A Journal of the Gesellschaft Deutscher Chemiker
Angewandte Chemie
GDCh
International Edition
www.angewandte.org

Title: Transition Metal pi-Ligation of a Tetrahalodiborane

Authors: Holger Braunschweig, Rian D. Dewhurst, J. Oscar C. Jimenez-Halla, Eduard Matito, and Jonas Muessig

To be cited as: *Angew. Chem. Int. Ed.* 10.1002/anie.201709515
Angew. Chem. 10.1002/ange.201709515

Link to VoR: http://dx.doi.org/10.1002/anie.201709515
http://dx.doi.org/10.1002/ange.201709515

WILEY-VCH

Transition Metal π-Ligation of a Tetrahalodiborane

Holger Braunschweig,* Rian D. Dewhurst, J. Oscar C. Jiménez-Halla, Eduard Matito, Jonas H. Muessig

Abstract: *The reaction of tetraiododiborane (B_2I_4) with trans-[$Pt(BI_2)I(PCy_3)_2$] led to isolation of the diplatinum(II) complex [{(Cy_3P)(I_2B)Pt}$_2$(μ_2:η^3:η^3-B_2I_4)], supported by the bridging diboranyl dianion ligand [B_2I_4]$^{2-}$. The complex is the first transition metal complex of a diboranyl dianion, as well as the first example of intact coordination of a B_2X_4 (X = halide) unit of any type to a metal center.*

Tetrahalodiboranes (B_2X_4; X = F, Cl, Br, I) are enigmatic compounds that are both steeped in history[1,2] and yet have massively underexplored synthetic chemistry. Unlike their synthetically useful tetrasubstituted cousins bis(pinacolato)- and bis(catecholato)diboron,[3] synthetic interest in tetrahalodiboranes ebbed after an initial spike in their use in the mid-20th century. In fact, as we pointed out recently,[4] over the past five years, the filing of patents involving tetrahalodiboranes(4) has outpaced their appearance in journal articles at a rate of two to one, mostly thanks to the current interest in B_2F_4 in the implantation of B^+ ions into silicon for semiconductor device fabrication.[5] Given their lability and immense potential reactivity, the relative absence of literature on tetrahalodiboranes is almost certainly due to their historically difficult preparation, which in many cases involved gas-phase synthesis.[6] Very recently, however, we presented simple solution-phase syntheses of B_2X_4 (X = F, Cl, I) from B_2Br_4, making all four tetrahalodiboranes considerably more accessible in practical amounts (Figure 1, top).[4]

In addition to our continuing interest in tetrahalodiboranes as precursors to species with boron-boron multiple bonds,[3c-e,6] we were also interested in the reactivity of these fundamental boron species with transition metal (TM) fragments, about which very little is known. The coordination chemistry of diboron units with transition metals is quite well-developed and diverse, including their metal-catalyzed boration and diboration chemistry,[3] as well as complexes where a metal binds inside a H-B-B-H cavity of sp^3-sp^3 diboranes,[7] complexes based on covalently-bound η^1- and η^2-diboran(4)yl ligands,[8] complexes of base-free[9] and base-stabilized η^2-diborenes,[10] and η^2-diborynes.[11] In contrast, the only known attempts to combine tetrahalodiboranes with transition metal fragments were made by Norman and coworkers with B_2F_4 (Figure 1, bottom), who isolated two products of B-B bond oxidative addition (*cis*-[$Pt(BF_3)_2L_2$], L_2 = $2PPh_3$, $Ph_2P(CH_2)_4PPh_2$), as well as an oxidative addition / disproportionation product with Vaska's complex (*fac,trans*-[$Ir(BF_3)_3(CO)L_2$]).[12]

