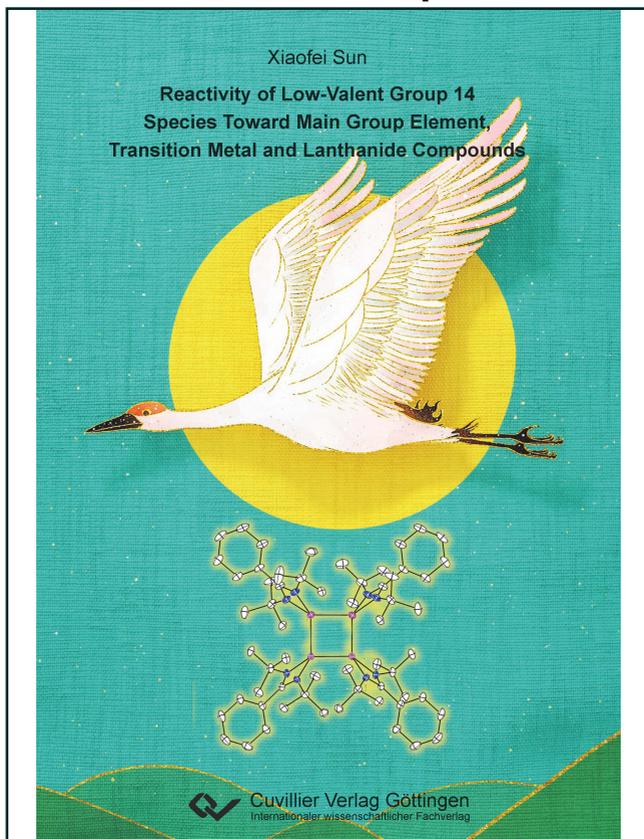




Xiaofei Sun (Autor)

# Reactivity of Low-Valent Group 14 Species Toward Main Group Element, Transition Metal and Lanthanide Compounds



<https://cuvillier.de/de/shop/publications/8685>

Copyright:

Cuvillier Verlag, Inhaberin Annette Jentzsch-Cuvillier, Nonnenstieg 8, 37075 Göttingen, Germany

Telefon: +49 (0)551 54724-0, E-Mail: [info@cuvillier.de](mailto:info@cuvillier.de), Website: <https://cuvillier.de>

## TABLE OF CONTENTS

<b>1. INTRODUCTION .....</b>	<b>1</b>
1.1 Low-coordinated silicon compounds.....	1
1.1.1 Silylenes .....	1
1.1.2 Silenes .....	8
1.2 Aromatic dianionic metalloles .....	12
1.3 Sandwich complexes.....	15
1.3.1 Pentaphosphaferrocene .....	15
1.3.2 Rare-earth element sandwich complexes .....	18
<b>2. MOTIVATION AND OBJECTIVES .....</b>	<b>21</b>
<b>3. RESULTS AND DISCUSSION .....</b>	<b>22</b>
3.1 Synthesis of aromatic tetrasilacyclobutadiene dications.....	22
3.1.1 Introduction .....	22
3.1.2 Synthesis of the tetrasilacyclobutadiene dication.....	24
3.1.3 Generality of the synthetic route .....	31
3.1.4 Mechanism study of the formation of the tetrasilacyclobutadiene dication.....	33
3.2 Synthesis of a chiral silene and its reactivity towards small molecules .....	36
3.2.1 Introduction .....	36
3.2.2 Synthesis of the chiral silene.....	36
3.2.3 Reactivity of the chiral silene .....	38
3.3 Rare-earth and alkaline-earth silylene complexes and their reactivities.....	48
3.3.1 Introduction .....	48
3.3.2 Synthesis and reactivity of divalent lanthanide bis(silylene) complexes .....	50
3.3.3 Synthesis and reactivity of a calcium bis(silylene) complex .....	56
3.3.4 Synthesis of rare-earth mono(silylene) complexes .....	59
3.3.5 Application of the rare-earth silylene complexes in hydrosilylation.....	63
3.3.6 Synthesis and reactivity of alkaline-earth mono(silylene) complexes .....	65
3.4 Zinc and cadmium silylene complexes and their reactivities .....	73
3.4.1. Introduction .....	73
3.4.2. Synthesis of zinc and cadmium mono(silylene) complexes.....	74
3.4.3. Reactivity of the zinc and cadmium silylene complexes toward S <sub>8</sub> and Se .....	77
3.5 Stepwise transformation of P <sub>4</sub> by different silylenes.....	81
3.5.1 Introduction .....	81
3.5.2 Stepwise P <sub>4</sub> functionalization by two different mono(silylenes).....	83

