

# The *ansa*-bridged cyclopentadienyl titanium complex [ $\{\eta^5\text{-C}_5\text{Me}_4\text{CH}_2\text{-C(NMe}_2\text{)=N}\}\text{TiCl}_2$ ]

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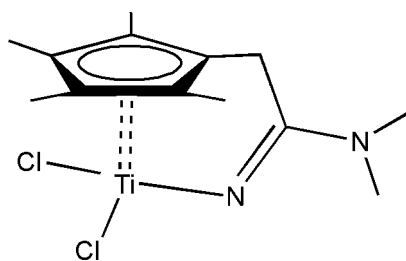
Received 22 April 2009; accepted 28 April 2009

Key indicators: single-crystal X-ray study;  $T = 213$  K; mean  $\sigma(\text{C}-\text{C}) = 0.005$  Å;  $R$  factor = 0.056;  $wR$  factor = 0.117; data-to-parameter ratio = 15.8.

The title complex, dichlorido[ $N,N$ -dimethyl-2-( $\eta^5$ -tetramethylcyclopentadienyl)acetamidinido- $\kappa N'$ ]titanium(IV),  $[\text{Ti}(\text{C}_{13}\text{H}_{20}\text{N}_2)\text{Cl}_2]$ , exhibits an unusual *ansa*-bridged conformation. The cyclopentadienyl ring and the mean plane of the  $\text{Ti}-\text{N}=\text{C}-\text{C}-\text{C}$  fragment form a dihedral angle of  $88.08$  ( $11$ )°.

## Related literature

For related crystal structures, see: Hughes *et al.* (1993); Zhang *et al.* (2004). For general background, see: Chen & Marks (1997); Mahanthappa *et al.* (2004).



## Experimental

### Crystal data

$[\text{Ti}(\text{C}_{13}\text{H}_{20}\text{N}_2)\text{Cl}_2]$	$V = 3041.1$ (19) Å <sup>3</sup>
$M_r = 323.11$	$Z = 8$
Orthorhombic, $Pbca$	Mo $K\alpha$ radiation
$a = 12.600$ (5) Å	$\mu = 0.90$ mm <sup>-1</sup>
$b = 15.498$ (6) Å	$T = 213$ K
$c = 15.574$ (5) Å	$0.30 \times 0.20 \times 0.20$ mm

### Data collection

Siemens SMART diffractometer	11691 measured reflections
Absorption correction: multi-scan ( <i>SADABS</i> ; Sheldrick, 1997)	2677 independent reflections
$T_{\min} = 0.774$ , $T_{\max} = 0.841$	2554 reflections with $I > 2\sigma(I)$
	$R_{\text{int}} = 0.037$

### Refinement

$R[F^2 > 2\sigma(F^2)] = 0.056$	169 parameters
$wR(F^2) = 0.117$	H-atom parameters constrained
$S = 1.27$	$\Delta\rho_{\text{max}} = 0.38$ e Å <sup>-3</sup>
2677 reflections	$\Delta\rho_{\text{min}} = -0.30$ e Å <sup>-3</sup>

Data collection: *SMART* (Siemens, 1996); cell refinement: *SAINTE* (Siemens, 1996); data reduction: *SAINTE*; program(s) used to solve structure: *SHELXS97* (Sheldrick, 2008); program(s) used to refine structure: *SHELXL97* (Sheldrick, 2008); molecular graphics: *ORTEP-3* (Farrugia, 1997); software used to prepare material for publication: *SHELXL97*.

The authors thank the Natural Science Foundation of China (grant No. 20672070 to MZ), the Natural Science Foundation of Shanxi (grant No. 2007011020) and the Foundation for Returned Overseas Chinese Scholars of Shanxi Province.

Supplementary data and figures for this paper are available from the IUCr electronic archives (Reference: CV2554).

