Amplified vibrational circular dichroism

Rosa Domingos, S.M.

Citation for published version (APA):
CONTENTS

1 INTRODUCTION 1
  1.1 The Difference Between Left and Right 1
  1.2 Homochiral Biochemistry and the Drug Industry 4
  1.3 Mirror Image Asymmetry and Optical Activity 5
  1.4 Vibrational Circular Dichroism 5
  1.5 From Theory to Practice 7

2 THEORY 9
  2.1 Rotational Strength 10
    2.1.1 Transitions between molecular states 10
    2.1.2 Interaction with a circularly polarized electromagnetic field 10
    2.1.3 VCD intensity 12
    2.1.4 Symmetry Breaking 13
  2.2 Theoretical framework of VCD 14
    2.2.1 Born-Oppenheimer Approximation 14
    2.2.2 Beyond the Born-Oppenheimer Approximation 17
  2.3 VCD calculations using Density Functional Theory 20
  2.4 VCD calculations using the coupled-oscillator model 21

3 EXPERIMENTAL METHODS 23
  3.1 Vibrational Circular Dichroism Measurements 24
    3.1.1 Fourier Transform Spectroscopy 24
    3.1.2 Fourier Transform VCD Spectroscopy 25
    3.1.3 Calibration Measurement 28
    3.1.4 Baseline correction 29
  3.2 OTTLE cell for VCD 31
    3.2.1 Introduction 31
    3.2.2 Practical considerations for spectroelectrochemical measurements 32
4 Elucidating the Conformation of Foldamers Using VCD 39
  4.1 Introduction 40
  4.2 Materials and methods 41
  4.3 Mode assignment 42
  4.4 N=N-stretch VCD spectra 43
    4.4.1 Coupled-oscillator model for the NN oscillators 43
    4.4.2 147 azo-foldamer 46
    4.4.3 Photo-induced 147 unfolding 49
  4.5 Conclusion 50
5 Amplifying VCD by Manipulation of the Electronic Manifold 51
  5.1 Introduction 52
  5.2 Synthetic methods and experimental procedures 53
  5.3 Results and Discussion 54
    5.3.1 VCD enhancement in electrochemically generated radical anions 54
    5.3.2 Low-lying electronically excited states 56
    5.3.3 Conformational analysis 59
  5.4 Final Remarks 63
6 Enhanced VCD and NLO in Crystalline Architectures 65
  6.1 Introduction 66
  6.2 Experimental Methods 68
    6.2.1 Synthesis 68
    6.2.2 X-ray Diffraction Studies 68
    6.2.3 Kurtz and Perry Powder Method 70
    6.2.4 IR and VCD Spectroscopy 70
  6.3 Theoretical Methods 70
    6.3.1 Microscopic Optical Properties 70
CONTENTS  vii

6.3.2 Macroscopic Nonlinear Optical Properties  71
6.3.3 Theoretical approach for VCD  72

6.4 Results and Discussion  72
6.4.1 Crystal Structure  72
6.4.2 Powder Diffraction Data  75
6.4.3 Nonlinear Optical Properties  76
6.4.4 VCD response  81

6.5 Conclusions  84

7 AMPLIFIED VCD AS A PROBE OF LOCAL BIOMOLECULAR STRUCTURE  87
7.1 Introduction  88
7.2 VCD of amino acids nearby cobalt ions  90
7.3 Enhanced VCD as a local probe in biological systems  95
  7.3.1 Deriving the coordination geometry from the amplified VCD signals  95
7.4 Final remarks  98
7.5 Configuration analysis of the amino acids binding pockets  98
7.6 Time-dependent DFT study of the binding pockets  103
7.7 Synthesis and characterization of the complexes  104
  7.7.1 Co\n\textsuperscript{II}(L-prolinate)\textsubscript{2}(H\textsubscript{2}O)\textsubscript{2}  104
  7.7.2 Co\n\textsuperscript{II}(L-alaninate)\textsubscript{2}(H\textsubscript{2}O)\textsubscript{2}  105
  7.7.3 Co\n\textsuperscript{II}(L-valinate)\textsubscript{2}(H\textsubscript{2}O)\textsubscript{2}  105
  7.7.4 Co\n\textsuperscript{II}(L-valinate-valinate)\textsubscript{2}(H\textsubscript{2}O)\textsubscript{2}  105
  7.7.5 Magnetic Susceptibility Measurements  106
  7.7.6 Sample Preparation and Methods  106

8 LOCAL VCD ENHANCEMENT IN SWITCHABLE FC-LINKED PEPTIDES  107
8.1 Introduction  108
8.2 Experimental Methods  110
  8.2.1 Synthesis and Characterization  110
  8.2.2 Spectroelectrochemical VCD measurements  112
8.3 Theoretical Methods  113
8.4 Results 113
8.5 Fc-Ala-Ala 113
8.6 Fc-Ala-Pro-Ala 116
8.7 Low-lying Electronically Excited States 120
  8.7.1 Fc-Ala-Ala, Fc-Ala-Pro-Ala 120
8.8 Conclusions and Outlook 123

BIBLIOGRAPHY 125
SUMMARY / RESUMO / SAMENVATTING 135
PUBLICATIONS 147
ACKNOWLEDGEMENTS 149