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ARTICLE

Derivatization of (quinolin-8-yl)phosphinimidic amides via ortho-lithiation revisited†

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The direct ortho-lithiation of N-H containing (quinolin-8-yl)phosphinimidic amides by reaction with 1 equiv of *n*-BuLi described by Wang and co-workers (see reference 12) has been re-examined. The multinuclear magnetic resonance (^{1}H, ^{2}H, ^{7}Li, ^{13}C, ^{15}N and ^{31}P) study of the species formed in the monolithiation of *N*-(*tert*-butyl)-*P,P*-diphenyl-*N′*-(quinolin-8-yl)phosphinimidic amide **5** with *n*-BuLi in THF showed that proton abstraction occurred exclusively and quantitatively at the NH. The combination of the NMR results with a DFT study made it possible to describe the structure of the N-lithiated species **9** as a dimer consisting of an eight-membered ring showing two lithium ions triply coordinated to nitrogen atoms corresponding to the deprotonated amine and aminoquinoline moieties of different monomers. The formation of a polymer featuring the same coordination mode coudn't be excluded. In addition, optimized conditions for the efficient derivatization of **5** via ortho-lithiation were found. The reaction of **5** with 2.4 equiv of *t*-BuLi in THF in the temperature range -80 ºC to 25 ºC for 3 h afforded a N,C_{ortho}-dilithiated species that was trapped with a series of electrophiles leading to new functionalized ortho derivatives of **5** in good yields.

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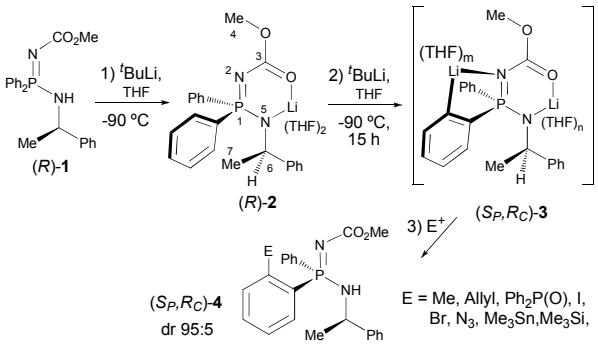
Introduction

Directed ortho-lithiation (DoLi) is a valuable synthetic method for the derivatization of aromatic rings. It is based on the ability of a polar group, commonly known as the directing metallation group (DMG), for increasing the acidity of the ortho protons and approaching an organolithium base to that position facilitating thus the selective deprotonation. Subsequent electrophilic quench provides the ortho-substituted products generally in high yields.[1] A large variety of C-based and heteroatom-based DMGs have been reported.[1,2] The application of this strategy to phosphorus-containing systems represents a very efficient route to the synthesis of ortho-functionalized derivatives.[3] In addition, the ortho-lithiated species can be used as chelating ligands for the construction of complexes of other main-group, transition metals and f-block elements via metathetical reactions with metal halides.[4]

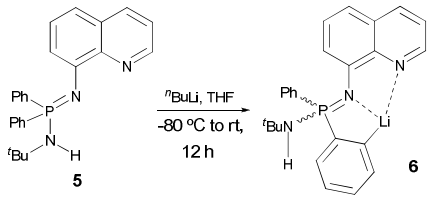
Functional groups bearing acidic protons may also act as efficient DMGs.[5,6] These include phosphinic acids[7] and phosphinic amides.[8] As can be expected, in these cases the first step of the process is the deprotonation of the DMG, i.e., the ortho-lithiation is directed by a lithiated functional group. Recently, we have shown that phosphinimidic amides **1** undergo ortho-lithiation with excellent diastereoselectivity by treatment with 3 equivalents of *t*-BuLi at -90 ºC in THF for 15 h (Scheme 1).[9] After electrophilic quench P-chiral ortho-functionalized derivatives **4** are obtained in high yield and optical purity. These primary products can be readily converted into a variety of P-stereogenic compounds via functional group transformations.[10] The study of the mechanism of this lithiation revealed that mono- deprotonation of **1** afforded the N-lithiated intermediate **2** which exist in a conformation that favours the almost exclusive DoLi reaction of the *pro-S* P-phenyl ring to give the N,C_{ortho} dianion **3**.[11]



Scheme 1 C_{ortho} lithiation of phosphinimidic amide (*R*)-**1**.

These results are in sharp contrast with those reported by Wang and co-workers on the monolithiation of (quinolin-8-yl)phosphinimidic amide **5**.[12] According to these authors, the reaction of **5** with one equivalent of *n*-BuLi in THF provides exclusively the ortho-lithiated derivative **6** (Scheme 2). Compound **6** was described as a yellow solid that was characterized based on its elemental analysis and NMR spectroscopy data. Apparently, the C/H/N analyses of **6** are in agreement with its expected elemental composition. Moreover, the ^{1}H NMR spectrum measured in benzene-d_6 showed a doublet at δ 3.56 ppm ($^2J_{PH}$ 6.3 Hz) assigned to the NH signal. Surprisingly, the ^{13}C NMR spectrum did not show any of the characteristic signals found in ortho-lithiated Ph_2P=X (X= O, N) moieties.[13] Particularly striking are the apparent absence of the doublets corresponding to the two *ipso* carbons linked to phosphorus of $^1J_{PC}$ > 80 Hz and the signal for the lithiated carbon for which one would expect a chemical shift of ca 200 ppm.[4d,13,14] In contrast to these foreseeable structural features, the ^{13}C NMR spectrum of **6** contains only two doublets of 2.2 Hz and 8.3 Hz that are appropriate for ^{31}P, ^{13}C scalar couplings transmitted through 4 and 2 bonds, respectively, and the most deshielded signal appears as a singlet at δ 144.17 ppm.

Due to the discrepancies between the ortho deprotonation of the structurally similar phosphinimidic amides **1** and **5** we decided to reinvestigate the DoLi reaction of **5**. The results of this study are reported here. They showed that ortho-lithiation of **5** proceeds in a similar manner to phosphinimidic amide **1**, that is, N-H abstraction by one equivalent of the organolithium base originates a N-lithiated species that is subsequently lithiated at the ortho position with respect to the phosphorus by a second equivalent of base. The structure of the N-lithium derivative has been elucidated using multinuclear magnetic resonance spectroscopic methods and DFT calculations. In addition, a procedure for the ortho-lithiation of **5** similar to that reported for (*R*)-**1** is described. Electrophilic trapping of the ortho-anion furnished ortho-functionalized products in high yield via carbon-carbon and carbon-heteroatom bond forming reactions.



Scheme 2 C_{ortho} lithiation of phosphinimidic amide **5**.

Results and discussion

Monolithiation of (quinolin-8-yl)phosphinimidic amide 5

Phosphinimidic amide **5** was prepared according to the the method of Wang *et al.*[12] through the Staudinger reaction between *N-tert*-butyl-1,1-diphenylphosphanamine[15] **7** and 8-azidoquinoline[16] **8** in CH_2Cl_2 at room temperature for 4 hours (Scheme 3). Solvent evaporation followed by precipitation from a mixture of CH_2Cl_2:hexane in a ratio of 1:2 afforded **5** in a yield of 82%.