## References

- Chen, Y. X. & Marks, T. J. (1997). *Organometallics*, **16**, 5958–5963.  
Farrugia, L. J. (1997). *J. Appl. Cryst.* **30**, 565.  
Hughes, A. K., Meetsma, A. & Teuben, J. H. (1993). *Organometallics*, **12**, 1936–1945.  
Mahanthappa, M. K., Cole, A. P. & Waymouth, R. M. (2004). *Organometallics*, **23**, 836–845.  
Sheldrick, G. M. (1997). *SADABS*. University of Göttingen, Germany.  
Sheldrick, G. M. (2008). *Acta Cryst.* **A64**, 112–122.  
Siemens (1996). *SMART* and *SAINTE*. Siemens Analytical X-ray Instruments Inc., Madison, Wisconsin, USA.  
Zhang, Y., Mu, Y., Lu, C., Li, G., Xu, J., Zhang, Y., Zhu, D. & Feng, S. (2004). *Organometallics*, **23**, 540–546.

**supplementary materials**

*Acta Cryst.* (2009). E65, m611 [ doi:10.1107/S1600536809015839 ]

## The *ansa*-bridged cyclopentadienyl titanium complex [ $\eta^5$ -C<sub>5</sub>Me<sub>4</sub>CH<sub>2</sub>-C(NMe<sub>2</sub>)=N}TiCl<sub>2</sub>]

D. Guo, H.-B. Tong and M. Zhou

### Comment

The homogeneous coordination polymerization catalysts, especially group IV metallocene catalysts, have created new opportunities for the production of ethylene  $\alpha$ -olefin copolymers and received extensive attention in recent years (Mahanthappa *et al.*, 2004). The constrained geometry catalysts with a pendant nitrogen or oxygen donor on the cyclopentadienyl ligand, such as Me<sub>2</sub>Si-( $\eta^5$ -Me<sub>4</sub>C<sub>5</sub>)(*t*-BuN)TiCl<sub>2</sub> (Hughes *et al.*, 1993) and 2-tetramethylcyclopentadienyl-4-methylphenoxytitaniumdibenzyl (Zhang *et al.*, 2004) have been developed due to their structural features and good catalytic activities (Chen *et al.*, 1997). Here we present the synthesis and crystal structure of a new *ansa*-bridged cyclopentadienyl titanium complex (**I**)

In (**I**) (Fig. 1), the distance from the central metal atom Ti to the centroid of Cp\* is 2.024 (2) Å. The bond lengths Ti—N1, Ti—Cl1 and Ti—Cl2 are 1.823 (3), 2.3104 (12) and 2.3036 (12) Å, respectively. The bond angle Cl1—Ti—Cl2 is 105.40 (5) °. Atoms C1, C6, C7, N1 and Ti are exactly co-planar with a highest deviation of 0.0191 Å. The two planes - Cp\* and C1/C6/C7/N1/Ti are almost perpendicular making a dihedral angle of 88.08 (11)°. The bond angles C1—C6—C7, C6—C7—N1 and C7—N1—Ti are 106.7 (3), 116.7 (3) and 129.5 (2) °, respectively.

### Experimental

(CH<sub>3</sub>)<sub>2</sub>NCN (0.36 ml, 4.52 mmol) was added to a solution of PhN(Li)SiMe<sub>3</sub> (0.386 g, 2.26 mmol) in THF (30 cm<sup>3</sup>) at -78 °C. The resulting mixture was warmed to *ca.*25°C and stirred for overnight. CpTiCl<sub>3</sub> (0.99 g, 4.52 mmol) was added at -78°C. The resulting mixture was warmed to *ca.*25°C and stirred for 24 h. The volatiles were removed *in vacuo*, and there residue was extracted with dichloromethane and filtered. The filtrate was concentrated to give red crystals of (**I**) (0.14 g, 13%).

