Rapid Identification, Enantiomeric Excess, and Concentration Determination Using Simple Racemic Metal Complexes

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Supporting Information

Supplementary Figures

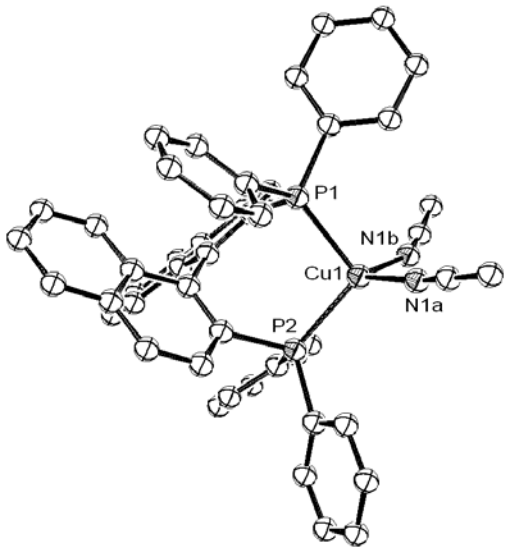


Figure S1. Side view of complex **1** showing a partial atom labeling scheme. Displacement ellipsoids are scaled to 30% probability level. For the sake of clarity hydrogen atoms and PF_6^- ions are not shown.

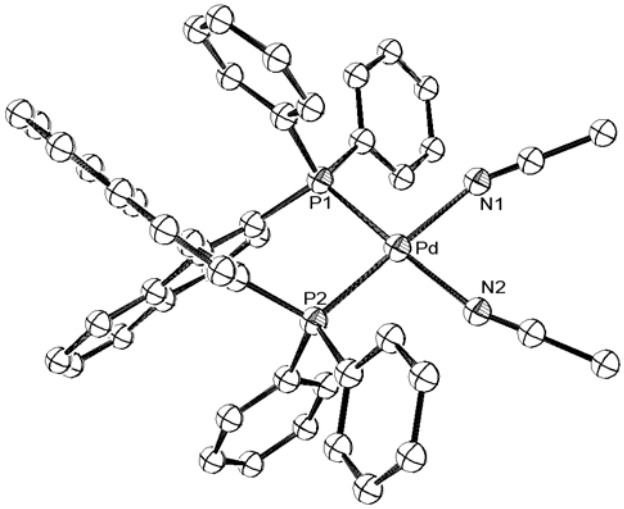
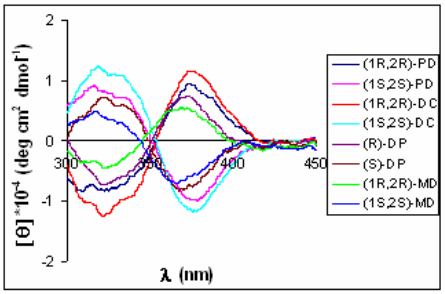


Figure S2. Thermal ellipsoid (30%) plot of the cation $[Pd(NCMe)_2(Binap)]^{2+}$ of compound **2**. For the sake of clarity hydrogen atoms and PF_6^- ions are not shown.

(A)



(B)

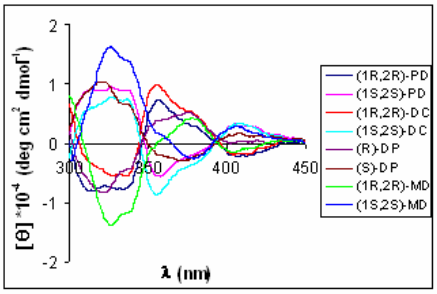
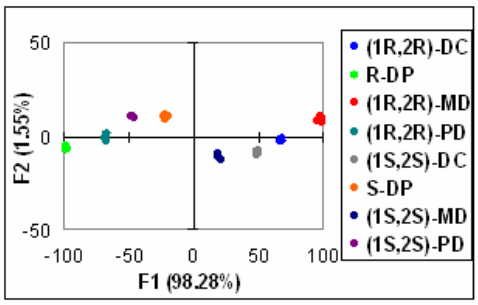


Figure S3. CD spectra for [0.8 mM] analytes and the receptors [0.4 mM]: A) **3**, and B) **4**.