3.5.3 Stepwise P <sub>4</sub> functionalization by mono- and bis(silylenes) .....	88
3.6 Triple-decker complexes incorporating three distinct deck architectures .....	91
3.6.1 Introduction .....	91
3.6.2 Reaction of dilithioplumbole with P <sub>4</sub> .....	92
3.6.3 Reaction of dilithioplumbole with pentaphospha- and pentaarsaferrocene .....	93
3.7 Lanthanide germole and silole complexes .....	99
3.7.1 Introduction .....	99
3.7.2 Synthesis of lanthanide germole and silole complexes .....	100
3.8 Synthesis and magnetic properties of lanthanide plumbole sandwich complexes .....	104
3.8.1 Introduction .....	104
3.8.2 Synthesis of the lanthanide plumbole complexes .....	106
3.8.3 Quantum chemical study of the lanthanide plumbole bonding .....	110
3.8.4 Magnetic properties of the erbium complexes 55 and 57 .....	111
<b>4. EXPERIMENTAL SECTION .....</b>	<b>116</b>
4.1 General methods .....	116
4.2 Syntheses and analytical data .....	117
4.2.1 Starting materials .....	117
4.2.2 Co-crystallized [(L <sup>Ph</sup> Si) <sub>4</sub> ][I] <sub>2</sub> ( <b>1A</b> ) and [(L <sup>Ph</sup> Si) <sub>3</sub> ][I] ( <b>1B</b> ) .....	117
4.2.3 [(L <sup>Ph</sup> Si) <sub>4</sub> ][BPh <sub>4</sub> ] <sub>2</sub> ( <b>2</b> ) .....	117
4.2.4 [L <sup>tol</sup> SiHCl <sub>2</sub> ] .....	118
4.2.5 [L <sup>tol</sup> SiCl] .....	119
4.2.6 [(L <sup>tol</sup> Si) <sub>n</sub> (L <sup>Ph</sup> Si) <sub>4-n</sub> ][BPh <sub>4</sub> ] <sub>2</sub> (n = 0-4) ( <b>3</b> ) .....	119
4.2.7 Scrambling experiment between [L <sup>tol</sup> SiCl] and [L <sup>Ph</sup> SiSiL <sup>Ph</sup> ] .....	120
4.2.8 [L <sup>tol</sup> SiSiL <sup>tol</sup> ] .....	120
4.2.9 [(L <sup>tol</sup> Si) <sub>4</sub> ][BPh <sub>4</sub> ] <sub>2</sub> ( <b>4</b> ) .....	121
4.2.10 [L <sup>tBuPh</sup> SiHCl <sub>2</sub> ] .....	122
4.2.11 [L <sup>tBuPh</sup> SiCl] .....	122
4.2.12 [L <sup>tBuPh</sup> SiSiL <sup>tBuPh</sup> ] .....	123
4.2.13 [(L <sup>tBuPh</sup> Si) <sub>4</sub> ][BPh <sub>4</sub> ] <sub>2</sub> ( <b>5</b> ) .....	123
4.2.14 [L <sup>Ph</sup> Si(DMAP)][BPh <sub>4</sub> ] <sub>2</sub> ( <b>6</b> ) .....	124
4.2.15 [BINO-Si(NtBu) <sub>2</sub> (PhC=SiL <sup>Ph</sup> )] ( <b>7</b> ) .....	124
4.2.16 [BINO-Si{C(Ph)(NtBu){N(tBu)(L <sup>Ph</sup> Si=S)}}] ( <b>8</b> ) .....	125
4.2.17 [BINO-SiN(tBu)C(Ph(C=O)NtBu)OSiL <sup>Ph</sup> ] ( <b>9</b> ) .....	126
4.2.18 [BINO-Si(NtBu) <sub>2</sub> (PhCH-SiL <sup>Ph</sup> Cl)] ( <b>10</b> ) .....	127