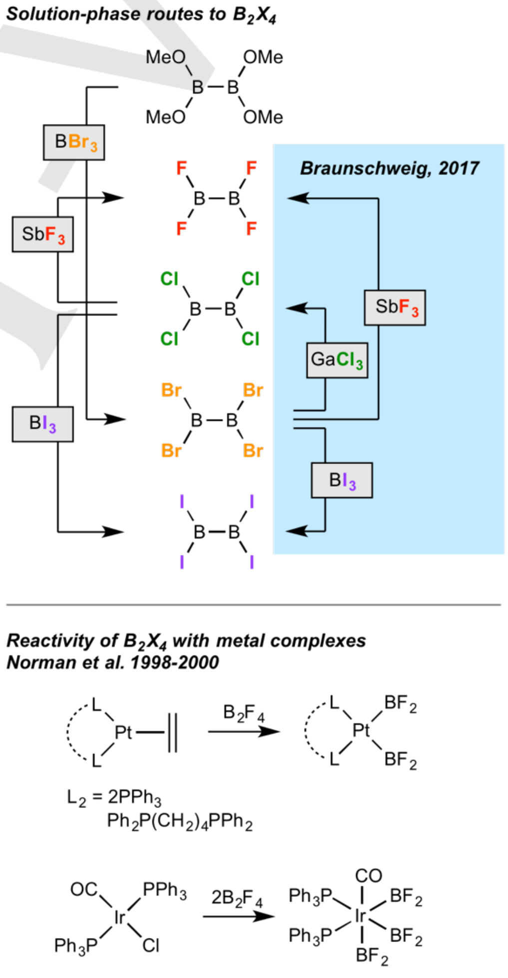


Figure 1. Top: Solution-phase routes to tetrahalodiboranes, with our recently-published routes highlighted in blue.[4] Bottom: Reactions of B_2F_4 with Pt^0 and Ir^I complexes from the group of Norman et al.

In Norman's work, the exclusive reactivity of B_2F_4 through its B-B bond is intuitive, given its substantially more inert boron-halide bonds than those of its heavier tetrahalodiborane congeners (B_2X_4; X = Cl, Br, I). In contrast, we envisaged more interesting reactivity of electron-rich transition metal fragments with the heavier tetrahalodiboranes, and thus initially sought to probe the reactivity of B_2I_4 with the low-valent transition metal species [$Pt(PCy_3)_2$]. The results of these studies, presented herein, are indeed underpinned by the greater lability of the B-I

---

[*] Prof. Dr. H. Braunschweig, Dr. R. D. Dewhurst, J. H. Muessig
Institute for Inorganic Chemistry
Julius-Maximilians-Universität Würzburg
Am Hubland, 97074 Würzburg, Germany
E-Mail: h.braunschweig@uni-wuerzburg.de
and
Institute for Sustainable Chemistry & Catalysis with Boron
Julius-Maximilians-Universität Würzburg
Am Hubland, 97074 Würzburg, Germany

Prof. Dr. J. O. C. Jimenez-Halla
Department of Chemistry (DCNE), Universidad de Guanajuato, Noria Alta s/n, 36050, Guanajuato, Mexico

Dr. E. Matito
Kimika Fakultatea, Euskal Herriko Unibertsitatea (UPV/EHU) and
Donostia International Physics Center (DIPC)
P.K. 1072, 20080 Donostia, Euskadi, Spain
and
IKERBASQUE, Basque Foundation for Science
48011 Bilbao, Euskadi, Spain

bonds, and led to the isolation of a highly unusual diplatinum complex containing two boryl ligands and a bridging $[B_2I_4]$ ligand best described as a diboranyl dianion. The complex is the first transition metal complex of an intact B_2X_4 (X = halide) species of any sort, and the first example of transition metal coordination to a reduced diborane species, compounds known since the pioneering work of Berndt, Nöth and Power in the 1980s and 1990s.[13,14]