Once available, compound **5** was monodeprotonated under the reaction conditions described by Wang and co-workers. Thus, a solution of **5** in THF at -80 ºC was treated with 1.1

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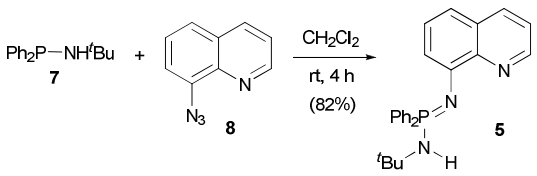
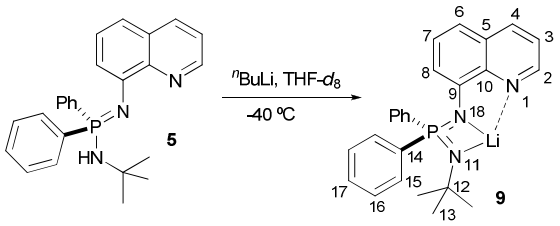
equiv of *n*-BuLi, and the reaction mixture was allowed to reach room temperature and stirred overnight. In order to identify the site of the deprotonation, the reaction was quenched with CD_3OD. After aqueous workup, the ^1H NMR spectrum of the crude mixture proved to be identical to that of the starting material. The recovery of non-deuterated **5** implies that ortho-deprotonation has not taken place. The aqueous workup of the reaction would not affect a carbon-deuterium bond. However, D/H exchange could restore the N-H bond of **5**. Rapid D/H exchange in **5** was confirmed by measuring the ^1H NMR spectrum of a sample of the compound in $CDCl_3$ after the addition of a drop of CD_3OD. As expected, the NH signal disappeared in agreement with the results of the lithiation-deuteration reaction.



Scheme 3 Synthesis of phosphinimidic amide **5**.

In order to ascertain unequivocally the site of monodeprotonation of **5** we carried out a NMR study of two monolithiated samples of concentration 0.42 M and 75 mM prepared by treating a solution of **5** in THF-d_6 with 1.1 equivalents of *n*-butyllithium (1.6 M solution in hexanes) at -60 ºC. The ^1H, ^7Li and $^{31}P\{^1H\}$ NMR spectra acquired in the temperature range of -110 ºC to 25 ºC showed that the anion was quite stable (Figs S12). The sample remained unaltered when stored in the refrigerator at ca. 4 ºC for 20 h and only a 2% of the neutral compound was detected when the sample was left standing at room temperature for 5 h (Fig S13).

The lithiated species **9** was characterized through the analysis of the NMR spectra measured at -40 ºC. The $^{31}P\{^1H\}$ NMR of the freshly prepared sample consisted of a singlet at δ -6.7 ppm together with a 3% of a by-product at δ 8.5 ppm (Fig S5). In this solvent, the ^{31}P signal of **5** appears at δ 0.2 ppm. Analogously, the ^7Li NMR spectrum was dominated by a singlet at δ 2.5 ppm (Fig S7). The ^1H and ^{13}C NMR spectra revealed significant changes in the chemical shift of the aromatic signals, especially those of the quinoline ring, as compared with **5** (Figs S4, S6). The important point is that both spectra showed that neither the heterocyclic system nor the Ph_2P moiety had been deprotonated. These data, together with the absence of the NH signal in the ^1H NMR spectrum of **9** indicate that the deprotonation of **5** occurred at the NH (Scheme 4).[17] The ^1H and ^{13}C signals were assigned based on the standard combination of 1D and 2D NMR spectra (Figs S8-S10). The protons most affected by the N-deprotonation are H2 ($\Delta\delta_{5-9}$ = -0.3 ppm), H6 ($\Delta\delta_{5-9}$ = 0.3 ppm) and H7 ($\Delta\delta_{5-9}$ = 0.36 ppm), whereas the largest changes in $\delta_C/^nJ_{PC}$ occurred for C6 ($\Delta\delta_{5-9}$ = 4.5 ppm), C8 ($\Delta\delta_{5-9}$ = 3.8 ppm/-14.3 Hz) and C14 ($\Delta\delta_{5-9}$ = -4.6 ppm/17.8 Hz). The deshielding of C14 promoted by the abstraction of the NH proton of **5** together with the notable decrease of $^1J_{PC}$ are in agreement with those observed for the N-lithiation of (*R*)-**1**.[11]



Scheme 4 N-lithiation of phosphinimidic amide **5** to give **9** and numbering scheme used.

The unequivocal demonstration of the N-lithiated structure of **9** was obtained through the analysis of the ^{15}N data of compounds **5** and **9** arising from their $^1H,^{15}N$ HMQC spectra (Fig. 1). The nitrogen atoms of the [N-P-NH] backbone of **5** were identified based on the correlations observed for the NH and the methyl protons with a signal at δ -297.1 ppm (N11) and the correlation detected at δ -289.5 ppm between N18 and the neighboring proton H8 of the quinoline heterocycle. The nitrogen N1 showed three correlations with H2, H3 and H8 at δ -70.2 ppm (Fig. 1a). The analogous spectrum of species **9** revealed that N1 (δ -96.1 ppm) underwent a significant shielding of $\Delta\delta_{5-9}$ = -25.9 ppm, whereas N11 (δ -300 ppm) is shielded by only -2.9 ppm. The apparent insensitivity of the ^{15}N chemical shift of N11 to the deprotonation is in agreement with the analogous observation for the lithiated nitrogen of complex (*R*)-**2**.[11] Unfortunately, no correlations were found for N18 neither in the $^1H,^{15}N$- nor the $^{31}P,^{15}N\{^1H\}$ HMQC spectra of **9**.[18]

These results, together with the fact that the known X-ray crystal structures of monolithiated phosphinimidic amides[19] consist of a four-membered metallacycle formed by *N,N*-chelation of the lithium cation, suggest that the anionic system of **9** is acting as a *N,N,N*-tridentate ligand toward the lithium ion. The NMR study indicates that this coordination mode is highly favored. A single species is observed in the ^7Li- and ^{31}P NMR spectra measured in the temperature range of 0 ºC to -100 ºC for both the concentrated and the highly diluted NMR samples (Fig. S12).

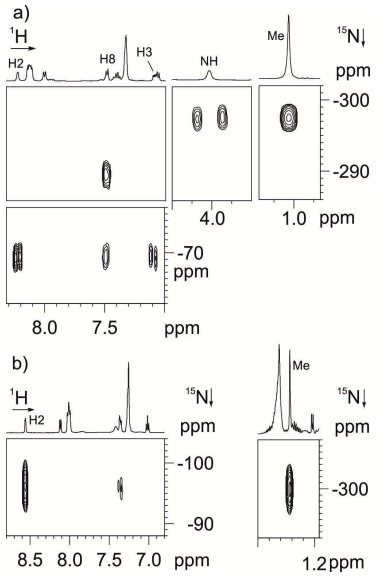


Figure 1 $^1H,^{15}N$ HMQC NMR spectra of a 75 mM sample in THF-d_8 of (a) compound **5** measured at 25 ºC and (b) the N-lithiated derivative **9** measured at -40 ºC.

