology and Ecology of <i>T. clavigera</i>	34
2.7.1.1.	Growth and Population Dynamic	34
2.7.1.2.	Feeding Ecology	36
2.7.1.3.	Reproduction	37
2.7.2.	Imposex of <i>T. clavigera</i> in Hong Kong and China	40
Chapter 3. Seasonal Changes in Imposex and Tissue Burden of Butyltin Compounds in <i>Thais clavigera</i> Populations along the Coastal Area of Mirs Bay, China		
3.1.	Abstract	43
3.2.	Introduction	44
3.3.	Materials and Methods	47
3.3.1.	Sample Collection	47

3.3.2.	Determination of Sex and Imposex in <i>T. clavigera</i>	49
3.3.3.	Butyltin Analysis	51
3.3.4.	Statistical Analysis	53
3.4.	Result	54
3.4.1.	Sex ratio and Imposex Level	54
3.4.2.	Butyltins in <i>T. clavigera</i> Tissues	55
3.4.3.	Correlation among Imposex, Tissue Burden of TBT, and Distance from Yantian Port	56
3.5.	Discussion	62
3.6.	Conclusions	66
Chapter 4.	Relationships Between Scope for Growth, Imposex Status and Tissue Burden of Butyltins in the Rock Shell, <i>Thais clavigera</i>	67
4.1.	Abstract	67
4.2.	Introduction	68
4.3.	Materials and Methods	70
4.3.1.	Sampling	70
4.3.2.	Physiological Measurements	72
4.3.2.1.	Respiration and Ammonia Excretion Rates	72
4.3.2.2.	Ingestion Rate	73
4.3.2.3.	Absorption Efficiency and Absorption Rate	73
4.3.2.4.	Scope for Growth (SFG)	74
4.3.3.	Determination of Sex and Imposex Status	75
4.3.4.	Butyltin Analysis	76

4.3.5.	Statistical Analyses	76
4.4.	Results	77
4.4.1.	Physiological Measurements	77
4.4.2.	Sex ratio and Imposex Status	78
4.4.3.	Tissue Burden of Butyltins	79
4.4.4.	Relationships between SFG, Imposex Status and Tissue Burden of TBT	79
4.5.	Discussion	86
4.6.	Conclusion	91
Chapter 5.	Sensitivity of Different Biological Responses to Exposure and Depuration of Butyltins in <i>Thais clavigera</i>: Reciprocal Transplant of the Neogastropod in Cages	92
5.1.	Abstract	92
5.2.	Introduction	93
5.3.	Materials and Methods	96
5.3.1.	Field Sites	96
5.3.2.	Transplant Experiment	98
5.3.3.	Physiological Measurements	98
5.3.3.1.	Respiration and Ammonia Excretion Rates	99
5.3.3.2.	Ingestion Rate	100
5.3.3.3.	Absorption Efficiency and Absorption Rate	100
5.3.3.4.	Scope for Growth (SFG)	101
5.3.4.	Determination of Sex and Imposex Status	102
5.3.5.	Butyltin Analysis	103

5.3.6. Statistical Analyses	104
5.4. Results	105
5.4.1. Cage Condition, Neogastropod Survival and Growth	105
5.4.2. Physiological Data	105
5.4.3. Imposex Status	106
5.4.4. Tissue Burden of Butyltins	106
5.5. Discussion	114
5.6. Conclusion	119
Chapter 6. General Discussion, Conclusion and Further Studies	120
6.1. General Discussion	120
6.1.1. TBT Contamination in Hong Kong and Shenzhen	120
6.1.2. Seasonal Variation in Imposex Level in <i>T. clavigera</i>	122
6.1.3. Transplant Experiment and TBT Monitoring	122
6.1.4. Biomarkers for TBT Monitoring	123
6.1.5. The values of <i>T. clavigera</i> as a Biomoniotor	125
6.2. Conclusions	126
6.3. Recommendation for Future Work	127
Reference	129
Curriculum Vitae	156
List of Publications	157