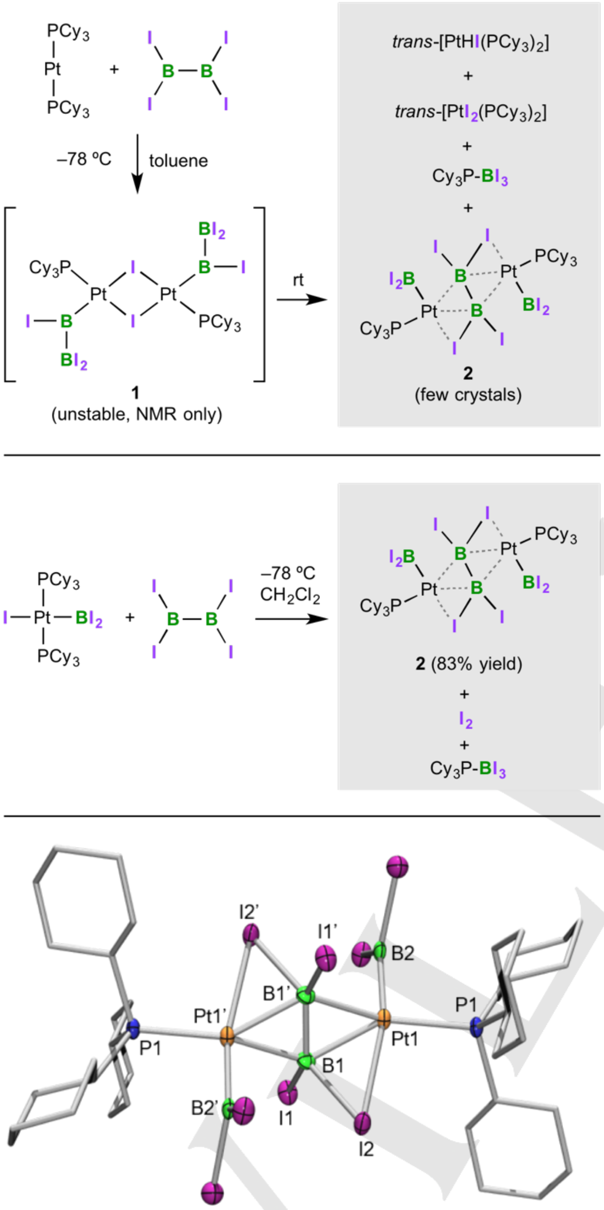


Figure 2. Unselective (top) and selective (middle) syntheses of complex **2**. Crystallographically derived structures of **2** (bottom). Ellipsoids shown at the 50% probability level. Some ellipsoids and all hydrogen atoms and solvent molecules (two molecules of CH_2Cl_2) have been removed for clarity. Selected bond lengths (Å) and angles (º): B1-B1' 1.744(6), Pt1-B1 2.202(4), Pt1-B1' 2.220(5), Pt1-B2 1.972(5), Pt1-I2 2.7834(5), B1-I1 2.194(4), B1-I2 2.287(5); B2-Pt1-I2 165.33(14); torsion Pt1-B1-B1'-Pt1'

Treating $[Pt(PCy_3)_2]$ with one equivalent of B_2I_4 at –78 ºC led to the observation of one predominant species with a single $^{31}P\{^1H\}$ NMR signal (δ 47.1; $^1J_{PPt}$ = 4320 Hz) and two ^{11}B NMR signals (δ 70, 40). These data were initially thought to correspond to the twofold iodide-bridged dinuclear complex $[Pt\{B(I)BI_2\}(\mu\text{-}I)(PCy_3)]_2$ (**1**), a product of oxidative addition of one B–I bond of B_2I_4 to the platinum center (Figure 2, top). However, the previously reported complexes $[Pt\{BBrFc\}(\mu\text{-}Br)(PCy_3)]_2$ (δ_P 23.6; $^1J_{PPt}$ = 4739 Hz)[15] and $[Pt\{BI_2\}(\mu\text{-}I)(PCy_3)]_2$ (δ_P 15.8; $^1J_{PPt}$ = 4460 Hz),[16] which have similar structures and the same phosphine ligand as **1**, show ^{31}P NMR signals significantly upfield of those observed herein, albeit with roughly similar ^{31}P-^{195}Pt coupling constants. Therefore, our assignment of the structure of **1** remains tentative.

