# metal-organic compounds

## {μ-[Dimethyl(1,1,2-trimethylpropyl)silyl](2-pyridylmethyl)amido}bis[methylzinc(II)]

### Christian Koch, Helmar Görls and Matthias Westerhausen*

Institute of Inorganic and Analytical Chemistry, Friedrich-Schiller-Universität Jena, August-Bebel-Strasse 2, D-07743 Jena, Germany

Correspondence e-mail: m.we@uni-jena.de

Zincation of (dimethylthexylsilyl)(2-pyridylmethyl)amine (thexyl = 1,1,2-trimethylpropyl) with dimethylzinc in toluene yields the dimeric title compound, $[Zn_2(CH_3)_2(C_{14}H_{25}N_2Si)_2]$. Each Zn atom is coordinated tetrahedrally by three N atoms and a methyl group. The molecule shows inversion symmetry. The central $Zn_2N_2$ ring is planar, with an N—Zn—N angle of 95.33 (9)°. The exocyclic Zn—C bond length of 1.995 (3) Å has a characteristic value.

## Related literature

For related literature, see: Westerhausen *et al.* (2001, 2002).
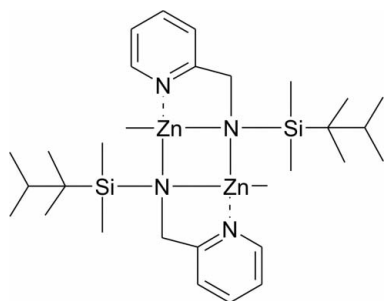


## Experimental

### Crystal data

| | |
|---|---|
| $[Zn_2(CH_3)_2(C_{14}H_{25}N_2Si)_2]$ | $V$ = 1641.2 (6) Å$^3$ |
| $M_r$ = 659.71 | $Z$ = 2 |
| Monoclinic, $P2_1/n$ | Mo $K\alpha$ radiation |
| $a$ = 9.2939 (19) Å | $\mu$ = 1.56 mm$^{-1}$ |
| $b$ = 9.888 (2) Å | $T$ = 183 (2) K |
| $c$ = 18.124 (4) Å | $0.05 \times 0.05 \times 0.04$ mm |
| $\beta$ = 99.83 (3)° | |

### Data collection

| | |
|---|---|
| Nonius KappaCCD diffractometer | 3737 independent reflections |
| Absorption correction: none | 2725 reflections with $I > 2\sigma(I)$ |
| 10869 measured reflections | $R_{int}$ = 0.061 |

### Refinement

| | |
|---|---|
| $R[F^2 > 2\sigma(F^2)]$ = 0.042 | 179 parameters |
| $wR(F^2)$ = 0.097 | H-atom parameters constrained |
| $S$ = 1.00 | $\Delta\rho_{max}$ = 0.46 e Å$^{-3}$ |
| 3737 reflections | $\Delta\rho_{min}$ = −0.46 e Å$^{-3}$ |

Data collection: *COLLECT* (Nonius, 1998); cell refinement: *DENZO* (Otwinowski & Minor, 1997); data reduction: *DENZO*; program(s) used to solve structure: *SHELXS97* (Sheldrick, 1997); program(s) used to refine structure: *SHELXL97* (Sheldrick, 1997); molecular graphics: *ORTEPIII* (Burnett & Johnson, 1996) and *ORTEP-3 for Windows* (Farrugia, 1997); software used to prepare material for publication: *SHELXL97*.

## References

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Westerhausen, M., Bollwein, T., Makropoulos, N., Schneiderbauer, S., Suter, M., Nöth, H., Mayer, P., Piotrowski, H., Polborn, K. & Pfitzner, A. (2002). *Eur. J. Inorg. Chem.* pp. 389–404.