4.2.19 [BINO-Si(NtBu) <sub>2</sub> (PhCH-Si(HL <sup>Ph</sup> Cl))][Cl] ( <b>11</b> ) .....	128
4.2.20 [BINO-Si(NtBu) <sub>2</sub> (PhCH-SiL <sup>Ph</sup> )](AlCl <sub>4</sub> ) ( <b>12</b> ).....	129
4.2.21 [BINO-Si(NtBu) <sub>2</sub> (PhC=SiL <sup>Ph</sup> -Cu(C <sub>6</sub> F <sub>5</sub> ))] ( <b>13</b> ).....	129
4.2.22 [L <sup>Ph</sup> SiFcSiL <sup>Ph</sup> -Eu{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>14</b> ).....	130
4.2.23 [L <sup>Ph</sup> SiFcSiL <sup>Ph</sup> -Yb{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>15</b> ).....	130
4.2.24 [L <sup>Ph</sup> SiNSiL <sup>Ph</sup> -Eu{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>16</b> ).....	131
4.2.25 [L <sup>Ph</sup> SiNSiL <sup>Ph</sup> -Yb{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>17</b> ).....	132
4.2.26 [L <sup>Ph</sup> SiNN-Yb{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>18</b> ) .....	132
4.2.27 [L <sup>Ph</sup> SiNN-CaN(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>19</b> ).....	133
4.2.28 [L <sup>Ph</sup> SiNSiL <sup>Ph</sup> -Ca{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>20</b> ).....	135
4.2.29 Reaction of [L <sup>Ph</sup> SiNSiL <sup>Ph</sup> -Yb{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>17</b> ) with THF- <i>d</i> <sub>8</sub> and NHCs.....	135
4.2.30 [L <sup>Ph</sup> SiN-Eu{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>21</b> ).....	136
4.2.31 [L <sup>Ph</sup> SiN-Yb{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>22</b> ).....	136
4.2.32 [L <sup>Ph</sup> SiN-La{N(SiHMe <sub>2</sub> ) <sub>2</sub> } <sub>3</sub> ] ( <b>23</b> ).....	137
4.2.33 [L <sup>Ph</sup> SiN-Y{N(SiHMe <sub>2</sub> ) <sub>2</sub> } <sub>3</sub> ] ( <b>24</b> ) .....	138
4.2.34 [L <sup>Ph</sup> SiN-Lu{N(SiHMe <sub>2</sub> ) <sub>2</sub> } <sub>3</sub> ] ( <b>25</b> ).....	138
4.2.35 General procedures for the catalytic hydrosilylation of alkenes.....	139
4.2.36 [L <sup>Ph</sup> SiN-Ca{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>26</b> ).....	139
4.2.37 [L <sup>Ph</sup> SiN-Sr{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>27</b> ).....	140
4.2.38 [L <sup>Ph</sup> SiN-Ba{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>28</b> ).....	141
4.2.39 [L <sup>Ph</sup> SiN-OCPh <sub>2</sub> ] ( <b>29</b> ) .....	141
4.2.40 [L <sup>Ph</sup> (Ph <sub>2</sub> C)NSi-O-M{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>30</b> : M = Ca, <b>31</b> : M = Sr, <b>32</b> : M = Ba).....	142
4.2.41 [PhCN(NtBu)(Ph <sub>2</sub> C)Si(2,6-(NEt) <sub>2</sub> -C <sub>5</sub> N)-O-Ca(thf) <sub>3</sub> ] ( <b>33</b> ) .....	142
4.2.42 [L <sup>Ph</sup> SiN-ZnCl <sub>2</sub> ] ( <b>34</b> ) .....	143
4.2.43 [L <sup>Ph</sup> SiN-ZnBr <sub>2</sub> ] ( <b>35</b> ).....	144
4.2.44 [L <sup>Ph</sup> SiN-ZnI <sub>2</sub> ] ( <b>36</b> ) .....	144
4.2.45 [L <sup>Ph</sup> SiN-CdI <sub>2</sub> ] ( <b>37</b> ) .....	145
4.2.46 [L <sup>Ph</sup> Si(S)N]-ZnCl <sub>2</sub> ] ( <b>38</b> ).....	146
4.2.47 [L <sup>Ph</sup> Si(S)N]-ZnI <sub>2</sub> ] ( <b>39</b> ).....	146
4.2.48 [L <sup>Ph</sup> Si(Se)N]-ZnCl <sub>2</sub> ] ( <b>40</b> ).....	147
4.2.49 [L <sup>Ph</sup> Si(S)N]-CdI <sub>2</sub> ] ( <b>41</b> ) .....	148
4.2.50 [(L <sup>Ph</sup> SiN)P(L <sup>BDI</sup> Si)P <sub>3</sub> (L <sup>Ph</sup> SiN)] ( <b>43</b> ) .....	149
4.2.51 [(L <sup>Ph</sup> SiFcSiL <sup>Ph</sup> )P <sub>4</sub> (L <sup>BDI</sup> Si)] ( <b>45</b> ) .....	150
4.2.52 [Li(thf)(η <sup>5</sup> -L <sup>P</sup> )] ( <b>46</b> ).....	151