(A)



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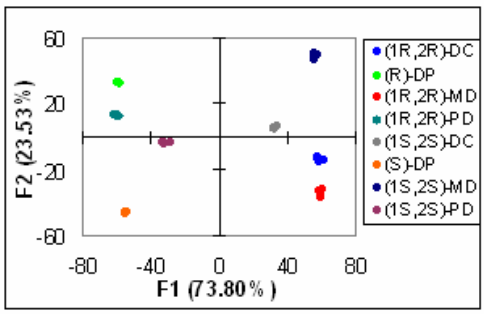


Figure S4. LDA plots obtained with: (A) **3**, and (B) **4** receptor.

Methods

^{1}H NMR and ^{13}C NMR spectra were recorded on a Varian Mercury 400 MHz spectrometer. CD measurements were performed on a Jasco J-815 spectropolarimeter and ASU-605 96 well-plate reader. High-resolution mass spectra were obtained at the University of Texas at Austin, Department of Chemistry and Biochemistry, Mass Spectrometry Facility using FT-ICR-MS-9.4T (Varian, Inc., Paso Alto, CA, USA). Reagents were used as purchased from various commercial sources. Compounds **1** and **3** are known compounds and were prepared by literature methods,[S1-S2] the purity of both compounds was determined by ^{1}H NMR spectra and the identity by high-resolution mass analysis. Compounds **2** and **4** were synthesized (see bellow) and characterized by ^{1}H NMR, ^{13}C NMR spectra and high-resolution mass analysis. The low solubility of the compound **4** does not permit obtain a full ^{13}C NMR spectra.

Experimental details and NMR data:

[Cu(Binap)(NCMe)$_2$][PF$_6$] (1).[S1] [Cu(NCMe)$_4$]PF$_6$ (12 mg, 0.032 mmol) and Binap (20 mg, 0.032 mmol) were used to prepare compound **1**. The crystal employed for the structure determination of (*Rac*)-**1** by X-ray diffraction was obtained by slow diffusion of diethylether into a concentrated solution of (*Rac*)-**1** in acetonitrile. Yield: 96% (28 mg, 0.031 mmol). mp> 200ºC. ^{1}H NMR (400MHz, CD_3CN) δ 7.88 (m, 4H), 7.68-7.61 (m, 10H), 7.38-7.27 (m, 4H), 7.23-7.17 (m, 4H), 7.11-7.06 (m, 2H), 6.80-6.71 (m, 4H), 6.67-6.62 (m, 4H). HR ESI-MS: m/z 685.1270 ± 0.002 (calc for $C_{44}H_{32}CuP_2$: 685.1275).

[Pd(Binap)(NCMe)$_2$][PF$_6$]$_2$ (2). Binap (81 mg, 0.13 mmol) was added to a solution of [PdCl$_2$(NCPh)$_2$] (50 mg, 0.13 mmol) in acetonitrile. After stirring for 15 min $AgPF_6$ (73 mg, 0.29 mmol) was added and the solution was stirred for 1 h. After filtration the

resulting solution was concentrated in vacuo and the addition of diethylether caused the precipitation of **2** as a yellow solid, which was washed with diethylether (2× 20 mL) and dried under vacuum. The crystal employed for the structure determination of (*Rac*)-**2** by X-ray diffraction was obtained by slow diffusion of diethylether into a concentrated solution of (*Rac*)-**2** in acetonitrile. Yield: 78% (112 mg, 0.10 mmol). mp 126ºC. ^{1}H NMR (400MHz, CD_3CN) δ 7.85-7.58 (m, 22H), 7.24-7.13 (m, 4H), 6.93 (m, 4H), 6.70-6.68 (m, 2H). ^{13}C NMR (400MHz, acetone-d_6) δ 140.3 (s), 135.3 (m), 134.9 (s), 133.4 (s), 132.5 (s), 131.4 (s), 130.9 (s), 129.6 (s), 129.4 (s), 129.0 (s), 128.7 (s), 128.1 (s), 127.8 (s), 127.4 (s). (HR ESI-MS: m/z 729.1087 ± 0.002 (calc (M+1) for $C_{44}H_{33}P_2Pd$: 729.1082).