**supplementary materials**

# {*μ*-[Dimethyl(1,1,2-trimethylpropyl)silyl](2-pyridylmethyl)amido}bis[methylzinc(II)]

## C. Koch, H. Görls and M. Westerhausen

## Comment

In the past, metallated (2-pyridylmethyl)(trialkysilyl)amines were used for oxidative C–C coupling reactions. Zincation of (2-pyridylmethyl)(trialkylsilyl)amine (**A**; trialkylsilyl=Me$_2$*tert*Bu, *i*Pr$_3$) yields dimeric methylzinc-(2-pyridylmethyl)(trialkylsilyl)amide (**B**). Further addition of dimethylzinc to a toluene solution to **A** at raised temperatures yields the C–C coupling product bis(methylzinc)-[1,2-dipyridyl-1,2-bis(trialkylsilylamido)ethane] (Westerhausen *et al.*, 2002). The synthesis of methylzinc-(2-pyridylmethyl)(dimethylthexylsilyl)amide (**1**, thexyl=1,1,2-trimethylpropyl) is similar (Westerhausen *et al.*, 2002). Neither thermal decomposition nor the addition of an other equivalent of dimethyl zinc at elevated temperature initiates an oxidative C–C coupling reaction. Two (2-pyridylmethyl)(dimethylthexylsilyl)amines adopt bridging position between two methylzinc units forming a centrosymmetric four-membered ZnNZn$^i$N$^i$ ring [symmetry code:(i) 1 − *x*, −*y*, −*z*]. The amine reacts as a bidentate ligand. The transannular Zn···Zn$^i$ distance of 2.8435 (9) Å compares as well to the transannular Zn···Zn$^i$ distance of 2.848 (1) Å in dimeric methylzinc-(2-pyridylmethyl)(triisopropylsilyl)amide (Westerhausen *et al.*, 2002). The zinc atoms are distorted tetrahedral coordinated by three nitrogen atoms and one methyl group. The Zn–N(1) distance of 2.100 (2) Å and Zn···N(2) of 2.113 (2) Å show characteristic values (Westerhausen *et al.*, 2001; Westerhausen *et al.*, 2002).

## Experimental

All manipulations were carried out in an atmosphere of argon using standard Schlenk techniques. Toluene and pentane were dried (Na/benzophenone) and distilled prior to use. 2-Pyridylmethylamine and butyllithium were purchased form Aldrich. Dimethylthexylchlorsilane was purchased from Merck. ^{1}HNMR and ^{13}CNMR spectra were recorded at[C$_6$D$_6$]benzene solution at ambient temperature on a Bruker AC 400 MHz s pectrometer and were referenced to deuterated benzene as an internal standard.

Methylzinc-(2-pyridylmethyl)(dimethylthexylsilyl)amide was prepared according to a literature procedure (Westerhausen *et al.* 2002) and recrystallized from pentane. After reduction of the volume to a third of the original volume crystals precipitated.

Physical data:

^{1}H NMR (200 MHz, [D6]benzene) $\delta$ = 8.10 (d, $^3J$(H$^1$,H$^2$) = 4.8, 1H, Pyr1); 6.79 (dt, $^5J$(H$^3$,H$^1$) = 1.6, $^3J$(H$^3$,H$^{2/4}$) = 7.8, 1H, Pyr3); 6.51 (d, $^3J$(H$^4$,H$^3$) = 8.0, 1H, Pyr4); 6.41 (t, $^3J$(H$^1$,H$^3$) = 6.4, 1H, Pyr2); 4.64 (s, 2H, CH$_2$); 1.87 (m, 1H, CH); 1.13 (s, 6H, SiC(CH$_3$)$_2$); 1.02 (d, 6H, SiCCH(CH$_3$)$_2$); 0.15 (s, 6H, Si(CH$_3$)); −0.12 (s, 3H, ZnCH$_3$).

$^{13}$C NMR (50 MHz, [D6]benzene) $\delta$ = 166.16 (Pyr5); 146.33 (Pyr1); 137.46 (Pyr3); 121.72 (Pyr2); 121.72 (Pyr4); 54.56 ($^2J$, CH2); 34.75 (SiCC*(CH₃)₂*); 27.11 (SiC*(CH₃)₂*); 22.52 (SiC*C*(CH₃)₂); 19.09 (Si*C*(CH₃)₂)) −0.56 ((Si*(CH₃)₂*); −12.56 (ZnCH₃).