Compound **1** decomposes within minutes at –78 °C to a complex mixture of products including *trans*-$[PtHI(PCy_3)_2]$, *trans*-$[PtI_2(PCy_3)_2]$, $Cy_3P\text{-}BI_3$ and other minor byproducts. Attempts to crystallize a pure product from this mixture provided a few yellow crystals, which were subjected to single-crystal X-Ray diffraction. This study revealed a highly unusual structure based on two $[Pt(BI_2)(PCy_3)]$ fragments bridged by a single B_2I_4 unit through a network of interactions of the Pt centers with B-I and B-B σ bonds ($[\{(Cy_3P)(I_2B)Pt\}(\mu_2{:}\eta^3{:}\eta^3\text{-}B_2I_4)]$ (**2**), structure discussed below; Figure 2, bottom).

Given the confirmed – but very low-yielding – synthesis of complex **2**, we were naturally eager to develop a selective preparation of this complex. During a number of attempts, we found that traces of BI_3 in the reaction mixture (from the spontaneous disproportionation of the thermally unstable B_2I_4) increased the amount of **2** in the product mixture, and that using a 50:50 mixture of BI_3 and B_2I_4 provided almost exclusively complex **2**, along with elemental iodine (as determined by a positive starch test from the mixture but a negative test with pure **2**) and one equivalent of Cy_3P–BI_3. To further improve the protocol, we reacted *trans*-$[Pt(BI_2)I(PCy_3)_2]$ with an equimolar amount of B_2I_4, providing **2** in 83% yield. The $^{31}P\{^1H\}$ NMR spectrum of **2** showed a singlet at δ = 30.5 ppm with a ^{31}P-^{195}Pt coupling constant of 2835 Hz, while the ^{11}B NMR spectrum showed two signals (δ 40, 7). The former ^{11}B NMR signal is identical to that found in **1**, presumably being that of the boron atoms of the terminal boryl ligands. Complex **2** is stable enough in solution to perform NMR experiments, but has to be stored at −30 °C and under exclusion of light to prevent decomposition.

An X-ray diffraction study of single crystals of **2** from this reaction further confirmed the successful synthesis of the minor product detected in the first reaction (Figure 2). The structure shows a planar Pt_2B_2 unit, with each Pt center binding in a σ fashion to one B-B bond (Pt−B1: 2.202(4) Å; Pt−B1': 2.220(5) Å) and one B-I bond (Pt1-I2: 2.7834(5) Å). It should be noted that the distance of the diborane unit to the platinum centers in **2** is about 11% longer than the Pt-B^{boryl} distance (1.972(5) Å), as the B_2I_4 ligand is bound through weaker 2e-3c bonds (see computational results below). The Pt-bound B-I bonds (2.287(5) Å) are significantly longer than the adjacent non-Pt-bound B-I bonds (2.194(4) Å), which in turn are longer than the B-I bonds of the terminal boryl ligand (2.150(5), 2.167(5) Å). Similarly, the Pt1-I2 distance (2.7834(5) Å) is significantly longer than regular Pt^{II}-I bonds.

The B−B bond length of complex **2** (1.744(9) Å) is identical to that of isolated B_2Cl_4 (1.75(5) Å)[17] within experimental uncertainty. However, this distance is much larger than the corresponding bonds of TM-bound neutral, base-stabilized diborenes of the form $[MX_n(\eta^2\text{-}ArLB{=}BLAr)]^{[10]}$ (d_{BB} = 1.61-1.65 Å; MX_n = CuCl, AgCl, $CdCl_2$, $ZnCl_2$, $ZnBr_2$; L = NHC, phosphine; Ar = duryl, anthryl), despite their isoelectronic relationship and the presence of a π_{BB} bond in both. The B–B distance of **2** is even further removed from that of the base-free diborene complex $[(Et_3P)_2Pt(B_2Dur_2)]$ (d_{BB} = 1.51(1) Å), which features B–B-bond-strengthening π backdonation from the metal.[9a] These data point to the diboranyl dianion complex **2** having much stronger covalent bonding with the Pt center than in TM complexes of neutral diborenes, where electrostatic contributions predominate.