[Cu(Tol-Binap)(NCMe)$_2$][PF$_6$] (3).[S2] Compound **3** was prepared starting from $[Cu(NCMe)_4]PF_6$ (12 mg, 0.032 mmol) and Tol-Binap (22 mg, 0.032 mmol). Yield: 94% (29 mg, 0.030 mmol). mp> 200ºC. ^{1}H NMR (400MHz, CD_3CN) δ 7.80-7.74 (m, 2H), 7.68-7.58 (m, 8H), 7.43-7.22 (m, 6H), 7.11-6.91 (m, 6H), 6.76-6.62 (m, 2H), 6.38-6.31 (m, 4H), 2.41 (s, 12H). HR ESI-MS: m/z 741.1896 ± 0.002 (calc for $C_{48}H_{40}CuP_2$: 741.1901).

[Pd(Tol-Binap)(NCMe)$_2$][PF$_6$]$_2$ (4). This compound was prepared similar than **2**, starting from $[PdCl_2(NCPh)_2]$ (50 mg, 0.13 mmol), Tol-Binap (88 mg, 0.13 mmol) and $AgPF_6$ (73 mg, 0.29 mmol). Yield: 72% (98 mg, 0.09 mmol). mp 133ºC. ^{1}H NMR (400MHz, CD_3CN) δ 7.82-7.41 (m, 20H), 7.27-7.20 (m, 4H), 6.79-6.61 (m, 4H), 2.42 (s, 12H). HR ESI-MS: m/z 785.1713 ± 0.002 (calc (M+1) for $C_{48}H_{41}P_2Pd$: 785.1725).

Chemometrics assays

Solutions with 0.4 mM of receptors and 0.8 mM of analytes in acetonitrile were employed for the LDA analysis. The PCA and ANN experiments were carried out

employing solutions with 0.4 mM of receptors and 0.2 mM, 0.4 mM, 0.8 mM and 1.4 mM of diamines in acetonitrile.

Supplementary notes

Linear Discriminant Analysis (LDA): XLSTAT [S3] was the program used to carry out LDA studies. LDA studies allows for differentiation and classification of the analytes. This kind of analysis reduces the complexity and size of the training and transformed them into roots that are linear combinations of the response patterns. The generalization error of this classification method is measured using Jackknife analysis. The jackknife classification matrix is an iterative method in which one sample pattern at a time is omitted from the LDA and treated as an unknown. The unknown pattern is then classified based on the LDA function generated from the remaining sample patterns.

Principal Component Analysis (PCA): The program used for PCA analysis was XLSTAT[S3]. PCA permits multivariate data to be represented in two-dimensional space. The axes of the PCA plot, which permit to visualize the objects in two-dimensions, are called principal components. The first principal component (PC1) is orthogonal to second principal component (PC2). PC1 is detected according to the direction of the maximum variance and PC2 presents the maximum possible variance.

Artificial Neural Network (ANN): The ANN analyses were carried out employing the program Stadistica Neural Networks 8.0[S4]. The training data consists in four *ee* trainings sets at four different $[G]_t$ values (0.2 mM, 0.4 mM, 0.8 mM and 1.4 mM). The Stadistica Neural Networks program has an embedded intelligent problem solver (IPS) function, which was requested to search for MLP networks with three layers. During learning, output values from the ANN are compared to true values and the coupling weights are

adjusted to give the best network. The hidden activation selected was hyperbolic tangent and the output activation was identity.