4.2.53	$[\{\text{Cp}^*\text{Fe}(\mu\text{-}\eta^4\text{:}\eta^3\text{-P}_5)\text{Li}(\eta^5\text{-L}^{\text{Pb}})\}\text{Li}(\text{thf})]_2$ ( <b>47</b> )	151
4.2.54	$[\{\text{Cp}^*\text{Fe}(\mu\text{-}\eta^4\text{:}\eta^2\text{-As}_5)\text{Li}(\eta^5\text{-L}^{\text{Pb}})\}\text{Li}(\text{thf})]_2$ ( <b>48</b> )	152
4.2.55	$[\text{K}(\text{thf})_3(\mu\text{-}\eta^8\text{:}\eta^8\text{-COT})\text{La}(\eta^5\text{-L}^{\text{Si}})]_2$ ( <b>49</b> )	153
4.2.56	$[\{\text{K}(\text{thf})(\mu\text{-}\eta^8\text{:}\eta^8\text{-COT})\text{La}(\eta^5\text{-L}^{\text{Ge}})\}_2]_n$ ( <b>50</b> )	154
4.2.57	$[\{\text{K}_{0.5}(\mu\text{-}\eta^8\text{:}\eta^8\text{-COT})\text{Ce}(\eta^5\text{-L}^{\text{Ge}})\text{K}(\text{thf})(\mu\text{-}\eta^8\text{:}\eta^8\text{-COT})\text{Ce}(\mu\text{-}\eta^8\text{:}\eta^8\text{-COT})\text{K}_{0.5}(\text{thf})_{0.5}\}_2]_n$ ( <b>51</b> )	154
4.2.58	$[\{\text{Li}(\text{thf})(\mu\text{-}\eta^5\text{:}\eta^5\text{-L}^{\text{Pb}})\text{La}(\eta^8\text{-COT}^{\text{TIPS}})\}]$ ( <b>52</b> )	155
4.2.59	$[\{\text{Li}(\text{thf})(\mu\text{-}\eta^5\text{:}\eta^5\text{-L}^{\text{Pb}})\text{Ce}(\eta^8\text{-COT}^{\text{TIPS}})\}]$ ( <b>53</b> )	156
4.2.60	$[\{\text{Li}(\text{thf})(\mu\text{-}\eta^5\text{:}\eta^5\text{-L}^{\text{Pb}})\text{Sm}(\eta^8\text{-COT}^{\text{TIPS}})\}]$ ( <b>54</b> )	156
4.2.61	$[\{\text{Li}(\text{thf})(\mu\text{-}\eta^5\text{:}\eta^5\text{-L}^{\text{Pb}})\text{Er}(\eta^8\text{-COT}^{\text{TIPS}})\}]$ ( <b>55</b> )	157
4.2.62	$[\text{Li}(\text{Et}_2\text{O})_{3.4}(\text{thf})_{0.6}][\{\eta^5\text{-L}^{\text{Pb}}\}\text{Er}(\eta^8\text{-COT}^{\text{TIPS}})]$ ( <b>56</b> )	158
4.2.63	$[\text{Li}(12\text{-crown-4})_2][\{\eta^5\text{-L}^{\text{Pb}}\}\text{Er}(\eta^8\text{-COT}^{\text{TIPS}})]$ ( <b>57</b> )	159