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To get insight into the NH vs CH_{ortho} deprotonation reaction and the structure of the lithiated species formed, a DFT computational study at the M06-2X(SMD,THF)/6-311+G(d,p)//M06-2X/6-31G(d) level of theory was carried out. All energies were calculated at a temperature of -40 ºC. Proton abstraction from **5** by *n*-BuLi was computed according to the CIPE model.[20] The approach of the organolithium base to the sites of deprotonation takes place by formation of pre-complexes **Pre-6** and **Pre-9** between both reagents through coordination of the lithium cation to the nitrogen atoms N1 and N18 of **5** (Fig 2 and S33). The reaction pathway via **Pre-9** is predicted to proceed virtually without energy cost to give the N-lithium species **9A**. In contrast, pre-complex **Pre-6** is destabilized by 3.6 kcal/mol with respect to **Pre-9** and the H_{ortho}-abstraction leading to **6** takes place through an energy barrier 14.4 kcal/mol higher than the NH deprotonation. Therefore, the *n*-BuLi will abstract the NH proton of **5** exclusively in agreement with the NMR measurements.

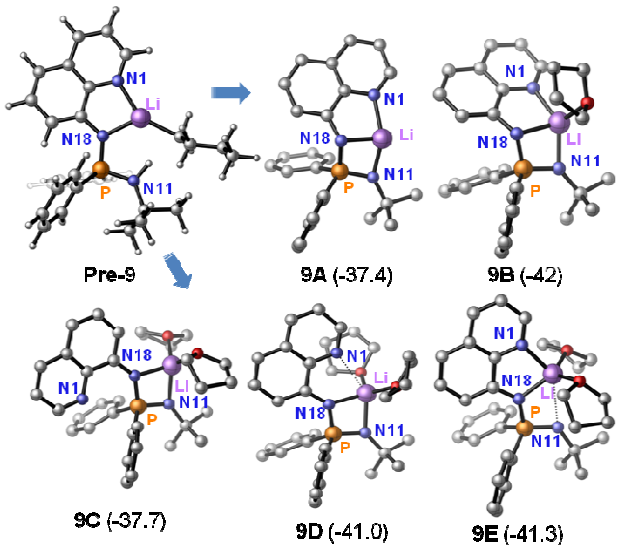

Figure 2 Computed structures of **Pre-9**, unsolvated **9A** monosolvated **9B**, and dis-solvated **9C**, **9D** and **9E**. Hydrogen atoms are omitted for clarity, except for **Pre-9**. Free energies (in parentheses) are given in kcal/mol with respect to the equations: a) **Pre-9** → **9A** + **″BuH**, b) **Pre-9** + **THF** → **9A** + **″BuH**, and c) **Pre-9** + 2**THF** → **9B-E** + **″BuH**.

Next, the structure of the N-lithiated species was investigated. The detection of only one species in diluted and concentrated NMR samples is consistent with the existence of a monomer or a very stable aggregate in THF solution. For the monomer, we have analyzed the geometry and thermodynamic of the structures in which the anion behaves as *N,N*-di- and *N,N,N*-tridentate ligand. In addition, lithium solvation by coordination to one or two THF molecules was also evaluated.[21] The ^{15}N chemical shifts of all structures were also calculated. Monosolvated **9B** showing triple nitrogen coordination to lithium (average N-Li distance of 2.04 Å) proved to be the most stable species ($\Delta G_{\mathbf{9A\text{-}9B}}$ = -4.6 kcal/mol) (Fig. 2, Table 1 entry 5). Notwithstanding, dis-solvated structures **9D** and **9E** are destabilized with respect to **9B** by ≤1 kcal/mol (entries 7 and 8). In a THF solution the three species could be in equilibrium. Structures **9D**/**9E** can be described as a four-/five-membered metallacycle in which the third nitrogen atom N1/N11 is weakly coordinated to the lithium cation (**9D**: distance N1-Li = 2.765 Å; **9E**: distance N11-Li = 2.851 Å). Interestingly, the relative energy of dis-solvated **9C** showing the prototypal N-P-N-Li four-membered ring of lithium phosphinimidic amides in the solid-state[19] without additional interaction with the nitrogen atom of the quinoline ring, N1, was essentially the same as that of **9A** ($\Delta G_{\mathbf{9A\text{-}9C}}$ = -0.3 kcal/mol, entry 6).

As for the aggregates, we focused on dimers formed by connecting two monomers via N-Li bridges. Aggregation through N_2Li_2 cores is a common structural feature of N-lithium species,[22] including phosphinimidic amides,[22e] and was regarded as a useful starting point for the calculations. The four most stable species found, **Dimer-A** to **Dimer-E**, are shown in Fig S35. Their relative energies with respect to two molecules of **9A** are given in Table 1 (entries 9-12). The first conclusion drawn from this study is that dimers are much more stable than monomers. The free energy differences of ca. 10 kcal/mol in favor of dimers indicate that N-lithiated **9** must exists as an aggregate in solution.

Table 1 Relative energies ΔG^{233} (in kcal/mol) of the computed lithiated structures with respect to **9A** and experimental and calculated ^{15}N chemical shifts (in ppm).

Entry	Species	ΔG^{233}	N1	N11	N18
1	**5**[a]		-70.2	-297.1	-289.5
2	**5**		-71.2	-324.8	-327.3
3	**9**[a]		-96.1	-300.0	nd[b]
4	**9A**	0.0	-111.5	-322.4	-311.3
5	**9B**	**-4.6**	**-100.2**	**-324.4**	**-316.5**
6	**9C**	-0.3	-58.8	-331.9	-308.3
7	**9D**	-3.6	-70.2	-331.7	-296.9
8	**9E**	-3.9	-95.6	-325.9	-295.5
9	**Dimer-A**	-9.9	-102.8	-331.6	-317.8
10	**Dimer-B**	-9.0	-96.3	-325.7	-331.2
11	**Dimer-C**	**-11.0**	**-99.1**	**-314.5**	**-295.3**
12	**Dimer-D**	-9.0	-101.1	-326.1	-285.1

a) Experimental results. b) Not determined.

We will focus on the two most stable dimers, **Dimer-A** and **Dimer-C**. **Dimer-A** exists as a twisted ladder structure of alternating N-P-N-Li and N-Li-N-Li four-membered rings with a syn arrangement of the quinoline moiety around the N_2Li_2 core due to the coordination of the quinoline and P=N nitrogen atoms (N1 and N18) of one monomer with the lithium cation of the second monomer (Li'). **Dimer-C** is stabilized by 1.1 kcal/mol with respect to **Dimer-A**. It consists of an eight-membered ring with an all-trans distribution of the *t*-Bu and quinoline groups around the ring.[23] This dimerization mode can be described as arising from a ladder structure similar to **Dimer-A**, that underwent ring-opening of the N-P-N-Li metallacycle due to the breaking of N-Li bonds.[24]

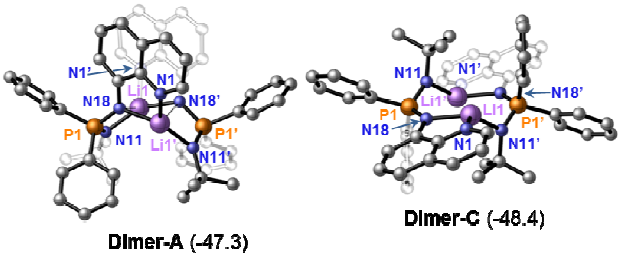

Figure 3 Computed structures of dimers **Dimer-A** and **Dimer-C**. Hydrogen atoms are omitted for clarity. Free energies (in parentheses) are given in kcal/mol with respect to the equation: **Pre-9** → ½**Dimer** + **″BuH**.