Anal. calcd. for C<sub>13</sub>H<sub>20</sub>Cl<sub>2</sub>N<sub>2</sub>Ti(%): C, 48.33; H, 6.24; N, 8.67. Found: C, 48.25; H, 6.25; N, 8.73. All manipulations were performed under argon using standard Schlenk and vacuum line techniques. THF was dried and distilled over Na-dergon prior to use. Elemental analysis and NMR spectra are completely in agreement with the structure of (**I**). Spectroscopic analysis, <sup>1</sup>H NMR (CDCl<sub>3</sub>):  $\delta$  2.11~2.18 (d, 12 H, Cp—CH<sub>3</sub>),  $\delta$  2.80, 3.10 (d, 6 H, N(CH<sub>3</sub>)<sub>2</sub>),  $\delta$  4.09 (s, 2 H, CH<sub>2</sub>). <sup>13</sup>C NMR (CDCl<sub>3</sub>):  $\delta$  10.0, 10.8 (Cp-CH<sub>3</sub>),  $\delta$  28.9 (CH<sub>2</sub>),  $\delta$  33.3, 35.9 (N(CH<sub>3</sub>)<sub>2</sub>),  $\delta$  118.5, 123.2, 127.4, 128.6, 129.0 (Cp), 171.6 (CH<sub>2</sub>-C(NMe<sub>2</sub>)-N).

### Refinement

The H atoms were positioned geometrically and allowed to ride on their parent atoms, with C—H = 0.93-0.97 Å, and U<sub>iso</sub> = 1.2-1.5 U<sub>eq</sub>(parent atom).

## Figures

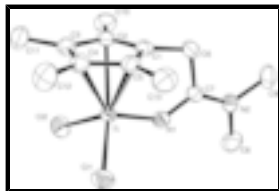


Fig. 1. The molecular structure of (I), showing the atom-labeling scheme. Displacement ellipsoids are drawn at the 50% probability level. H atoms are omitted for clarity.

## dichlorido[*N,N*-dimethyl-2-( $\eta^5$ -tetramethylcyclopentadienyl)acetamidinido- $\kappa N'$ ]titanium(IV)

### Crystal data

[Ti(C<sub>13</sub>H<sub>20</sub>N<sub>2</sub>)Cl<sub>2</sub>]

$M_r = 323.11$

Orthorhombic, *Pbca*

$a = 12.600$  (5) Å

$b = 15.498$  (6) Å

$c = 15.574$  (5) Å

$V = 3041.1$  (19) Å<sup>3</sup>

$Z = 8$

$F_{000} = 1344$

$D_x = 1.411$  Mg m<sup>-3</sup>

Mo  $K\alpha$  radiation

$\lambda = 0.71073$  Å

Cell parameters from 4409 reflections

$\theta = 2.5$ – $27.0^\circ$

$\mu = 0.90$  mm<sup>-1</sup>

$T = 213$  K

Block, orange

$0.30 \times 0.20 \times 0.20$  mm

### Data collection

Siemens SMART  
diffractometer

Radiation source: fine-focus sealed tube

Monochromator: graphite

$T = 213$  K

$\omega$  scans

Absorption correction: multi-scan  
(SADABS; Sheldrick, 1997)

$T_{\min} = 0.774$ ,  $T_{\max} = 0.841$

11691 measured reflections

2677 independent reflections

2554 reflections with  $I > 2\sigma(I)$

$R_{\text{int}} = 0.037$

$\theta_{\max} = 25.0^\circ$

$\theta_{\min} = 2.5^\circ$

$h = -14 \rightarrow 14$

$k = -18 \rightarrow 12$

$l = -18 \rightarrow 18$

### Refinement

Refinement on  $F^2$

Least-squares matrix: full

$R[F^2 > 2\sigma(F^2)] = 0.056$

$wR(F^2) = 0.117$

$S = 1.27$

2677 reflections

Secondary atom site location: difference Fourier map

Hydrogen site location: inferred from neighbouring sites

H-atom parameters constrained

$w = 1/[\sigma^2(F_o^2) + (0.036P)^2 + 4.3005P]$

where  $P = (F_o^2 + 2F_c^2)/3$

$(\Delta/\sigma)_{\max} = 0.001$

$\Delta\rho_{\max} = 0.38$  e Å<sup>-3</sup>

169 parameters

$$\Delta\rho_{\min} = -0.30 \text{ e } \text{\AA}^{-3}$$

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 ( $\text{\AA}^2$ )