## 5. CRYSTAL STRUCTURE MEASUREMENTS .....160

5.1	Data collection and refinement	160
5.2	Crystal data	161
5.2.1	$[(\text{L}^{\text{Ph}}\text{Si})_4][\text{I}]_2$ ( <b>1A</b> ) and $[(\text{L}^{\text{Ph}}\text{Si})_3][\text{I}]$ ( <b>1B</b> )	161
5.2.2	$[(\text{L}^{\text{Ph}}\text{Si})_4][\text{BPh}_4]_2 \cdot \text{THF}$ ( <b>2</b> )	162
5.2.3	$[(\text{L}^{\text{Ph}}\text{Si})_4][\text{BPh}_4]_2 \cdot 2 \text{ MeCN}$ ( <b>2</b> )	163
5.2.4	$[(\text{L}^{\text{toI}}\text{Si})_n(\text{L}^{\text{Ph}}\text{Si})_{4-n}][\text{BPh}_4]_2$ ( $n = 0\text{-}4$ ) ( <b>3</b> )	164
5.2.5	$[(\text{L}^{\text{toI}}\text{Si})_4][\text{BPh}_4]_2$ ( <b>4</b> )	165
5.2.6	$[(\text{L}^{\text{tBuPh}}\text{Si})_4][\text{BPh}_4]_2$ ( <b>5</b> )	166
5.2.7	$[\text{L}^{\text{Ph}}\text{Si}(\text{DMAP})][\text{BPh}_4]$ ( <b>6</b> )	167
5.2.8	$[\text{BINO-Si}(\text{NtBu})_2(\text{PhC}=\text{SiL}^{\text{Ph}})]$ ( <b>7</b> )	168
5.2.9	$[\text{BINO-Si}\{\text{C}(\text{Ph})(\text{NtBu})\}\{\text{N}(\text{tBu})(\text{L}^{\text{Ph}}\text{Si}=\text{S})\}]$ ( <b>8</b> )	169
5.2.10	$[\text{BINO-SiN}(\text{tBu})\text{C}(\text{Ph}(\text{C}=\text{O})\text{NtBu})\text{OSiL}^{\text{Ph}}]$ ( <b>9</b> )	170
5.2.11	$[\text{BINO-Si}(\text{NtBu})_2\{\text{PhCH-Si}(\text{HL}^{\text{Ph}}\text{Cl})\}[\text{Cl}]$ ( <b>11</b> )	171
5.2.12	$[\text{BINO-Si}(\text{NtBu})_2\{\text{PhCH-SiL}^{\text{Ph}}\}][\text{AlCl}_4]$ ( <b>12</b> )	172
5.2.13	$[\text{L}^{\text{Ph}}\text{SiFcSiL}^{\text{Ph}}\text{-Eu}\{\text{N}(\text{SiMe}_3)_2\}_2]$ ( <b>14</b> )	173
5.2.14	$[\text{L}^{\text{Ph}}\text{SiFcSiL}^{\text{Ph}}\text{-Yb}\{\text{N}(\text{SiMe}_3)_2\}_2]$ ( <b>15</b> )	174
5.2.15	$[\text{L}^{\text{Ph}}\text{SiNSiL}^{\text{Ph}}\text{-Eu}\{\text{N}(\text{SiMe}_3)_2\}_2]$ ( <b>16</b> )	175
5.2.16	$[\text{L}^{\text{Ph}}\text{SiNSiL}^{\text{Ph}}\text{-Yb}\{\text{N}(\text{SiMe}_3)_2\}_2]$ ( <b>17</b> )	176
5.2.17	$[\text{L}^{\text{Ph}}\text{SiNN-Yb}\{\text{N}(\text{SiMe}_3)_2\}_2]$ ( <b>18</b> )	177
5.2.18	$[\text{L}^{\text{Ph}}\text{SiNN-CaN}(\text{SiMe}_3)_2]_2$ ( <b>19</b> )	178
5.2.19	$[\text{L}^{\text{Ph}}\text{SiNSiL}^{\text{Ph}}\text{-Ca}\{\text{N}(\text{SiMe}_3)_2\}_2]$ ( <b>20</b> )	179