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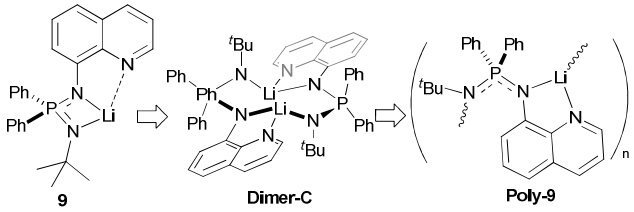
The analysis of the ^{15}N NMR data supports the coordination of all nitrogen atoms of **9** to lithium ions (Table 1). Starting with the substrate **5**, the experimental and calculated ^{15}N chemical shifts match very well for the quinoline nitrogen, whereas the calculated δ(N) for the NPN linkage show a shielding of -27.7 ppm for N11 and -37.8 ppm for N18 (entries 1,2). Although these deviations are significant, the similarity of δ(N) for these two nitrogen atoms is reasonably well estimated. As mentioned above, N-deprotonation produced a large deshielding for N1 and a very small one for N11. The shifts observed are in good agreement with those calculated for **Dimer-C** (entry 11).

The results of the computational study indicate that aggregation of N-lithiated **9** is thermodynamically highly favoured. As shown in **Dimer-A** and **Dimer-C,** the preferred mode of aggregation involves the direct connection of the deprotonated nitrogen N11 to a lithium cation of one monomer and the formation of a five-membered metallacycle through N1,N18 chelation of the lithium ion of a second monomer. This binding mode can be easily transformed into a polymeric structure **Poly-9** (Scheme 5). The existence of a polymeric structure will be consistent with the detection of a single species in either diluted or concentrated THF solutions and with the failure to obtain a crystalline material for X-ray diffraction pointed out by Wang *et al*.[12]



Scheme 5 Preferred structures of aggregates of N-lithiated **9**.

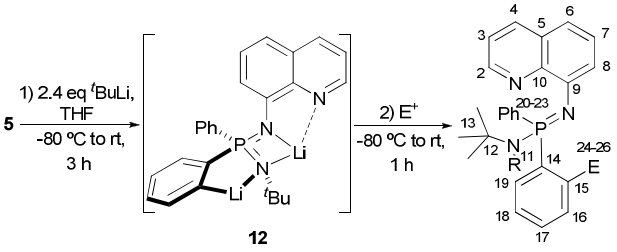
Ortho lithiation of (quinolin-8-yl)phosphinimidic amide 5

Having ascertained the N-H deprotonation of compound **5** by treatment with one equivalent of *n*-BuLi, we decided to investigate the feasibility of its *ortho*-lithiation. Given the similarity between phosphinimidic amides **1** and **5**, we began this study by applying the reaction conditions stablished for the ortho lithiation of **1**.[9,10] Thus, compound **5** was allowed to react with 3 equiv of *t*-BuLi in THF at -90 ºC for 15 h. Subsequently, CD_3OD was added as electrophile for trapping the ortho anion generated. Disappointingly, however, after aqueous workup the ^1H and ^{31}P NMR spectra of the crude reaction mixture showed no evidences of the formation of the ortho-deuterated product. After some experimentation, we found that **5** could be *ortho*-lithiated efficiently by adding 2.4 equiv of *t*-BuLi to a THF solution of the phosphinimidic amide at -80 ºC, allowing the reaction mixture to reach room temperature and continue stirring for 3 h at this temperature (Table 2). Quenching the N,C_{ortho} dianion **12** formed with CD_3OD afforded ortho-deuterated phosphinimidic amide **13** quantitatively (entry 1).

Ortho deuteration of **5** was established based on the analysis of the NMR spectroscopic data of **13**. Key NMR data include the presence of only three protons ortho to the phosphorus in the ^1H NMR spectrum at δ 8.16 ppm, the appearance of a deuterium signal at δ 8.18 ppm in the ^2H NMR spectrum and the triplet of doublets observed at δ 131.3 ppm ($^1J_{CD}$ = 24.9, $^2J_{PC}$ = 8.6 Hz) arising from the deuterated carbon in the $^{13}C\{^1H\}$ jmod spectrum optimized for the detection of quaternary carbons, that collapses into a triplet upon ^{31}P decoupling (Figs 4 and S17). In addition, the introduction of a deuterium atom at the ortho position with respect to the phosphorus induced noticeable isotopic shifts on the adjacent carbons as compared with the P-phenyl ring (e.g., $^1\Delta$(C19-C15) = 300 ppb, $^2\Delta$(C18-C16) = 115 ppb).

Next, we examined the reactivity of dianion **12** toward a variety of electrophiles involving carbon-heteroatom and carbon-carbon bond forming reactions (Table 2). Alkylations via alkyl halides (MeI, allylBr, entries 2, 3), stannylation with Me_3SnCl (entry 4), as well as iodination and hydroxylation through the reaction with 1,2-diiodoethane (entry 5) and dioxygen (entry 6), respectively, provided products **14** – **18** in high yield. In the reaction with MeI as electrophile the product of double methylation at the ortho carbon of a P-phenyl ring and at the amino group was isolated. The desymmetrization of the Ph_2P group of **5** was readily established through the identification in the ^1H and ^{13}C NMR spectra of the expected set of signals for the ortho-disubstituted aromatic ring of **14** – **18** (see experimental). N-Methylation in **14** seems to hinder the rotation of the ortho substituents. Although atropisomers were not observed at room temperature, this restriction to the free rotation produced a significant broadening of the ^1H and ^{13}C NMR signals up to the point that some of the latter were not detected.

Table 2 *Ortho*-lithiation-substitution of **5**.



Entry	Comp	E^+	E	R	Yield (%)[a]
1	**13**	CD_3OD	D	H	98[b]
2	**14**	MeI	Me	Me	49
3	**15**	AllylBr	Allyl	H	58
4	**16**	Me_3SnCl	Me_3Sn	H	67
5	**17**	$(CH_2I)_2$	I	H	98[b]
6	**18**	O_2	OH	H	45

a) Isolated yield. b) Conversion determined from the integrals of the $^{31}P\{^1H\}$ NMR spectra of the crude reaction mixture.

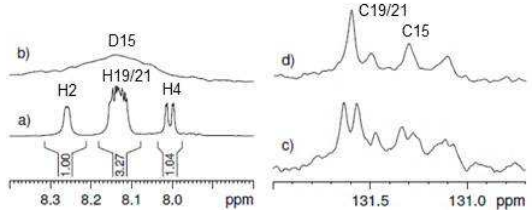


Figure 4 Expansions of NMR spectra of **13** showing the region of the C-D bond: (a) ^1H (500.13) MHz) with integration; (b) ^2H (76.77 MHz); (c) $^{13}C\{^1H\}$ jmod (125.76 MHz) and (d) $^{13}C\{^{31}P,^1H\}$ jmod (125.76 MHz).

The compounds in Table 2 indicate that the D*o*Li methodology developed for phosphinimidic amide **1** can be applied to the quinoline derivative **5** for synthesizing new *ortho*-functionalized derivatives. The use of higher temperatures for the ortho lithiation of **5** suggest that the N-lithiated NPN moiety of species **9** is a weaker DMG than the analogous system of (*R*)-**2**.