Attempts to prepare analogous complexes by the reactions of (a) *trans*-$[Pt(BX_2)X(PCy_3)_2]$ (X = Cl, Br, I) with B_2Cl_4, (b) *trans*-$[Pt(BBr_2)Br(PCy_3)_2]$ with B_2Br_4, and (c) *trans*-$[Pt(BI_2)I(PCy_3)_2]$ with B_2Br_4, were all unsuccessful. It should also be noted that based on these results, and the diverse coordination modes of diboranes proposed theoretically with the $[Cr(CO)_4]$ fragment by Jemmis et al.,[18] we also attempted to coordinate a range of tetrahalodiboranes to zerovalent chromium. However, treatment of B_2X_4 (X = Cl, Br, I) with $[Cr(CO)_6]$ failed to provide tractable products either under thermal or photolytic conditions.

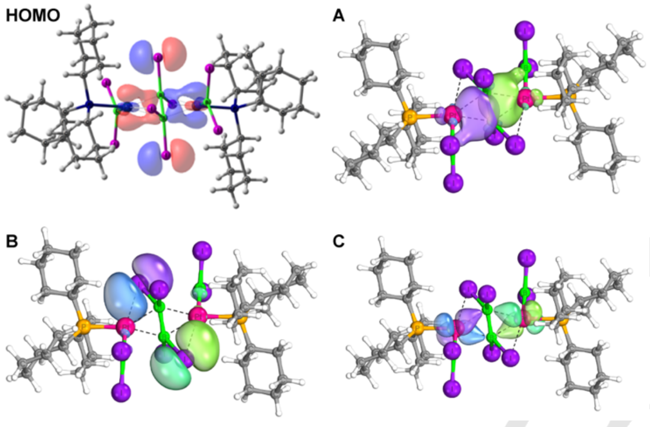


Figure 3. Calculated HOMO (top left) and the three intrinsic bond orbitals of most relevance to the Pt-B_2I_4 interaction of **2** (**A-C**).

The connectivity of **2** naturally raises questions about the identity of the diborane briding ligand and the nature of the Pt-B bonding, prompting us to undertake theoretical calculations at the lc-ωPBE/SBKJC level. The solid-state structure of **2** shows that both the B-I and Pt-I bonds of the B-Pt-I triangle are very long (vide supra), and this is reflected in the low atoms-in-molecules (AIM)[19] bond orders[20] calculated for these bonds (B-$I^{bridging}$: 0.72, c.f. B-$I^{terminal}$: 0.91; Pt-I: 0.60). These data suggest a relatively even sharing of the bridging iodides between the boron and platinum atoms. This unit is bound to the Pt centers through three-center-two-electron (3c2e) PtB_2 bonds as confirmed by multicenter bond indices[21] that are larger than those present in diborane, and the presence of ring critical points (RCPs) of electron density in the center of each B-Pt-B triangle.[19] The shape of the HOMO of **2** (Figure 3, top left), reveals an interaction between the $[B_2I_4]$ unit and the two Pt atoms. Analysis of the intrinsic bond orbitals (IBOs)[22] related to the Pt-$[B_2I_4]$ interaction shows that the most relevant interactions are: (**A**, Figure 3) twofold $\pi_{BB}\rightarrow d_{Pt}$ donation, (**B**) iodide lone-pair-to-platinum ($LP_I\rightarrow d_{Pt}$) donation, and (**C**) twofold $d_{Pt}\rightarrow\pi^*_{BB}$ backdonation. Interaction **A** is characterized by a two-fold interaction of the B-B bond with the Pt centers, thus confirming the multicenter character of this bond.

Formal considerations dictate either a Pt(II) / $[B_2I_4]^{2-}$ or a Pt(I) / $[B_2I_4]^0$ description for **2**. However, the latter case invokes rare monovalent Pt and implies the presence of a platinum-based diradical, which we do not observe. Thus, from an experimental standpoint the former situation appears to be a far better description. AIM analysis suggests the presence of two multicenter PtB_2 3c2e bonds, similar to the two B_3 3c2e bonds seen in Himmel's rhomboidal B_4 compound.[23] The observation of PtB_2 RCPs in **2** (Figure 4) is furthermore in line with the calculation of a similar NiC_2 RCP for the π-olefin complex $[Ni(C_2H_4)(tBu_2PCH_2CH_2PtBu_2)]$,[24] to which the Dewar-Chatt-Duncanson (σ-donation / π-backbonding) model applies. Thus, the B_2I_4 unit can be seen as an analogue of an olefin.