MS (DEI, *m/z* [%]): 644 (M—CH₄, 5), 575 (M—C(CH₃)₂CH(CH₃)₂), 477 (*M*-(C₆H₆N)₂, 100); 330 (*M*/2, 2); 245 (*M*/2-(C₆H₁₃), 10); 165 (C₈H₁₃N₂Si, 26).

IR (cm$^{−1}$): 3374, 3065, 3003, 2958, 2925, 2855, 1592, 1570, 1465, 1433, 1405, 1377, 1347, 1249, 1125, 1046, 995, 825, 774.

**Refinement**

All hydrogen atoms were set to idealized positions and were refined with 1.2 times (1.5 for methyl groups) the isotropic displacement parameter of the corresponding carbon atom. The methyl groups were allowed to rotate but not to tip.

**Figures**
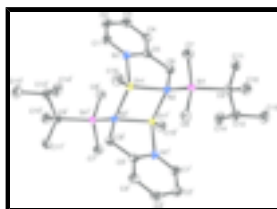


Fig. 1. The molecular structure of **1**, showing 40% probability displacement ellipsoides and the atom-numbering scheme. H atoms have been omitted for clarity. [Symmetry code: (i) −*x* + 1, −*y*, −*z*].

**{µ-[Dimethyl(1,1,2-trimethylpropyl)silyl](2- pyridylmethyl)amido}bis[methylzinc(II)]**

*Crystal data*

| | |
|---|---|
| [Zn₂(CH₃)₂(C₁₄H₂₅N₂Si)₂] | $F_{000}$ = 704 |
| $M_r$ = 659.71 | $D_x$ = 1.335 Mg m$^{−3}$ |
| Monoclinic, $P2_1/n$ | Mo *Kα* radiation<br>$\lambda$ = 0.71073 Å |
| Hall symbol: -P 2yn | Cell parameters from 10869 reflections |
| $a$ = 9.2939 (19) Å | $\theta$ = 2.3–27.4º |
| $b$ = 9.888 (2) Å | $\mu$ = 1.56 mm$^{−1}$ |
| $c$ = 18.124 (4) Å | $T$ = 183 (2) K |
| $\beta$ = 99.83 (3)º | Prism, colourless |
| $V$ = 1641.2 (6) Å$^3$ | 0.05 × 0.05 × 0.04 mm |
| $Z$ = 2 | |

*Data collection*

| | |
|---|---|
| Nonius KappaCCD diffractometer | 2725 reflections with $I > 2\sigma(I)$ |
| Radiation source: fine-focus sealed tube | $R_{int}$ = 0.061 |
| Monochromator: graphite | $\theta_{max}$ = 27.4º |

| | |
|---|---|
| $T = 183(2)$ K | $\theta_{min} = 2.3°$ |
| φ and ω scans | $h = -12 \rightarrow 10$ |
| Absorption correction: none | $k = -11 \rightarrow 12$ |
| 10869 measured reflections | $l = -23 \rightarrow 22$ |
| 3737 independent reflections | |

*Refinement*

| | |
|---|---|
| Refinement on $F^2$ | Secondary atom site location: difference Fourier map |
| Least-squares matrix: full | Hydrogen site location: inferred from neighbouring sites |
| $R[F^2 > 2\sigma(F^2)] = 0.042$ | H-atom parameters constrained |
| $wR(F^2) = 0.097$ | $w = 1/[\sigma^2(F_o^2) + (0.0467P)^2]$ where $P = (F_o^2 + 2F_c^2)/3$ |
| $S = 1.00$ | $(\Delta/\sigma)_{max} = 0.013$ |
| 3737 reflections | $\Delta\rho_{max} = 0.46$ e Å$^{-3}$ |
| 179 parameters | $\Delta\rho_{min} = -0.46$ e Å$^{-3}$ |
| Primary atom site location: structure-invariant direct methods | Extinction correction: none |

*Special details*

**Geometry**. All e.s.d.'s (except the e.s.d. in the dihedral angle between two l.s. planes) are estimated using the full covariance matrix. The cell e.s.d.'s are taken into account individually in the estimation of e.s.d.'s in distances, angles and torsion angles; correlations between e.s.d.'s in cell parameters are only used when they are defined by crystal symmetry. An approximate (isotropic) treatment of cell e.s.d.'s is used for estimating e.s.d.'s involving l.s. planes.