Conclusions

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We have shown that, contrary to the ortho-lithiation claimed by Wang and co-workers, (quinolin-8-yl)phosphinimidic amide **5** is quantitatively N-deprotonated by treatment with one equivalent of *n*-BuLi in THF. The structure of the N-lithiated species has been identified on the basis of a multinuclear magnetic resonance and DFT study. The most stable structure found for the complex consists of a dimer in which two lithium atoms bridge the monomers giving rise to an eight-membered ring. In this metallacycle, each lithium is coordinated to the depronated nitrogen of one monomer and chelated by the two nitrogen atoms of the aminoquinoline moiety of the second monomer. These structural features would be also compatible with the existence of a polymeric structure in solution. Ortho-lithiation of **5** has been efficiently achieved by reaction with 2.5 equiv of *t*-BuLi in THF. Trapping of the ortho anion with a series of electrophiles represents a useful route for accessing to new ortho-functionalized derivatives in high yield.

Experimental

Materials and methods

All reactions and manipulations were carried out in a dry N_2 gas atmosphere using standard Schlenk procedures. THF and THF-d_8 were distilled from sodium/benzophenone immediately prior to use. Low temperatures were achieved with a N_2(l)/MeOH bath. Commercial reagents were distilled prior to their use, except alkyllithiums that were used as received. TLC was performed on Merck plates with aluminum backing and silica gel 60 F_{254}. For column chromatography silica gel 60 (40-63 μm) from Scharlau was used.

NMR spectra were measured in a Bruker Avance 300 (^{1}H, 300.13 MHz; ^{13}C, 75.47 MHz; ^{31}P, 121.49 MHz) and a Bruker Avance 500 spectrometer equipped with a third radiofrequency channel (^{1}H, 500.13 MHz; ^{2}H, 76.77 MHz; ^{7}Li, 194.4 MHz; ^{13}C, 125.7 MHz; ^{15}N, 50.7 MHz; ^{31}P, 202.4 MHz). The probes used were a 5 mm QNP ^{1}H/^{13}C/^{19}F/^{31}P probe for the Avance 300 and a pair of direct/inverse 5 mm TBO/TBI ^{1}H/^{31}P/BB triple probes for the Avance 500. The lock channel was used for acquiring the ^{2}H NMR spectrum. The spectral references used were internal tetramethylsilane for ^{1}H/^{2}H and ^{13}C, 1 M LiBr in D_2O for ^{7}Li, $MeNO_2$ for ^{15}N and external 85% H_3PO_4 for ^{31}P. High resolution mass spectra were recorded on Agilent Technologies LC/MSD TOF and HP 1100 MSD instrument using electrospray ionization.

Structural assignments are based on the analysis of the combination of 1D (^{1}H, ^{1}H{^{31}P}, ^{13}C, dept135) and 2D (COSY45, HSQC, HMBC, ^{1}H,^{15}N HMQC, ^{31}P,^{15}N{^{1}H} HMQC[25]) NMR spectra. A set of two complementary ^{31}P/^{7}Li-selective band pass/stop frequency filters was used for the measurement of NMR spectra involving ^{31}P and ^{7}Li nuclei. Standard Bruker software was used for acquisition and processing routines. Resolution enhancement processing through Gaussian multiplication of the FID was applied to resolve the smallest coupling constants. Selected spectral parameters were as follows: ^{7}Li NMR: 16 *K* data points; spectral width 3094 Hz; exponential multiplication with a line broadening factor of 2 Hz. ^{31}P NMR (202.4 MHz): 32 *K* data points; spectral width 5952 Hz; exponential multiplication with a line broadening factor of 2 Hz. The ^{1}H,^{15}N HMQC 2D experiment was performed using spectral widths of 4795 Hz (^{1}H) and 20275 Hz (^{15}N), a final matrix after zero filling of 2048×1024 and an evolution delay of $^nJ_{NH}$ of 63 ms The ^{31}P,^{15}N{^{1}H} HMQC 2D experiment was performed using spectral widths of 15205 Hz (^{15}N) and 5081 Hz (^{31}P), a final matrix after zero filling of 4096×512 and an evolution delay of $^nJ_{PN}$ of 16 ms.

Computational Methods

The geometries of all compounds were optimized with the meta-hybrid density functional M06-2X[26] and a 6-31G(d) basis set in gas phase. Single point energy calculations were performed with the M06-2X functional and a 6-311+G(d,p) basis. The SMD solvation model[27] was used in M06-2X single point energy calculations. THF was used as solvent. All stationary points were characterized as minimum or transition states and checked by vibrational analysis. The reported free energies and enthalpies include zero-point energies and thermal corrections calculated at 233K. As regards to the NMR computations, the ^{15}N chemical shifts were computed using the gauge-including atomic orbital (GIAO) method.[28] All NMR computations were performed at the same level of theory for which the geometry was optimized (M06-2X/6-31G(d) in gas phase). The calculated chemical shifts were obtained by subtracting the shielding constants of ^{15}N from CH_3NO_2 (reference compound). All calculations were performed with Gaussian 09.[29] The 3D structures of molecules were generated using CYLView (http://www.cylview.org)

***N*-(*tert*-butyl)-*P*,*P*-diphenyl-*N'*-(quinolin-8-yl)phosphinimidic amide (5).** Compound **5** was prepared following literature methods (0.87 g, 82%).[12] The NMR characterization has been achieved in THF-d_8 in order to facilitate comparison with the data obtained for the N-lithiated species. ^{1}H NMR (500.13 MHz, THF-d_8) δ 1.05 (s, 9H, H13), 3.76 (bs, 1H, H11), 7.09 (dd, 1H, ^3J = 8.2, 4.1 Hz, H3), 7.10 (dd, 1H, ^3J = 7.7, ^4J = 1.6 Hz, H6), 7.34 (m, 6H, H16, H17), 7.44 (td, 1H, ^3J = 7.7, $^5J_{PH}$ = 1.8 Hz, H7), 7.55 (dd, 1H, ^3J = 7.7, ^4J = 1.6 Hz, H8), 8.01 (dd, 1H, ^3J = 8.2, ^4J = 1.7 Hz, H4), 8.16 (m, 4H, H15), 8.25 (dd, 1H, ^3J = 4.1, ^4J = 1.7 Hz, H2) ppm.^{13}C NMR (125.76 MHz, THF-d_8) δ 32.7 (d, $^3J_{PC}$ = 4.8 Hz, C13), 53.6 (d, $^2J_{PC}$ = 4.1 Hz, C12), 115.5 (C6), 120.9 (C3), 122.8 (d,$^3J_{PC}$ = 28.3 Hz, C8), 128.8 (d, $^3J_{PC}$ = 12.3 Hz, C16), 129.0 (d, $^4J_{PC}$ = 4.0 Hz, C7), 130.7 (d, $^4J_{PC}$ = 2.3 Hz, C17), 131.2 (C5), 132.7 (d, $^2J_{PC}$ = 8.4 Hz, C15), 136.8 (C4), 138.9 (d, $^1J_{PC}$ = 135.0 Hz, C14), 143.7 (d, $^3J_{PC}$ = 8.2 Hz, C10), 145.2 (C2), 151.9 (C9) ppm. ^{15}N NMR (50.67 MHz, THF-d_8) δ -70.2 (N1), -289.5 (d, $^1J_{PN}$ = 22.5 Hz, N18), -297.1 (d, $^1J_{PN}$ = 17.3 Hz, N11), ppm. ^{31}P NMR (202.45 MHz, THF-d_8) δ 0.2 ppm (δ 2.3 ppm in $CDCl_3$).