However, regardless of the true nature of the bonding in **2**, the complex is the surprising first example of the intact coordination of a reactive tetrahalodiborane unit to a metal. The results reported herein provide a glimpse of the potentially exciting coordination chemistry of tetrahalodiboranes, about which very little is currently known.

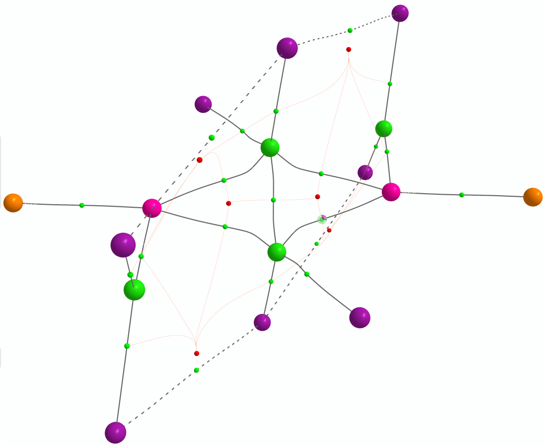


Figure 4. Topological analysis of the electron density[19] of **2**. Only the core of the complex is shown; Pt: pink, B: green, I: purple, P: orange. The analysis reveals bond critical points (small dots in green) for B-B, Pt-B and several B-I bonds, as well as two ring critical points (small dots in red) in the two B-Pt-B triangular structures. The bond paths (grey lines) are slightly curved for the four B-Pt bonds that form the romboid structures. All these features suggest two 2e3c bonds for each B-Pt-B structure.

Acknowledgements

Financial support from the Julius-Maximilians-Universität Würzburg is gratefully acknowledged. The authors thank AllyChem Ltd. for a generous gift of B2(NMe2)4. J.O.C.J.-H. thanks CONACyT through project CB2014-241803 for a research stay at Julius-Maximilians-Universität Würzburg. E.M. acknowledges funding from Spanish MINECO Project (CTQ2014-52525-P) and the Basque Country Consolidated Group (IT588-13).

Keywords: boron • platinum • σ-bond complexes • diboranes • haloboranes

[1] J. A. Morrison, *Chem. Rev.* **1991**, *91*, 35-48.

[2] Selected key syntheses of tetrahalodiboranes in the 20th century: a) A. L. McCloskey, J. L. Boone, R. J. Brotherton, *J. Am. Chem. Soc.* **1961**, *83*, 1766-1767; b) J. Feeney, A. K. Holliday, F. J. Marsden, *J. Chem. Soc.* **1961**, 356–360; c) W. B. Fox, T. Wartik, *J. Am. Chem. Soc.* **1961**, *83*, 498–499; d) R. J. Brotherton, A. L. McCloskey, H. M. Manasevit, *Inorg. Chem.* **1963**, *2*, 41-43; e) H. Nöth, H. Pommerening, *Chem. Ber.* **1981**, *114*, 398–399. f) W. Haubold, P. Jacob, *Z. Anorg. Allg. Chem.* **1983**, *507*, 231–234. g) M. Hildenbrand, H. Pritzkow, U. Zenneck, W. Siebert, *Angew. Chem.* **1984**, *96*, 371–372; h) P. Hornbach, M. Hildenbrand, H. Pritzkow, W. Siebert, *Angew. Chem.* **1986**, *98*, 1121–1123

[3] a) E. C. Neeve, S. J. Geier, I. A. I. Mkhalid, S. A. Westcott, T. B. Marder, *Chem. Rev.* **2016**, *116*, 9091-9161; b) R. D. Dewhurst, E. C. Neeve, H. Braunschweig, T. B. Marder, *Chem. Commun.* **2015**, *51*, 9594–9607; c) H. Braunschweig, R. D. Dewhurst, *Angew. Chem. Int. Ed.* **2013**, *52*, 3574–3583; d) H. Braunschweig, R. D. Dewhurst, S. Mozo, *Chem. Cat. Chem.* **2015**, *7*, 1630–1638. e) M. Arrowsmith, H. Braunschweig, T. E. Stennett, *Angew. Chem. Int. Ed.* **2017**, 56*,* 96–115.

