

Table of Contents

STATEMENT	xi
CERTIFICATE	xiii
ACKNOWLEDGEMENTS	xv

Chapter 1: Background of the Theoretical Methods and Abstract of the Thesis

1.1	General Introduction	3
1.2	Overview of Theoretical Methods	4
1.3	Quantum Mechanical Methods	4
1.3.1	The Born-Oppenheimer Approximation	5
1.3.2	Hartree-Fock Method	6
	1.3.2.1 Basis Sets	10
	1.3.2.2 Semi Empirical Methods	13
1.3.3	Post Hartree-Fock Methods	15
	1.3.3.1 Many Body Perturbation Theory	16
	1.3.3.2 Configuration Interaction	16
	1.3.3.3 Coupled Cluster Theory	17
1.3.4	Density Functional Theory	18
	1.3.4.1 Local Density Approximation	21
	1.3.4.2 Generalized Gradient Approximation	21
	1.3.4.3 Hybrid Functionals	22
1.3.5	Composite Methods	22

1.4	Molecular Mechanical Methods	23
1.4.1	Force Fields	24
1.4.2	Molecular Dynamics	26
1.4.3	Docking	29
1.5	Quantum Mechanical/Molecular Mechanical Methods	32
1.6	A Brief Outline of the Chapters	34
1.7	References	41

Chapter 2: Electronic Structure and Bonding in Neutral and Dianionic Boradiphospholes: $R'BC_2P_2R_2$ ($R=H, tBu, R'=H, Ph$)

2.1	Abstract	51
2.2	Introduction	52
2.3	Details of Computational Methods	57
2.4	Results and Discussions	58
2.4.1	Electron-Counting Considerations and Optimized Skeletons	58
2.4.2	Global Minima of <i>neutral</i> and <i>dianionic</i> $R'BC_2P_2R_2$	62
2.4.3	Isomers Containing 5-Membered Rings	66
2.4.4	Isomers Containing 4-Membered Rings	71
2.4.5	Isomers Containing 3-Membered Rings	78
2.4.6	Acyclic Isomers	84
2.5	Conclusions	86
2.6	References	88
2.7	Appendix	96

Chapter 3: Electronic Structure and Bonding Studies on Triple-Decker Sandwich Complexes with a P₆ as Middle Ring

3.1	Abstract	103
3.2	Introduction	104
3.3	Details of Computational Methods	106
3.4	Results and Discussions	106
3.4.1	The <i>mno</i> Rule and the Valence Electron Count	106
3.4.2	28 Valence Electron Count Complexes	109
3.4.3	26 Valence Electron Count Complexes	115
3.4.4	24 Valence Electron Count Complexes	119
3.4.5	22 Valence Electron Count Complexes	121
3.4.6	20 and 18 Valence Electron Count Complexes	125
3.5	Conclusions	128
3.6	References	129

Chapter 4: A pH Dependence of 3₁₀-Helix versus Turn in M-loop Region of PDE4: Observations on PDB Entries and an Electronic Structure Study

4.1	Abstract	137
4.2	Introduction	138
4.3	Details of Computational Methods	142
4.4	Results and Discussions	145
4.4.1	Crystal Structure Analysis	145
4.4.2	Root Mean Square Deviation	148
4.4.3	Importance of Secondary Structural Change and its Cause	150

4.4.4 Influence of pH on M-loop Region	153
4.4.5 Influence of M-loop Region on Subtype Selectivity	162
4.5 Conclusions	163
4.6 References	163

Chapter 5: Molecular Insights for the Inhibitor Selectivity between PDE4 and PDE7: Docking Study

5.1 Abstract	173
5.2 Introduction	174
5.3 Details of Computational Methods	178
5.4 Results and Discussions	179
5.4.1 Structural Comparison of PDE4 and PDE7	179
5.4.2 Docking	182
5.4.2.1 Substrate (cAMP)	182
5.4.2.2 Nonselective Inhibitor (IBMX)	183
5.4.2.3 PDE4 Inhibitors	184
5.4.2.4 PDE7 Inhibitors	188
5.4.2.5 Dual-Selective PDE4 and PDE7 Inhibitors	189
5.5 Conclusions	192
5.6 References	193