5.2.20 [L <sup>Ph</sup> SiN-Eu{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>21</b> )	180
5.2.21 [L <sup>Ph</sup> SiN-Yb{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>22</b> )	181
5.2.22 [L <sup>Ph</sup> SiN-La{N(SiHMe <sub>2</sub> ) <sub>2</sub> } <sub>3</sub> ] ( <b>23</b> )	182
5.2.23 [L <sup>Ph</sup> SiN-Y{N(SiHMe <sub>2</sub> ) <sub>2</sub> } <sub>3</sub> ] ( <b>24</b> )	183
5.2.24 [L <sup>Ph</sup> SiN-Lu{N(SiHMe <sub>2</sub> ) <sub>2</sub> } <sub>3</sub> ] ( <b>25</b> )	184
5.2.25 [L <sup>Ph</sup> SiN-Ca{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>26</b> )	185
5.2.26 [L <sup>Ph</sup> SiN-Sr{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>27</b> )	186
5.2.27 [L <sup>Ph</sup> SiN-Ba{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>28</b> )	187
5.2.28 [L <sup>Ph</sup> SiN-OCPh <sub>2</sub> ] ( <b>29</b> )	188
5.2.29 [L <sup>Ph</sup> (Ph <sub>2</sub> C)NSi-O-Ca{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>30</b> )	189
5.2.30 [L <sup>Ph</sup> (Ph <sub>2</sub> C)NSi-O-Sr{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>31</b> )	190
5.2.31 [L <sup>Ph</sup> (Ph <sub>2</sub> C)NSi-O-Ba{N(SiMe <sub>3</sub> ) <sub>2</sub> } <sub>2</sub> ] ( <b>32</b> )	191
5.2.32 [PhCN(NtBu)(Ph <sub>2</sub> C)Si(2,6-(NEt) <sub>2</sub> -C <sub>5</sub> N)-O-Ca(thf) <sub>3</sub> ] ( <b>33</b> )	192
5.2.33 [L <sup>Ph</sup> SiN-ZnCl <sub>2</sub> ] ( <b>34</b> )	193
5.2.34 [L <sup>Ph</sup> SiN-ZnBr <sub>2</sub> ] ( <b>35</b> )	194
5.2.35 [L <sup>Ph</sup> SiN-ZnI <sub>2</sub> ] ( <b>36</b> )	195
5.2.36 [L <sup>Ph</sup> SiN-CdI <sub>2</sub> ] ( <b>37</b> )	196
5.2.37 [L <sup>Ph</sup> Si(S)N-ZnCl <sub>2</sub> ] ( <b>38</b> )	197
5.2.38 [L <sup>Ph</sup> Si(S)N-ZnI <sub>2</sub> ] ( <b>39</b> )	198
5.2.39 [L <sup>Ph</sup> Si(Se)N-ZnCl <sub>2</sub> ] ( <b>40</b> )	199
5.2.40 [L <sup>Ph</sup> Si(S)N-CdI <sub>2</sub> ] ( <b>41</b> )	200
5.2.41 [L <sup>Ph</sup> SiN]P(L <sup>BDI</sup> Si)P <sub>3</sub> (L <sup>Ph</sup> SiN)] ( <b>43</b> )	201
5.2.42 [L <sup>BDI</sup> Si]P <sub>2</sub> (L <sup>Ph</sup> Si)] ( <b>44</b> )	202