[4] M. Arrowsmith, J. Böhnke, H. Braunschweig, A. Deißenberger, R. D. Dewhurst, W. C. Ewing, C. Hörl, J. Mies, J. H. Muessig, *Chem. Commun.* **2017**, *53*, 8265–8267.

[5] a) O. Byl, E. Jones, J. Sweeney, R. Kaim, *AIP Conf. Proc.* **2011**, *1321*, 408–410; b) Y. Tang, O. Byl, A. Avila, J. Sweeney, R. Ray, J. Koo, M.-S. Jeon, T. Miller, S. Krause, W. Skinner, J. Mullin, 20th International Conference on Ion Implantation Technology (IIT), 2014, DOI: 10.1109/IIT.2014.6939984.

[6] H. Braunschweig, R. D. Dewhurst, K. Hammond, J. Mies, K. Radacki, A. Vargas, *Science* **2012**, *336*, 1420–1422.

[7] a) S. A. Snow, G. Kodama, *Inorg. Chem.* **1985**, *24*, 796–797; b) M. Shimoi, K. Katoh, H. Ogino, *J. Chem. Soc., Chem. Commun.* **1990**, 811–812; c) A. Wagner, S. Litters, J. Elias, E. Kaifer, H.-J. Himmel, *Chem. Eur. J.* **2014**, *20*, 12514–12527; d) A. Wagner, E. Kaifer, H.-J. Himmel, *Chem. Eur. J.* **2013**, *19*, 7395–7409.

[8] a) H. Braunschweig, B. Ganter, M. Koster, T. Wagner, *Chem. Ber.* **1996**, *129*, 1099–1101; b) H. Braunschweig, M. Koster, R. Wang, *Inorg. Chem.* **1999**, *38*, 415–416; c) H. Braunschweig, M. Koster, K. W. Klinkhammer, *Angew. Chem. Int. Ed.* **1999**, *38*, 2229–2231; d) H. Braunschweig, K. W. Klinkhammer, M. Koster, K. Radacki, *Chem. Eur. J.* **2003**, *9*, 1303–1309; e) H. Braunschweig, A. Damme, T. Kupfer, *Angew. Chem. Int. Ed.* **2011**, *50*, 7179–7182.

[9] a) H. Braunschweig, A. Damme, R. D. Dewhurst, A. Vargas, *Nat. Chem.* **2013**, *5*, 115–121; b) N. Arnold, H. Braunschweig, R. D. Dewhurst, W. C. Ewing, *J. Am. Chem. Soc.* **2016**, *138*, 76–79.

[10] a) P. Bissinger, H. Braunschweig, A. Damme, T. Kupfer, A. Vargas, *Angew. Chem., Int. Ed.* **2012**, *51*, 9931−9934; b) P. Bissinger, A. Steffen, A. Vargas, R. D. Dewhurst, A. Damme, H. Braunschweig, *Angew. Chem., Int. Ed.* **2015**, *54*, 4362−4366; c) S. R. Wang, M. Arrowsmith, H. Braunschweig, R. D. Dewhurst, M. Dömling, J. D. Mattock, C. Pranckevicius, A. Vargas, *J. Am. Chem. Soc.* **2017**, *139*, 10661-10664.

[11] H. Braunschweig, T. Dellermann, R. D. Dewhurst, B. Hupp, T. Kramer, J. Mattock, J. Mies, A. K. Phukan, A. Steffen, A. Vargas, *J. Am. Chem. Soc.* **2017**, *139*, 4887–4893.

[12] a) N. Lu, N. C. Norman, A. G. Orpen, M. J. Quayle, P. L. Timms, G. R. Whittell, *J. Chem. Soc., Dalton Trans.* **2000**, 4032–4037; b) A. Kerr, T. B. Marder, N. C. Norman, A. G. Orpen, M. J. Quayle, C. R. Rice, P. L. Timms, G. R. Whittell, *Chem. Commun.* **1998**, 319–320.