	<i>x</i>	<i>y</i>	<i>z</i>	$U_{\text{iso}}^*/U_{\text{eq}}$
Ti	0.21528 (5)	0.56734 (4)	0.10562 (4)	0.02449 (19)
Cl1	0.10277 (7)	0.66810 (6)	0.04506 (6)	0.0396 (3)
Cl2	0.11570 (8)	0.49802 (7)	0.20873 (6)	0.0416 (3)
N1	0.3122 (2)	0.63161 (19)	0.16445 (18)	0.0302 (7)
N2	0.4755 (2)	0.69295 (19)	0.19627 (19)	0.0326 (7)
C1	0.3752 (3)	0.5272 (2)	0.0479 (2)	0.0289 (8)
C2	0.3304 (3)	0.4522 (2)	0.0835 (2)	0.0285 (8)
C3	0.2387 (3)	0.4307 (2)	0.0348 (2)	0.0314 (8)
C4	0.2270 (3)	0.4933 (2)	-0.0298 (2)	0.0313 (8)
C5	0.3117 (3)	0.5534 (2)	-0.0221 (2)	0.0299 (8)
C6	0.4650 (3)	0.5788 (2)	0.0867 (2)	0.0347 (9)
H6A	0.5014	0.6123	0.0423	0.042*
H6B	0.5166	0.5403	0.1141	0.042*
C7	0.4158 (3)	0.6384 (2)	0.1528 (2)	0.0282 (8)
C8	0.4285 (3)	0.7477 (3)	0.2621 (3)	0.0458 (10)
H8A	0.3529	0.7362	0.2658	0.069*
H8B	0.4396	0.8078	0.2473	0.069*
H8C	0.4615	0.7356	0.3171	0.069*
C9	0.5892 (3)	0.7047 (3)	0.1806 (3)	0.0447 (10)
H9A	0.6176	0.6536	0.1531	0.067*
H9B	0.6253	0.7141	0.2348	0.067*
H9C	0.5999	0.7544	0.1437	0.067*
C10	0.3711 (3)	0.4014 (3)	0.1590 (2)	0.0421 (10)
H10A	0.4040	0.3486	0.1387	0.063*
H10B	0.3125	0.3872	0.1968	0.063*
H10C	0.4229	0.4355	0.1900	0.063*
C11	0.1708 (3)	0.3522 (2)	0.0475 (3)	0.0442 (10)
H11A	0.0967	0.3678	0.0412	0.066*
H11B	0.1826	0.3290	0.1046	0.066*
H11C	0.1892	0.3090	0.0050	0.066*

## supplementary materials

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C12	0.1436 (3)	0.4946 (3)	-0.0985 (3)	0.0448 (10)
H12A	0.1733	0.4725	-0.1516	0.067*
H12B	0.1194	0.5534	-0.1073	0.067*
H12C	0.0842	0.4588	-0.0812	0.067*
C13	0.3304 (3)	0.6293 (3)	-0.0800 (2)	0.0438 (10)
H13A	0.3836	0.6667	-0.0547	0.066*
H13B	0.2647	0.6611	-0.0872	0.066*
H13C	0.3550	0.6091	-0.1355	0.066*