5.2.43 [L <sup>Ph</sup> SiFcSiL <sup>Ph</sup> ]P <sub>4</sub> (L <sup>BDI</sup> Si)] ( <b>45A</b> )	203
5.2.44 [Li(thf)(η <sup>5</sup> -L <sup>P</sup> )] ( <b>46</b> )	204
5.2.45 [Cp*Fe(μ-η <sup>4</sup> :η <sup>3</sup> -P <sub>5</sub> )Li(η <sup>5</sup> -L <sup>Pb</sup> )Li(thf)] <sub>2</sub> ( <b>47</b> )	205
5.2.46 [Cp*Fe(μ-η <sup>4</sup> :η <sup>2</sup> -As <sub>5</sub> )Li(η <sup>5</sup> -L <sup>Pb</sup> )Li(thf)] <sub>2</sub> ( <b>48</b> )	206
5.2.47 [K(thf) <sub>3</sub> (μ-η <sup>8</sup> :η <sup>8</sup> -COT)La(η <sup>5</sup> -L <sup>Si</sup> )] <sub>2</sub> ( <b>49</b> )	207
5.2.48 [K(thf)(μ-η <sup>8</sup> :η <sup>8</sup> -COT)La(η <sup>5</sup> -L <sup>Ge</sup> )] <sub>2</sub> ] ( <b>50</b> )	208
5.2.49 [K <sub>0.5</sub> (μ-η <sup>8</sup> :η <sup>8</sup> -COT)Ce(η <sup>5</sup> -L <sup>Ge</sup> )K(thf)(μ-η <sup>8</sup> :η <sup>8</sup> -COT)Ce(μ-η <sup>8</sup> :η <sup>8</sup> -COT)K <sub>0.5</sub> (thf) <sub>0.5</sub> ] <sub>2</sub> ] ( <b>51</b> )	209
5.2.50 [Li(thf)(μ-η <sup>5</sup> :η <sup>5</sup> -L <sup>Pb</sup> )La(η <sup>8</sup> -COT <sup>TIPS</sup> )] ( <b>52</b> )	210
5.2.51 [Li(thf)(μ-η <sup>5</sup> :η <sup>5</sup> -L <sup>Pb</sup> )Ce(η <sup>8</sup> -COT <sup>TIPS</sup> )] ( <b>53</b> )	211
5.2.52 [Li(thf)(μ-η <sup>5</sup> :η <sup>5</sup> -L <sup>Pb</sup> )Sm(η <sup>8</sup> -COT <sup>TIPS</sup> )] ( <b>54</b> )	212

5.2.53 [(Li(thf)( $\mu$ - $\eta^5$ -L <sup>Pb</sup> )Er( $\eta^8$ -COT <sup>TIPS</sup> ))] (55) .....	213
5.2.54 [Li(Et <sub>2</sub> O) <sub>3.4</sub> (thf) <sub>0.6</sub> ][( $\eta^5$ -L <sup>Pb</sup> )Er( $\eta^8$ -COT <sup>TIPS</sup> )] (56).....	214
5.2.55 [Li(12-crown-4) <sub>2</sub> ][( $\eta^5$ -L <sup>Pb</sup> )Er( $\eta^8$ -COT <sup>TIPS</sup> )] (57).....	215
<b>6. SUMMARY (ZUSAMMENFASSUNG) .....</b>	<b>216</b>
6.1 Summary .....	216
6.2 Zusammenfassung .....	221
<b>7. REFERENCES .....</b>	<b>226</b>
<b>8. APPENDIX.....</b>	<b>235</b>
<b>CURRICULUM VITAE (CV).....</b>	<b>237</b>
<b>CONFERENCES .....</b>	<b>238</b>
<b>PUBLICATIONS .....</b>	<b>239</b>
<b>ACKNOWLEDGEMENT .....</b>	<b>241</b>