**Refinement**. Refinement of $F^2$ against ALL reflections. The weighted $R$-factor $wR$ and goodness of fit $S$ are based on $F^2$, conventional $R$-factors $R$ are based on $F$, with $F$ set to zero for negative $F^2$. The threshold expression of $F^2 > \sigma(F^2)$ is used only for calculating $R$-factors(gt) *etc*. and is not relevant to the choice of reflections for refinement. $R$-factors based on $F^2$ are statistically about twice as large as those based on $F$, and $R$- factors based on ALL data will be even larger.

*Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å$^2$)*

| | $x$ | $y$ | $z$ | $U_{iso}*/U_{eq}$ |
|---|---|---|---|---|
| Zn1 | 0.65416 (3) | 0.01284 (3) | 0.007395 (18) | 0.02359 (12) |
| Si1 | 0.56248 (8) | 0.06666 (7) | 0.16433 (4) | 0.02352 (19) |
| N1 | 0.7051 (2) | −0.1940 (2) | 0.01801 (13) | 0.0246 (5) |
| N2 | 0.5159 (2) | −0.0342 (2) | 0.08506 (13) | 0.0230 (5) |
| C1 | 0.7981 (3) | −0.2629 (3) | −0.01697 (17) | 0.0307 (7) |
| H1A | 0.8574 | −0.2143 | −0.0456 | 0.037* |
| C2 | 0.8108 (3) | −0.4016 (3) | −0.01292 (17) | 0.0354 (7) |
| H2A | 0.8785 | −0.4475 | −0.0379 | 0.043* |
| C3 | 0.7235 (4) | −0.4732 (3) | 0.02802 (19) | 0.0356 (7) |
| H3A | 0.7283 | −0.5691 | 0.0307 | 0.043* |
| C4 | 0.6292 (3) | −0.4019 (3) | 0.06490 (17) | 0.0297 (7) |
| H4A | 0.5689 | −0.4487 | 0.0938 | 0.036* |
| C5 | 0.6226 (3) | −0.2616 (3) | 0.05964 (15) | 0.0232 (6) |

| | | | |
|---|---|---|---|
| C6 | 0.5276 (3) | −0.1805 (3) | 0.10344 (17) | 0.0274 (6) |
| H6A | 0.4282 | −0.2199 | 0.0945 | 0.033* |
| H6B | 0.5670 | −0.1902 | 0.1575 | 0.033* |
| C7 | 0.7601 (3) | 0.0335 (3) | 0.20441 (19) | 0.0376 (7) |
| H7A | 0.8220 | 0.0674 | 0.1698 | 0.056* |
| H7B | 0.7755 | −0.0640 | 0.2116 | 0.056* |
| H7C | 0.7855 | 0.0798 | 0.2527 | 0.056* |
| C8 | 0.5454 (3) | 0.2484 (3) | 0.13393 (17) | 0.0299 (7) |
| H8A | 0.5789 | 0.2583 | 0.0858 | 0.045* |
| H8B | 0.6054 | 0.3051 | 0.1716 | 0.045* |
| H8C | 0.4431 | 0.2766 | 0.1285 | 0.045* |
| C9 | 0.4582 (3) | 0.0474 (3) | 0.24740 (16) | 0.0285 (6) |
| C10 | 0.5223 (4) | 0.1584 (3) | 0.30329 (18) | 0.0397 (8) |
| H10A | 0.4854 | 0.1465 | 0.3504 | 0.060* |
| H10B | 0.4933 | 0.2475 | 0.2822 | 0.060* |
| H10C | 0.6291 | 0.1516 | 0.3128 | 0.060* |
| C11 | 0.4913 (4) | −0.0908 (3) | 0.28696 (18) | 0.0410 (8) |
| H11A | 0.4526 | −0.0913 | 0.3340 | 0.062* |
| H11B | 0.5971 | −0.1054 | 0.2976 | 0.062* |
| H11C | 0.4450 | −0.1632 | 0.2543 | 0.062* |
| C12 | 0.2897 (3) | 0.0733 (3) | 0.22700 (18) | 0.0337 (7) |
| H12A | 0.2767 | 0.1667 | 0.2057 | 0.040* |
| C13 | 0.2119 (4) | 0.0692 (4) | 0.2954 (2) | 0.0469 (9) |
| H13A | 0.1095 | 0.0953 | 0.2802 | 0.070* |
| H13B | 0.2598 | 0.1322 | 0.3336 | 0.070* |
| H13C | 0.2170 | −0.0226 | 0.3160 | 0.070* |
| C14 | 0.2123 (4) | −0.0213 (4) | 0.1687 (2) | 0.0487 (9) |
| H14A | 0.1094 | 0.0051 | 0.1558 | 0.073* |
| H14B | 0.2189 | −0.1138 | 0.1884 | 0.073* |
| H14C | 0.2580 | −0.0171 | 0.1239 | 0.073* |
| C15 | 0.8221 (3) | 0.1412 (3) | 0.01791 (19) | 0.0343 (7) |
| H15A | 0.9128 | 0.0905 | 0.0183 | 0.051* |
| H15B | 0.8280 | 0.1916 | 0.0649 | 0.051* |
| H15C | 0.8079 | 0.2045 | −0.0243 | 0.051* |