General procedure for the monolithiation of 5 and NMR sample preparation. To a solution of phosphinimidic amide **5** (120 mg, 0.3 mmol) in dry THF-d_8 (0.5 mL) was added a solution of *n*-BuLi (0.21 mL of a 1.6 M solution in hexanes, 0.33 mmol) at -60 ºC. After stirring for 30 min, 0.5 mL of the reaction mixture were transferred under N_2 atmosphere to a 5 mm NMR tube placed into a refrigerated bath at the same temperature. Subsequently, the sample was transferred to the previously cooled magnet. A very diluted sample was prepared following the same procedure by treating a solution of 12 mg of **5** (0.03 mmol) in 0.4 mL of THF-d_8 with 21 μL of *n*-BuLi (1.6 M solution in hexanes, 0.33 mmol). Complex **9** (data obtained at -40 ºC): ^{1}H NMR (500.13 MHz, THF-d_8) δ 1.33 (s, 9H, H13), 6.80 (d, 1H, ^3J = 8.0 Hz, H6), 7.08 (t, 1H, ^3J = 8.0 Hz, H7), 7.28 (m, 6H, H16, H17), 7.35 (dd, 1H, ^3J = 8.0, 4.2 Hz, H3), 7.52 (m, 1H, H8), 8.09 (m, 5H, H4, H15), 8.55 (dd, 1H, ^3J = 4.2, ^4J = 1.4 Hz, H2) ppm.^{13}C NMR (125.76 MHz, THF-d_8) δ 36.2 (d, $^3J_{PC}$ = 10.5 Hz, C13), 51.9 (d, $^2J_{PC}$ = 2.4 Hz, C12), 111.0 (C6), 119.0 (d, $^3J_{PC}$ = 14.0 Hz, C8), 120.9 (C3), 128.1 (d, $^3J_{PC}$ = 10.8 Hz, C16), 128.9 (C17), 129.2 (C7), 131.1 (C5), 132.8 (d, $^2J_{PC}$ = 8.0 Hz, C15), 137.7 (C4), 143.5 (d, $^1J_{PC}$ = 117.2 Hz, C14), 144.8 (C2), 146.4 (d, $^3J_{PC}$ = 19.9 Hz, C10), 155.4 (C9), ppm. ^{7}Li NMR (194.37 MHz, THF-d_8) δ 2.5 ppm. ^{15}N NMR (50.67 MHz, THF-d_8) δ -96.1 (N1), -300.0 (N11) ppm. ^{31}P NMR (202.45 MHz, THF-d_8) δ -6.1 ppm.

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General procedure for the synthesis of *o*-functionalized phosphinimidic amided (13 - 18). To a solution of phosphinimidic amide **5** (50 mg, 0.13 mmol) in dry THF (1.5 mL) was added a solution of *t*-BuLi (0.2 mL of a 1.7 M solution in cyclohexane; 0.31 mmol; 2.4 eq) at -80 °C. The reaction was allowed to reach room temperature and stirred for 3 h. Then, the corresponding electrophile (0.31 mmol; 2.4 eq) was added at -80 °C and the reaction was allowed to reach room temperature. After stirring for one hour, the reaction was quenched with MeOH (0.5 mL), poured into ice water and extracted with CH_2Cl_2 (3x5 mL). The organic layers were collected together and dried over Na_2SO_4. Solvent evaporation under vacuo afforded a crude reaction mixture from which ^{1}H, ^{1}H{^{31}P}, and ^{31}P{^{1}H} NMR spectra were measured in order to determine the conversion of the process. Purification was achieved by flash column chromatography using a mixture of ethyl acetate:hexanes of 1:4 as eluent. Significant decomposition was observed during purification. The purity of the compounds isolated is ≥95% as determined from their quantitative ^{31}P NMR spectra, except for the ortho-hydroxy derivative **18** which purity is of 90%. Compounds **13** and **17** with conversions of 98% were characterized from the respective crude reaction mixtures.

Compound 13. Yield 98%, oil. ^{1}H NMR (500.13 MHz, $CDCl_3$) δ 1.08 (s, 9H, H13), 3.79 (bs, 1H, H11), 7.11 (dd, 1H, ^3J = 8.2, 4.1 Hz, H3), 7.14 (dd, 1H, ^3J = 7.8, ^4J = 1.4 Hz, H6), 7.37 (m, 6H, H16-H18, H22, H23), 7.49 (td, 1H, ^3J = 7.8, $^5J_{PH}$ = 2.0 Hz, H7), 7.57 (dd, 1H, ^3J = 7.8, ^4J = 1.4 Hz, H8), 8.01 (dd, 1H, ^3J = 8.2, ^4J = 1.8 Hz, H4), 8.13 (m, 3H, H19, H21), 8.26 (dd, 1H, ^3J = 4.1, ^4J = 1.8 Hz, H2) ppm. ^{13}C NMR (125.76 MHz, $CDCl_3$) δ 32.2 (d, $^3J_{PC}$ = 4.9 Hz, C13), 52.7 (d, $^2J_{PC}$ = 3.6 Hz, C12), 114.9 (C6), 120.0 (C3), 121.7 (d, $^3J_{PC}$ = 26.6 Hz, C8), 127.8 (d, $^3J_{PC}$ = 12.4 Hz, C16), 127.9 (d, $^3J_{PC}$ = 12.4 Hz, C18, C22), 128.1 (d, $^4J_{PC}$ = 3.6 Hz, C7), 129.9 (C5), 129.9 (C17, C23), 131.3 (td, $^1J_{CD}$ = 24.9, $^2J_{PC}$ = 8.6 Hz, C15), 131.6 (d, $^2J_{PC}$ = 8.6 Hz, C19, C21), 136.0 (C4), 136.79 (d, $^1J_{PC}$ = 134.3 Hz, C14), 136.85 (d, $^1J_{PC}$ = 134.7 Hz, C20), 142.6 (d, $^3J_{PC}$ = 10.0 Hz, C10), 144.3 (C2), 150.6 (d, $^2J_{PC}$ = 7.0 Hz, C9) ppm. ^{31}P NMR (202.45 MHz, $CDCl_3$) δ 2.3 ppm. ^{2}H NMR (76.77 MHz, $CHCl_3$) δ 8.2 ppm. HRMS (ESI$^+$): calcd. for $C_{25}H_{26}DN_3P$ $[M+H]^+$: 401.2005, found m/z 401.2009.