### Atomic displacement parameters ( $\text{\AA}^2$ )

	$U^{11}$	$U^{22}$	$U^{33}$	$U^{12}$	$U^{13}$	$U^{23}$
Ti	0.0217 (3)	0.0269 (3)	0.0249 (3)	0.0006 (3)	0.0008 (2)	-0.0016 (3)
Cl1	0.0328 (5)	0.0388 (5)	0.0471 (6)	0.0091 (4)	-0.0028 (4)	0.0043 (4)
Cl2	0.0404 (5)	0.0474 (6)	0.0370 (5)	-0.0053 (5)	0.0098 (4)	0.0072 (4)
N1	0.0284 (16)	0.0325 (16)	0.0296 (15)	0.0011 (13)	0.0017 (13)	-0.0100 (13)
N2	0.0275 (16)	0.0341 (17)	0.0362 (17)	-0.0027 (13)	-0.0056 (13)	-0.0058 (14)
C1	0.0254 (18)	0.0333 (19)	0.0281 (18)	0.0029 (15)	0.0048 (14)	-0.0097 (16)
C2	0.0273 (18)	0.0292 (18)	0.0292 (18)	0.0055 (15)	0.0010 (15)	-0.0057 (15)
C3	0.0316 (19)	0.0304 (19)	0.0322 (19)	0.0039 (16)	-0.0029 (16)	-0.0050 (16)
C4	0.034 (2)	0.0330 (19)	0.0270 (18)	0.0037 (16)	-0.0009 (15)	-0.0057 (16)
C5	0.0337 (19)	0.0284 (18)	0.0275 (18)	0.0008 (16)	0.0073 (15)	-0.0039 (15)
C6	0.0242 (18)	0.040 (2)	0.040 (2)	-0.0016 (16)	0.0036 (16)	-0.0100 (17)
C7	0.0259 (18)	0.0284 (18)	0.0302 (19)	0.0013 (15)	-0.0026 (15)	-0.0004 (15)
C8	0.049 (2)	0.041 (2)	0.047 (2)	-0.002 (2)	-0.010 (2)	-0.018 (2)
C9	0.035 (2)	0.045 (2)	0.054 (3)	-0.0144 (19)	-0.0090 (19)	0.000 (2)
C10	0.044 (2)	0.041 (2)	0.041 (2)	0.0107 (19)	-0.0116 (19)	0.0001 (19)
C11	0.045 (2)	0.034 (2)	0.054 (3)	-0.0069 (19)	-0.009 (2)	-0.0018 (19)
C12	0.052 (3)	0.049 (2)	0.034 (2)	-0.003 (2)	-0.0164 (19)	-0.0002 (19)
C13	0.053 (3)	0.042 (2)	0.036 (2)	-0.001 (2)	0.0120 (19)	0.0009 (18)

### Geometric parameters ( $\text{\AA}$ , $^\circ$ )

Ti—N1	1.823 (3)	C6—C7	1.515 (5)
Ti—C1	2.292 (3)	C6—H6A	0.9800
Ti—Cl2	2.3036 (12)	C6—H6B	0.9800
Ti—Cl1	2.3104 (12)	C8—H8A	0.9700
Ti—C2	2.325 (3)	C8—H8B	0.9700
Ti—C5	2.341 (3)	C8—H8C	0.9700
Ti—C4	2.405 (3)	C9—H9A	0.9700
Ti—C3	2.406 (4)	C9—H9B	0.9700
N1—C7	1.322 (4)	C9—H9C	0.9700
N2—C7	1.319 (4)	C10—H10A	0.9700
N2—C8	1.457 (5)	C10—H10B	0.9700
N2—C9	1.464 (5)	C10—H10C	0.9700
C1—C2	1.406 (5)	C11—H11A	0.9700
C1—C5	1.412 (5)	C11—H11B	0.9700
C1—C6	1.512 (5)	C11—H11C	0.9700
C2—C3	1.422 (5)	C12—H12A	0.9700