*Atomic displacement parameters (Å$^2$)*

| | $U^{11}$ | $U^{22}$ | $U^{33}$ | $U^{12}$ | $U^{13}$ | $U^{23}$ |
|---|---|---|---|---|---|---|
| Zn1 | 0.02182 (19) | 0.02322 (18) | 0.0269 (2) | −0.00257 (12) | 0.00748 (13) | 0.00065 (13) |
| Si1 | 0.0224 (4) | 0.0245 (4) | 0.0237 (4) | 0.0010 (3) | 0.0039 (3) | 0.0013 (3) |
| N1 | 0.0205 (12) | 0.0269 (12) | 0.0263 (14) | −0.0001 (9) | 0.0038 (10) | −0.0019 (9) |
| N2 | 0.0226 (12) | 0.0198 (10) | 0.0278 (13) | 0.0020 (9) | 0.0077 (10) | 0.0032 (9) |
| C1 | 0.0237 (15) | 0.0373 (16) | 0.0313 (18) | 0.0020 (12) | 0.0048 (13) | −0.0014 (13) |
| C2 | 0.0340 (18) | 0.0381 (17) | 0.0344 (19) | 0.0116 (13) | 0.0063 (15) | −0.0060 (14) |
| C3 | 0.0442 (19) | 0.0231 (14) | 0.0371 (19) | 0.0061 (13) | 0.0005 (15) | −0.0014 (13) |
| C4 | 0.0310 (16) | 0.0258 (14) | 0.0310 (17) | −0.0020 (12) | 0.0012 (13) | 0.0015 (12) |
| C5 | 0.0193 (14) | 0.0248 (13) | 0.0242 (15) | −0.0003 (10) | 0.0000 (12) | 0.0002 (11) |
| C6 | 0.0296 (16) | 0.0244 (13) | 0.0300 (17) | 0.0014 (11) | 0.0104 (13) | 0.0041 (12) |