[13] a) H. Klusik, A. Berndt, *Angew. Chem. Int. Ed. Engl.* **1981**, *20*, 870–871; b) W. J. Grigsby, P. P. Power, *Chem. Commun.* **1996**, 2235–2236; c) W. J. Grigsby, P. P. Power, *Chem. Eur. J.* **1997**, *3*, 368–375.

[14] a) H. Nöth, J. Knizek, W. Ponikwar, *Eur. J. Inorg. Chem.* **1999**, 1931–1937; b) A. Moezzi, M. M. Olmstead, P. P. Power, *J. Am. Chem. Soc.* **1992**, 114, 2715–2717; c) A. Moezzi, R. A. Bartlett, P. P. Power, *Angew. Chem. Int. Ed. Engl.* **1992**, *31*, 1082–1083; d) H. Braunschweig, R. D. Dewhurst, *Organometallics* **2014**, *33*, 6271–6277.

[15] H. Braunschweig, P. Brenner, K. Radacki, *Z. anorg. allg. Chem.* **2009**, *635*, 2089-2092.

[16] H. Braunschweig, K. Radacki, K. Uttinger, *Inorg. Chem.* **2007**, *46*, 8796–8800.

[17] M. Atoji, P. J. Wheatley, W. N. Lipscomb, *J. Chem. Phys.* **1957**, *27*, 196–199.

[18] K. H. K. Reddy, E. D. Jemmis, *Dalton Trans.* **2013**, *42*, 10633–10639.

[19] R. F. W. Bader, Atoms in Molecules: A Quantum Theory. Oxford Univ. Press, Oxford, **1990**;

[20] a) X. Fradera, M. A. Austen, R. F. W. Bader, *J. Phys. Chem. A* **1999**, *103,* 304–314; b) E. Matito, M. Solà, P. Salvador, M. Duran, *Faraday Discuss.* **2007**, *135*, 325–345.

[21] a) P. Bultinck, R. Ponec, S. Van Damme, *J. Phys. Org. Chem.* **2005**, *18*, 706–718; b) J. Cioslowski, E. Matito, M. Solà, *J. Phys. Chem. A* **2007**, *111*, 6521–6525.

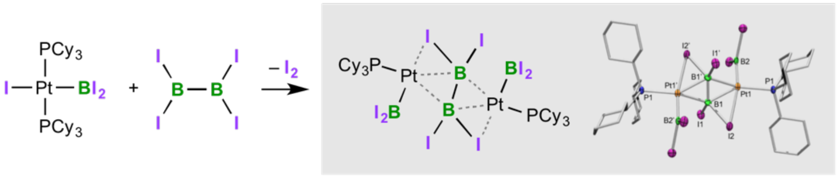
[22] a) G. Knizia, *J. Chem. Theory Comput.* **2013**, *9*, 4834–4843; b) G. Knizia, J. E. M. N. Klein, *Angew. Chem. Int. Ed.* **2015**, *54*, 5518–5522.

[23] S. Litters, E. Kaifer, M. Enders, H.-J. Himmel, *Nat. Chem.* **2013**, *5*, 1029-1034.

[24] W. Scherer, G. Eickerling, D. Shorokhov, E. Gullo, G. S. McGrady, P. Sirsch, *New J. Chem.* **2006**, *30*, 309-312.

Entry for the Table of Contents

FULL PAPER



The reaction of tetraiododiborane with trans-[Pt(BI_2)I(PCy_3)$_2$] led to isolation of a diplatinum(II) complex supported by a bridging [B_2I_4] unit. The complex is the first transition metal complex of a diboranyl dianion, as well as the first example of intact coordination of a B_2X_4 (X = halide) unit of any type to a metal center.

Holger Braunschweig, Rian D. Dewhurst, J. Oscar C. Jiménez-Halla, Eduard Matito, Jonas H. Muessig

Page No. – Page No.

Transition Metal π-Ligation of a Tetrahalodiborane