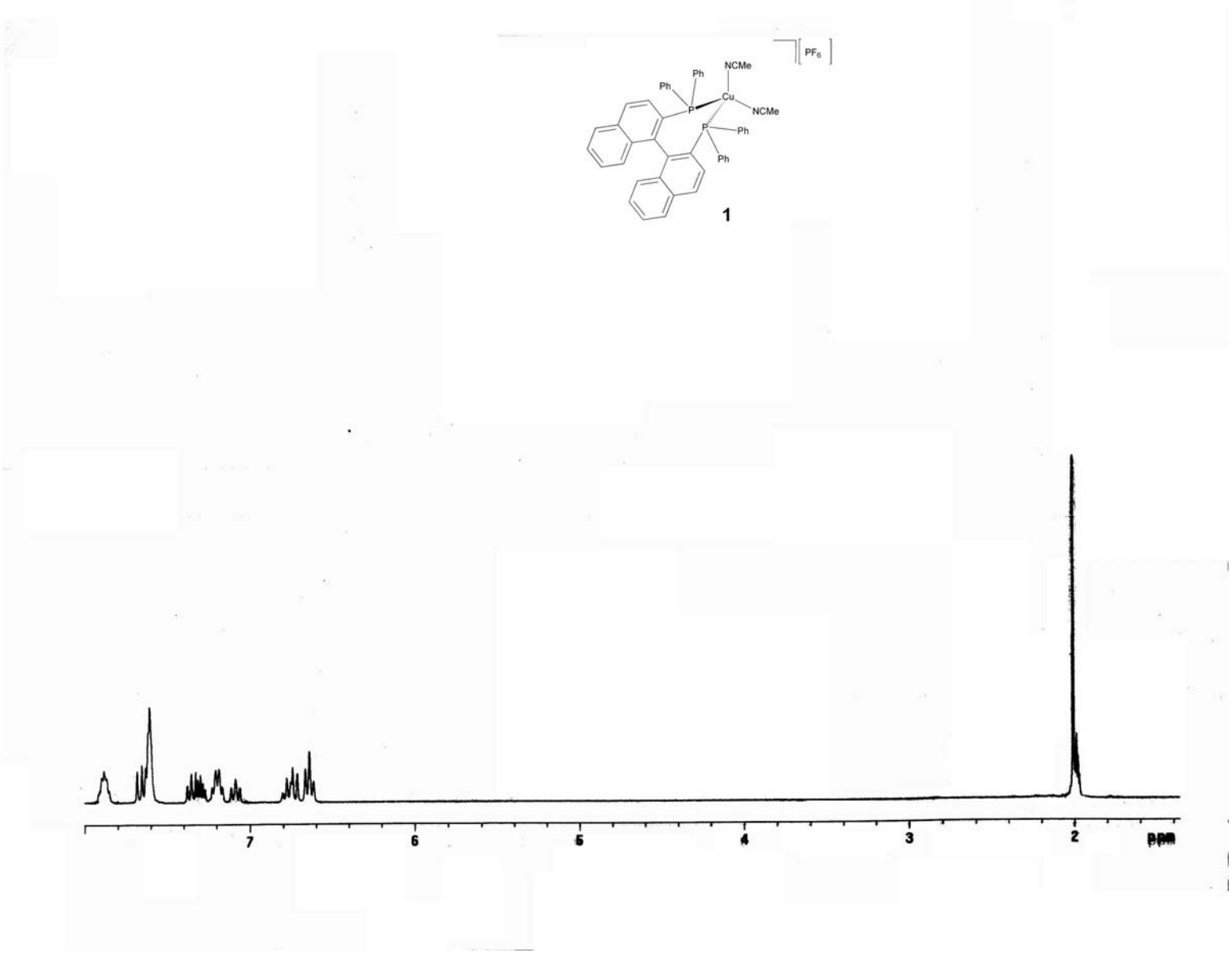
References

S1. (a) Nieto, S.; Lynch, V. M.; Anslyn, E. V.; Kim, H.; Chin, J. *J. Am. Chem. Soc.* **2008**, *130*, 9232. (b) Ferraris, D., Young, B., Dudding, T.; Lectka, T. *J. Am. Chem. Soc.* **1998**, *120*, 4548. (c) Ferraris, D., Young, B., Cox, C., Drury III, W. J., Dudding, T.; Lectka, T. *J. Org. Chem.* **1998**, *63*, 6090.