| | | | | | |
|---|---|---|---|---|---|
| C7 | 0.0295 (17) | 0.0455 (18) | 0.0372 (19) | 0.0048 (13) | 0.0040 (15) | 0.0052 (14) |
| C8 | 0.0304 (17) | 0.0279 (14) | 0.0308 (17) | −0.0051 (12) | 0.0034 (14) | −0.0009 (12) |
| C9 | 0.0339 (17) | 0.0307 (14) | 0.0211 (16) | 0.0044 (12) | 0.0052 (13) | 0.0014 (12) |
| C10 | 0.0398 (19) | 0.0473 (19) | 0.0318 (19) | 0.0033 (14) | 0.0050 (15) | −0.0065 (14) |
| C11 | 0.054 (2) | 0.0410 (18) | 0.0319 (19) | 0.0110 (15) | 0.0190 (17) | 0.0105 (14) |
| C12 | 0.0299 (17) | 0.0352 (16) | 0.0390 (19) | −0.0007 (12) | 0.0142 (15) | 0.0026 (14) |
| C13 | 0.043 (2) | 0.060 (2) | 0.042 (2) | 0.0032 (16) | 0.0207 (17) | −0.0012 (17) |
| C14 | 0.0339 (19) | 0.072 (2) | 0.043 (2) | −0.0029 (17) | 0.0149 (17) | −0.0074 (18) |
| C15 | 0.0277 (16) | 0.0328 (15) | 0.044 (2) | −0.0069 (12) | 0.0093 (15) | −0.0019 (14) |

*Geometric parameters (Å, °)*

| | | | |
|---|---|---|---|
| Zn1—C15 | 1.995 (3) | C7—H7C | 0.9800 |
| Zn1—N1 | 2.100 (2) | C8—H8A | 0.9800 |
| Zn1—N2$^i$ | 2.109 (3) | C8—H8B | 0.9800 |
| Zn1—N2 | 2.113 (2) | C8—H8C | 0.9800 |
| Zn1—Zn1$^i$ | 2.8435 (8) | C9—C10 | 1.542 (4) |
| Si1—N2 | 1.742 (2) | C9—C11 | 1.550 (4) |
| Si1—C8 | 1.878 (3) | C9—C12 | 1.567 (4) |
| Si1—C7 | 1.885 (3) | C10—H10A | 0.9800 |
| Si1—C9 | 1.934 (3) | C10—H10B | 0.9800 |
| N1—C5 | 1.343 (3) | C10—H10C | 0.9800 |
| N1—C1 | 1.342 (3) | C11—H11A | 0.9800 |
| N2—C6 | 1.484 (3) | C11—H11B | 0.9800 |
| N2—Zn1$^i$ | 2.109 (3) | C11—H11C | 0.9800 |
| C1—C2 | 1.377 (4) | C12—C14 | 1.500 (4) |
| C1—H1A | 0.9500 | C12—C13 | 1.539 (4) |
| C2—C3 | 1.384 (4) | C12—H12A | 1.0000 |
| C2—H2A | 0.9500 | C13—H13A | 0.9800 |
| C3—C4 | 1.383 (4) | C13—H13B | 0.9800 |
| C3—H3A | 0.9500 | C13—H13C | 0.9800 |
| C4—C5 | 1.391 (4) | C14—H14A | 0.9800 |
| C4—H4A | 0.9500 | C14—H14B | 0.9800 |
| C5—C6 | 1.514 (4) | C14—H14C | 0.9800 |
| C6—H6A | 0.9900 | C15—H15A | 0.9800 |
| C6—H6B | 0.9900 | C15—H15B | 0.9800 |
| C7—H7A | 0.9800 | C15—H15C | 0.9800 |
| C7—H7B | 0.9800 | | |
| C15—Zn1—N1 | 116.74 (10) | H7A—C7—H7C | 109.5 |
| C15—Zn1—N2$^i$ | 118.69 (11) | H7B—C7—H7C | 109.5 |
| N1—Zn1—N2$^i$ | 107.29 (8) | Si1—C8—H8A | 109.5 |
| C15—Zn1—N2 | 129.13 (11) | Si1—C8—H8B | 109.5 |
| N1—Zn1—N2 | 82.98 (8) | H8A—C8—H8B | 109.5 |
| N2$^i$—Zn1—N2 | 95.33 (9) | Si1—C8—H8C | 109.5 |
| C15—Zn1—Zn1$^i$ | 145.59 (9) | H8A—C8—H8C | 109.5 |
| N1—Zn1—Zn1$^i$ | 97.45 (6) | H8B—C8—H8C | 109.5 |
| N2$^i$—Zn1—Zn1$^i$ | 47.73 (6) | C10—C9—C11 | 107.5 (3) |