Compound 14. Yield after chromatography 49%, oil. ^{1}H NMR (500.13 MHz, $CDCl_3$) δ 1.38 (s, 9H, H13), 2.38 (s, 3H, H24), 2.83 (s, 3H, H11), 6.91 (d, 1H, ^3J = 7.7 Hz, H_{Ar}), 7.14 (m, 2H, H_{Ar}), 7.24 (bs, 1H, H3), 7.28 (m, 2H, H_{Ar}), 7.39 (m, 3H, H22, H23), 7.45 (m, 1H_{Ar}), 7.86 (ddd, 1H, $^3J_{PH}$ = 14.1, ^3J = 7.8, ^4J = 1.2 Hz, H19), 7.91 (m, 2H, H21), 8.03 (d, 1H, ^3J = 8.1 Hz, H4), 8.56 (bs, 1H, H2) ppm. ^{13}C NMR (125.76 MHz, $CDCl_3$) (broad and missing lines due to restricted rotation, see text) δ 21.9 (d, $^3J_{PC}$ = 2.8 Hz, C24), 29.5 (d, $^3J_{PC}$ = 2.5 Hz, C13), 33.6 (d, $^2J_{PC}$ = 5.1 Hz, C11), 57.3 (bs, C12), 115.4 (bs, CH), 118.9 (bs, CH), 120.5 (bs, CH), 125.3 (bd, $^3J_{PC}$ = 12.2 Hz, CH), 127.4 (CH), 127.9 (bd, $^3J_{PC}$ = 12.2 Hz, C22), 129.7 (C5), 130.8 (bs, C), 131.9 (d, $^3J_{PC}$ = 11.3 Hz, CH), 132.7 (d, $^2J_{PC}$ = 9.8 Hz, C21), 133.4 (d, $^2J_{PC}$ = 10.5 Hz, CH), 135.7 (CH), 142.2 (d, $^2J_{PC}$ = 9.9 Hz, C15), 146.5 (C2) ppm. ^{31}P NMR (202.45 MHz, $CDCl_3$) δ 14.8 ppm. HRMS (ESI$^+$): calcd. for $C_{27}H_{32}N_3P$ $C_{27}H_{31}N_3P$ $[M+H]^+$ 428,2256, found *m/z* 428.2256.

Compound 15. Yield after chromatography 58%, oil. ^{1}H NMR (500.13 MHz, $CDCl_3$) δ 1.08 (s, 9H, H13), 3.65 (ddq, 1H, ^2J = 15.8, ^3J = 6.8 Hz, ^4J = $^4J_{PH}$ = 1.3 Hz, H24), 3.76 (ddq, 1H, ^2J = 15.8, ^3J = 6.8, ^4J = $^4J_{PH}$ = 1.3 Hz, H24'), 4.06 (bs, 1H, H11), 4.69 (dq, 1H, ^3J = 17.1, ^2J = ^4J = 1.8 Hz, H26^{trans}), 4.73 (ddt, 1H, ^3J = 10.1, ^2J = 1.8, ^4J = 1.3 Hz, H26^{cis}), 5.32 (dddt, 1H, ^3J = 17.1, ^3J = 10.1, ^3J = 6.8, $^5J_{PH}$ = 0.7 Hz, H25), 7.06 (m, 2H, H6, H16), 7.11 (dd, 1H, ^3J = 8.2, ^3J = 4.1 Hz, H3), 7.30 (tt, 1H, ^3J = 7.4, ^4J = $^5J_{PH}$ = 1.5 Hz, H17), 7.34 (tdd, 1H, ^3J = 7.7, $^4J_{PH}$ = 2.6, ^4J = 1.6 Hz, H18), 7.39 – 7.42 (m, 4H, H8, H22, H23), 7.43 (td, 1H, ^3J = 7.6, $^5J_{PH}$ = 1.7 Hz, H7), 7.98 (dd, 1H, ^3J = 8.2, ^4J = 1.7 Hz, H4), 8.14 (m, 2H, H21), 8.27 (dd, 1H, ^3J = 4.1, ^4J = 1.7 Hz, H2), 8.41 (ddd, 1H, ^3J = 7.7, ^4J = 1.5, $^3J_{PH}$ = 11.1 Hz, H19) ppm. ^{13}C NMR (125.76 MHz, $CDCl_3$) δ 32.2 (d, $^3J_{PC}$ = 4.9 Hz, C13), 37.6 (d, $^3J_{PC}$ = 3.2 Hz, C24), 53.0 (d, $^2J_{PC}$ = 4.5 Hz, C12), 114.4 (C6), 115.0 (C26), 120.0 (C3), 121.4 (d, $^3J_{PC}$ = 26.4 Hz, C8), 125.5 (d, $^3J_{PC}$ = 10.4 Hz, C18), 127.7 (d, $^3J_{PC}$ = 12.8 Hz, C22), 128.2 (d, $^4J_{PC}$ = 3.6 Hz, C7), 129.87 (C5), 129.89 (d, $^4J_{PC}$ = 2.2 Hz, C17), 130.1 (d, $^4J_{PC}$ = 2.6 Hz, C23), 130.8 (d, $^3J_{PC}$ = 12.0 Hz, C16), 132.2 (d, $^2J_{PC}$ = 6.3 Hz, C19), 133.1 (d, $^2J_{PC}$ = 9.0 Hz, C21), 135.8 (d, $^1J_{PC}$ = 117.9 Hz, C20), 135.9 (d, $^1J_{PC}$ = 140.9 Hz, C14), 136.0 (C4), 137.5 (C25), 142.65 (d, $^{3/2}J_{PC}$ = 11.6 Hz, C10/C15), 142.74 (d, $^{2/3}J_{PC}$ = 8.8 Hz, C15/C10), 144.2 (C2), 150.6 (C9) ppm. ^{31}P NMR (202.46 MHz, $CDCl_3$) δ 1.4 ppm. HRMS (ESI$^+$): calcd. for $C_{28}H_{31}N_3P$ $[M+H]^+$ 440.2256, found *m/z* 440.2258.

Compound 16. Yield after chromatography 67%, oil. ^{1}H NMR (300.13 MHz, $CDCl_3$) 0.50 (s, 9H, H24), 0.97 (s, 9H, H13), 7.07 (dd, 1H, ^3J = 8.2, 4.1 Hz, H3), 7.12 (dd, 1H, ^3J = 7.8, ^4J = 1.8 Hz, H6), 7.23 (m, 3H, H22, H23), 7.34 (tdd, 1H, ^3J = 7.2, $^4J_{PH}$ = 3.4, ^4J = 1.8 Hz, H18), 7.37 (tt, 1H, ^3J = 7.2, ^4J = $^5J_{PH}$ = 1.7 Hz, H17), 7.48 (td, 1H, ^3J = 7.8, $^5J_{PH}$ = 1.8 Hz, H7), 7.53 (dd, 1H, ^3J = 7.8, ^4J = 1.8 Hz, H8), 7.76 (m, 2H, H21), 7.81 (ddd, 1H, ^3J = 7.2, $^4J_{PH}$ = 3.2, ^4J = 1.8 Hz, H16), 7.97 (dd, 1H, ^3J = 8.2, ^4J = 1.8 Hz, H4), 8.08 (dd, 1H, ^3J = 4.1, ^4J = 1.8 Hz, H2), 8.12 (m, 1H, H19) ppm. ^{13}C NMR (75.46 MHz, $CDCl_3$) δ -3.0 (d,$^4J_{PC}$ = 0.9 Hz, C24), 32.1 (d, $^3J_{PC}$ = 5.2 Hz, C13), 52.7 (d, $^2J_{PC}$ = 4.4 Hz, C12), 115.2 (C6), 119.9 (s, C3), 121.8 (d, $^3J_{PC}$ = 25.3 Hz, C8), 127.4 (d, $^3J_{PC}$ = 14.0 Hz, C18), 128.0 (d, $^4J_{PC}$ = 3.4 Hz, C7), 128.2 (d, $^3J_{PC}$ = 12.2 Hz, C22), 128.96 (d, $^2J_{PC}$ = 8.3 Hz, C21), 128.99 (d, $^4J_{PC}$ = 2.4 Hz, C17/23), 129.04 (d, $^4J_{PC}$ = 2.8 Hz, C23/17), 129.9 (C5), 134.5 (d, $^2J_{PC}$ = 15.3 Hz, C19), 136.2 (C4), 136.6 (d, $^3J_{PC}$ = 15.3 Hz, C16), 140.6 (d, $^1J_{PC}$= 151.6 Hz, C14), 140.6 (d, $^1J_{PC}$ = 119.3 Hz, C20), 142.0 (d, $^3J_{PC}$ = 7.7 Hz, C10), 143.1 (C2), 148.0 (d, $^2J_{PC}$ = 12.8 Hz, C15), 149.7 (d, $^2J_{PC}$ = 7.7 Hz, C9), ppm. ^{31}P NMR (121.49 MHz, $CDCl_3$) δ 9.3 ppm. HRMS (ESI$^+$): calcd. for $C_{28}H_{35}N_3PSn$ $[M+H]^+$ 564.1591, found *m/z* 564.1608.