C2—C10	1.504 (5)	C12—H12B	0.9700
C3—C4	1.405 (5)	C12—H12C	0.9700
C3—C11	1.500 (5)	C13—H13A	0.9700
C4—C5	1.422 (5)	C13—H13B	0.9700
C4—C12	1.500 (5)	C13—H13C	0.9700
C5—C13	1.500 (5)		
N1—Ti—C1	75.92 (13)	C5—C4—Ti	70.10 (19)
N1—Ti—C12	105.63 (10)	C12—C4—Ti	125.2 (3)
C1—Ti—C12	128.71 (10)	C1—C5—C4	107.5 (3)
N1—Ti—C11	104.29 (10)	C1—C5—C13	126.9 (3)
C1—Ti—C11	124.25 (10)	C4—C5—C13	125.5 (3)
C12—Ti—C11	105.40 (5)	C1—C5—Ti	70.40 (19)
N1—Ti—C2	94.34 (13)	C4—C5—Ti	75.1 (2)
C1—Ti—C2	35.44 (13)	C13—C5—Ti	121.3 (2)
C12—Ti—C2	94.88 (10)	C1—C6—C7	106.7 (3)
C11—Ti—C2	147.26 (9)	C1—C6—H6A	110.4
N1—Ti—C5	97.46 (13)	C7—C6—H6A	110.4
C1—Ti—C5	35.48 (12)	C1—C6—H6B	110.4
C12—Ti—C5	146.31 (9)	C7—C6—H6B	110.4
C11—Ti—C5	91.94 (10)	H6A—C6—H6B	108.6
C2—Ti—C5	58.66 (12)	N2—C7—N1	122.9 (3)
N1—Ti—C4	131.33 (13)	N2—C7—C6	120.4 (3)
C1—Ti—C4	58.19 (12)	N1—C7—C6	116.7 (3)
C12—Ti—C4	114.96 (10)	N2—C8—H8A	109.5
C11—Ti—C4	90.13 (9)	N2—C8—H8B	109.5
C2—Ti—C4	57.72 (12)	H8A—C8—H8B	109.5
C5—Ti—C4	34.83 (12)	N2—C8—H8C	109.5
N1—Ti—C3	128.99 (13)	H8A—C8—H8C	109.5
C1—Ti—C3	58.23 (12)	H8B—C8—H8C	109.5
C12—Ti—C3	88.61 (10)	N2—C9—H9A	109.5
C11—Ti—C3	118.89 (9)	N2—C9—H9B	109.5
C2—Ti—C3	34.93 (12)	H9A—C9—H9B	109.5
C5—Ti—C3	57.70 (12)	N2—C9—H9C	109.5
C4—Ti—C3	33.97 (12)	H9A—C9—H9C	109.5
C7—N1—Ti	129.5 (2)	H9B—C9—H9C	109.5
C7—N2—C8	120.2 (3)	C2—C10—H10A	109.5
C7—N2—C9	123.5 (3)	C2—C10—H10B	109.5
C8—N2—C9	116.3 (3)	H10A—C10—H10B	109.5
C2—C1—C5	108.4 (3)	C2—C10—H10C	109.5
C2—C1—C6	125.4 (3)	H10A—C10—H10C	109.5
C5—C1—C6	125.5 (3)	H10B—C10—H10C	109.5
C2—C1—Ti	73.55 (19)	C3—C11—H11A	109.5
C5—C1—Ti	74.12 (19)	C3—C11—H11B	109.5
C6—C1—Ti	110.9 (2)	H11A—C11—H11B	109.5
C1—C2—C3	108.0 (3)	C3—C11—H11C	109.5
C1—C2—C10	127.2 (3)	H11A—C11—H11C	109.5
C3—C2—C10	124.8 (3)	H11B—C11—H11C	109.5
C1—C2—Ti	71.01 (19)	C4—C12—H12A	109.5
C3—C2—Ti	75.7 (2)	C4—C12—H12B	109.5

## supplementary materials

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C10—C2—Ti	119.9 (2)	H12A—C12—H12B	109.5
C4—C3—C2	107.8 (3)	C4—C12—H12C	109.5
C4—C3—C11	126.4 (3)	H12A—C12—H12C	109.5
C2—C3—C11	125.7 (3)	H12B—C12—H12C	109.5
C4—C3—Ti	73.0 (2)	C5—C13—H13A	109.5
C2—C3—Ti	69.41 (19)	C5—C13—H13B	109.5
C11—C3—Ti	125.7 (3)	H13A—C13—H13B	109.5
C3—C4—C5	108.3 (3)	C5—C13—H13C	109.5
C3—C4—C12	126.4 (3)	H13A—C13—H13C	109.5
C5—C4—C12	125.2 (3)	H13B—C13—H13C	109.5
C3—C4—Ti	73.1 (2)		



Fig. 1