| | | | |
|---|---|---|---|
| N2—Zn1—Zn1<sup>i</sup> | 47.60 (7) | C10—C9—C12 | 107.3 (2) |
| N2—Si1—C8 | 108.03 (12) | C11—C9—C12 | 111.4 (2) |
| N2—Si1—C7 | 107.85 (13) | C10—C9—Si1 | 104.6 (2) |
| C8—Si1—C7 | 107.90 (13) | C11—C9—Si1 | 111.16 (19) |
| N2—Si1—C9 | 119.94 (12) | C12—C9—Si1 | 114.4 (2) |
| C8—Si1—C9 | 107.10 (12) | C9—C10—H10A | 109.5 |
| C7—Si1—C9 | 105.51 (14) | C9—C10—H10B | 109.5 |
| C5—N1—C1 | 119.2 (2) | H10A—C10—H10B | 109.5 |
| C5—N1—Zn1 | 113.26 (17) | C9—C10—H10C | 109.5 |
| C1—N1—Zn1 | 127.22 (19) | H10A—C10—H10C | 109.5 |
| C6—N2—Si1 | 112.01 (18) | H10B—C10—H10C | 109.5 |
| C6—N2—Zn1<sup>i</sup> | 106.98 (17) | C9—C11—H11A | 109.5 |
| Si1—N2—Zn1<sup>i</sup> | 130.14 (11) | C9—C11—H11B | 109.5 |
| C6—N2—Zn1 | 109.58 (15) | H11A—C11—H11B | 109.5 |
| Si1—N2—Zn1 | 109.25 (11) | C9—C11—H11C | 109.5 |
| Zn1<sup>i</sup>—N2—Zn1 | 84.67 (9) | H11A—C11—H11C | 109.5 |
| N1—C1—C2 | 122.5 (3) | H11B—C11—H11C | 109.5 |
| N1—C1—H1A | 118.8 | C14—C12—C13 | 108.4 (3) |
| C2—C1—H1A | 118.8 | C14—C12—C9 | 113.8 (2) |
| C1—C2—C3 | 119.0 (3) | C13—C12—C9 | 113.2 (3) |
| C1—C2—H2A | 120.5 | C14—C12—H12A | 107.0 |
| C3—C2—H2A | 120.5 | C13—C12—H12A | 107.0 |
| C4—C3—C2 | 118.4 (3) | C9—C12—H12A | 107.0 |
| C4—C3—H3A | 120.8 | C12—C13—H13A | 109.5 |
| C2—C3—H3A | 120.8 | C12—C13—H13B | 109.5 |
| C3—C4—C5 | 120.0 (3) | H13A—C13—H13B | 109.5 |
| C3—C4—H4A | 120.0 | C12—C13—H13C | 109.5 |
| C5—C4—H4A | 120.0 | H13A—C13—H13C | 109.5 |
| N1—C5—C4 | 120.8 (2) | H13B—C13—H13C | 109.5 |
| N1—C5—C6 | 118.1 (2) | C12—C14—H14A | 109.5 |
| C4—C5—C6 | 121.0 (2) | C12—C14—H14B | 109.5 |
| N2—C6—C5 | 115.2 (2) | H14A—C14—H14B | 109.5 |
| N2—C6—H6A | 108.5 | C12—C14—H14C | 109.5 |
| C5—C6—H6A | 108.5 | H14A—C14—H14C | 109.5 |
| N2—C6—H6B | 108.5 | H14B—C14—H14C | 109.5 |
| C5—C6—H6B | 108.5 | Zn1—C15—H15A | 109.5 |
| H6A—C6—H6B | 107.5 | Zn1—C15—H15B | 109.5 |
| Si1—C7—H7A | 109.5 | H15A—C15—H15B | 109.5 |
| Si1—C7—H7B | 109.5 | Zn1—C15—H15C | 109.5 |
| H7A—C7—H7B | 109.5 | H15A—C15—H15C | 109.5 |
| Si1—C7—H7C | 109.5 | H15B—C15—H15C | 109.5 |

Symmetry codes: (i) −x+1, −y, −z.

**Fig. 1**