Compound 17. Yield 98%, oil. ^{1}H NMR (300.13 MHz, $CDCl_3$) δ 1.14 (s, 9H, H13), 3.90 (bs, 1H, H11), 6.99 (dddd, 1H, ^3J = 7.8, ^3J = 7.3, $^5J_{PH}$ = 1.3, ^4J = 1.2 Hz, H17), 7.09 (dd, 1H, ^3J = 5.0, ^3J = 4.5 Hz, H7), 7.14 (dd, 1H, ^3J = 8.2, ^3J = 4.1 Hz, H3), 7.38-7.44 (m, 5H, H6, H8, H22, H23), 7.51 (dddd, 1H, ^3J = 7.9, ^3J = 7.3, $^4J_{PH}$ = 2.3, ^4J = 1.2 Hz, H18), 7.83 (ddd, 1H, ^3J = 7.8, $^4J_{PH}$ = 3.9, ^4J = 1.2, Hz, H16), 7.98 (dd, 1H, ^3J = 8.2, ^4J = 1.7 Hz, H4), 8.10 (m, 2H, H21), 8.38 (dd, ^3J = 4.2, ^4J = 1.7 Hz, 1H, H2), 8.82 (ddd, 1H, $^3J_{PH}$ = 11.0, ^3J = 7.9, ^4J = 1.2 Hz, H19) ppm. ^{13}C NMR (75.46 MHz, $CDCl_3$) δ 32.0 (d, $^3J_{PC}$ = 4.5 Hz, C13), 53.2 (d, $^2J_{PC}$ = 3.8 Hz, C12), 97.9 (d, $^2J_{PC}$ = 8.8 Hz, C15), 115.0 (C7), 120.1 (C3), 121.0 (d, $^3J_{PC}$ = 23.5 Hz, C8), 127.7 (d, $^3J_{PC}$ = 12.4 Hz, C22), 127.9 (d, $^3J_{PC}$ = 14.9 Hz, C18), 128.0 (C6), 129.8 (C5), 130.5 (d, $^4J_{PC}$ = 2.8 Hz, C23), 131.1 (d, $^4J_{PC}$ = 2.5 Hz, C17), 133.2 (d, $^2J_{PC}$ = 9.1 Hz, C21), 133.6 (d, $^1J_{PC}$ = 132.1 Hz, C20), 135.1 (d, $^2J_{PC}$ = 5.4 Hz, C19), 136.0 (C4), 139.7 (d, $^1J_{PC}$ = 127.3 Hz, C14), 142.0 (d, $^3J_{PC}$ = 11.0 Hz, C16), 143.6 (d, $^3J_{PC}$ = 10.2 Hz, C10), 144.9 (C2), 149.8 (bs, C9) ppm. ^{31}P NMR (121.49 MHz, $CDCl_3$) δ 2.4 ppm. HRMS (ESI$^+$): calcd. for $C_{25}H_{26}IN_3P$ $[M+H]^+$ 526.0909, found *m/z* 526.0917.

Compound 18. Yield after chromatography 45%, oil. ^{1}H NMR (300.13 MHz, $CDCl_3$) δ 1.19 (s, 9H, H13), 6.50 (dddd, 1H, ^3J = 8.1, ^3J = 7.0, $^4J_{PH}$ = 3.3, ^4J = 1.0 Hz, H18), 6.90 (ddd, 1H, ^3J = 8.5, $^4J_{PH}$ = 6.0, ^4J = 1.0, Hz, H16), 7.22 (ddd, 1H, $^3J_{PH}$ = 18.2, ^3J = 8.1, ^4J = 1.8 Hz, H19), 7.26 (m, 1H, H17), 7.30 (dd, 1H, ^3J = 7.4, ^4J = 2.2 Hz, H6), 7.36 (dd, 1H, ^3J = 8.3, ^3J = 4.2 Hz, H3), 7.42 (m, 2H, H7, H8), 7.50 (m, 3H, H22, H23), 7.99 (m, 2H, H21), 8.10 (dd, 1H, ^3J = 8.3, ^4J = 1.7 Hz, H4), 8.67 (dd, 1H, ^3J

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= 4.2, ^4J = 1.7 Hz, H2), 13.37 (bs, 1H, H24), ppm. ^{13}C NMR (75.46 MHz, $CDCl_3$) δ 31.8 (d, $^3J_{PC}$ = 5.8 Hz, C13), 53.0 (d, $^2J_{PC}$ = 4.8 Hz, C12), 105.5 (d, $^1J_{PC}$ = 135.1 Hz, C14), 114.9 (d, $^3J_{PC}$ = 14.7 Hz, C18), 117.0 (d, $^3J_{PC}$ = 11.3 Hz, C8), 118.6 (C6), 121.0 (d, $^3J_{PC}$ = 12.6, C16), 121.2 (C3), 127.5 (C7), 129.0 (C5), 129.04 (d, $^3J_{PC}$ = 12.6 Hz, C22), 130.5 (d, $^2J_{PC}$ = 9.9 Hz, C21), 131.8 (d, $^4J_{PC}$ = 2.7 Hz, C23), 132.2 (d, $^2J_{PC}$ = 11.6 Hz, C19), 132.9 (d, $^1J_{PC}$ = 120.4 Hz, C20), 134.0 (d, $^4J_{PC}$ = 2.7 Hz, C17), 136.2 (C4), 140.7 (d, $^3J_{PC}$ = 9.8 Hz, C10), 141.5 (C9), 147.1 (C2), 169.4 (C15) ppm. ^{31}P NMR (121.49 MHz, $CDCl_3$) δ 20.5 ppm. HRMS (ESI^+): calcd. for $C_{25}H_{27}N_3OP$ $[M+H]^+$ 416.1892, found *m/z* 416.1893.

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Notes and references
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Electronic Supplementary Information (ESI) available: NMR spectra of the reported compounds, reaction pathway of NH/CHortho deprotonation, structures of the most stable monomers and dimers computed and Cartesian coordinates of all computed structures are available in the ESI. For ESI data see DOI: 10.1039/b000000x/

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Derivatization of (quinolin-8-yl)phosphinimidic amides via ortho-lithiation revisited

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Graphical Content Entry

The structure of N-lithium $Ph_2P[=N(quinolin\text{-}8\text{-}yl]NH^tBu$ has been established based on a NMR and computational study. Its PC_{ortho}-functionalization is also reported.