S2. Yao, S.; Fang, X.; Jorgensen, K. A. *Chem. Commun.* **1998**, 2547-2548.

S3. From xlstat.com

S4. StatSoft, Inc.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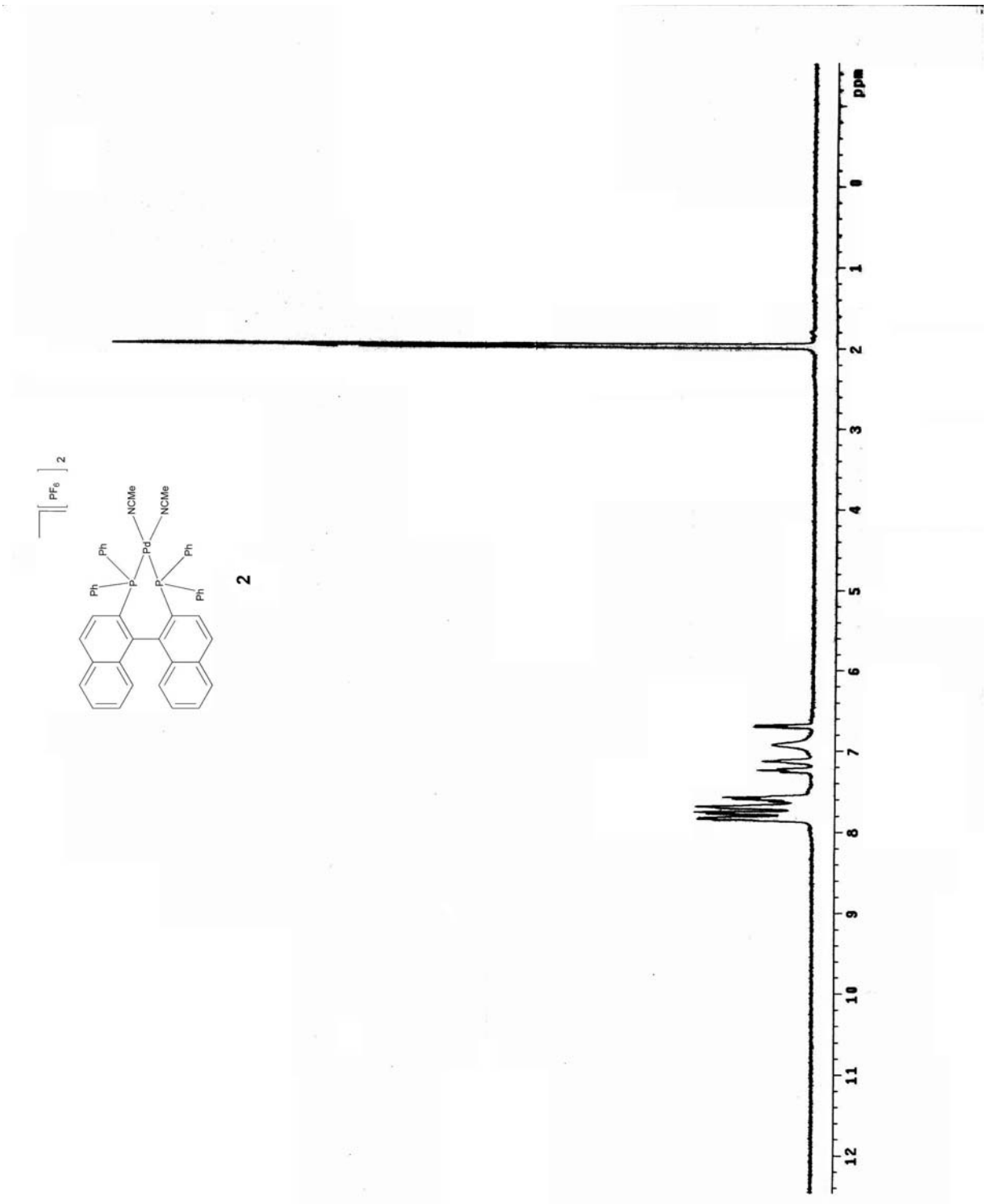
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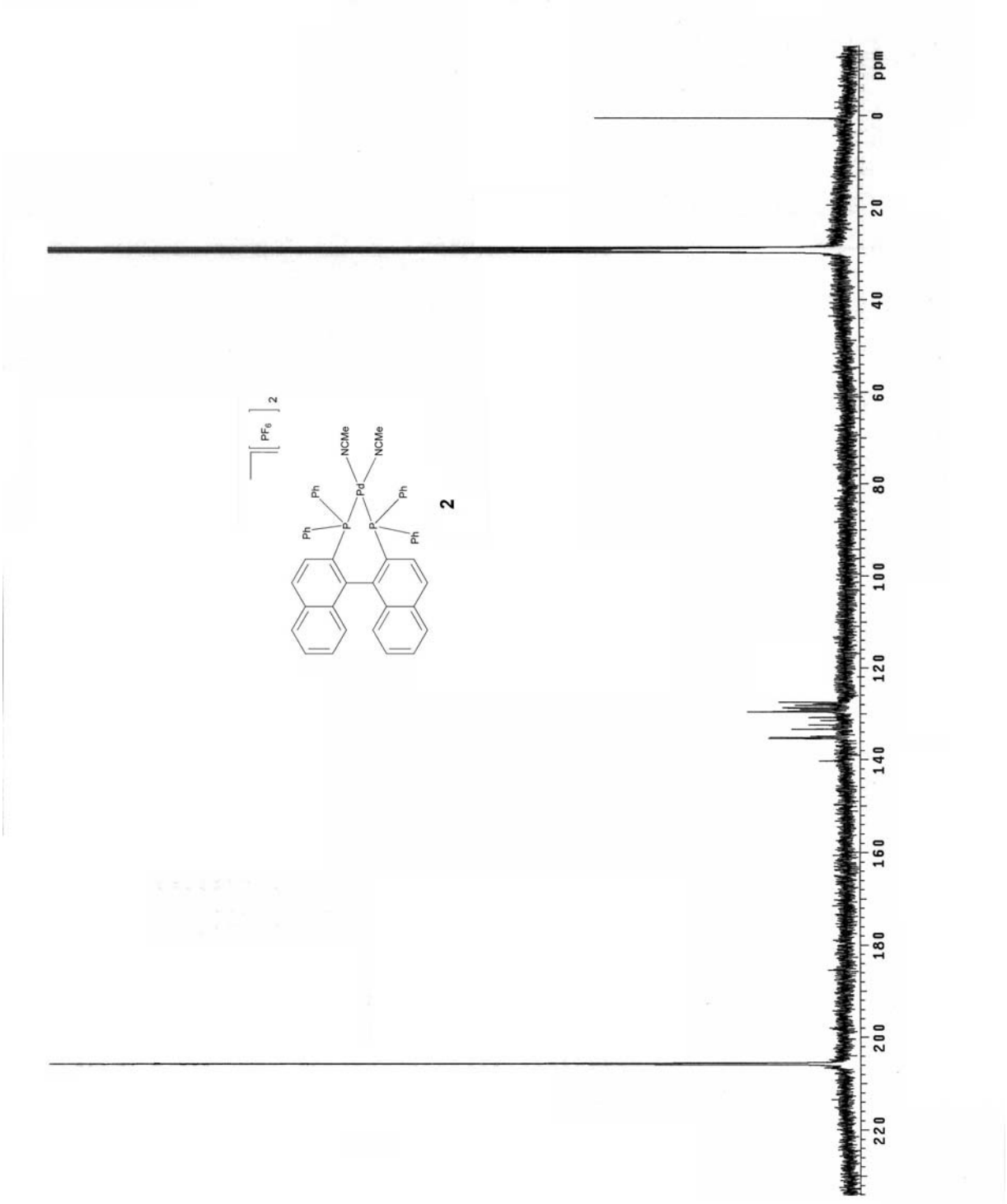
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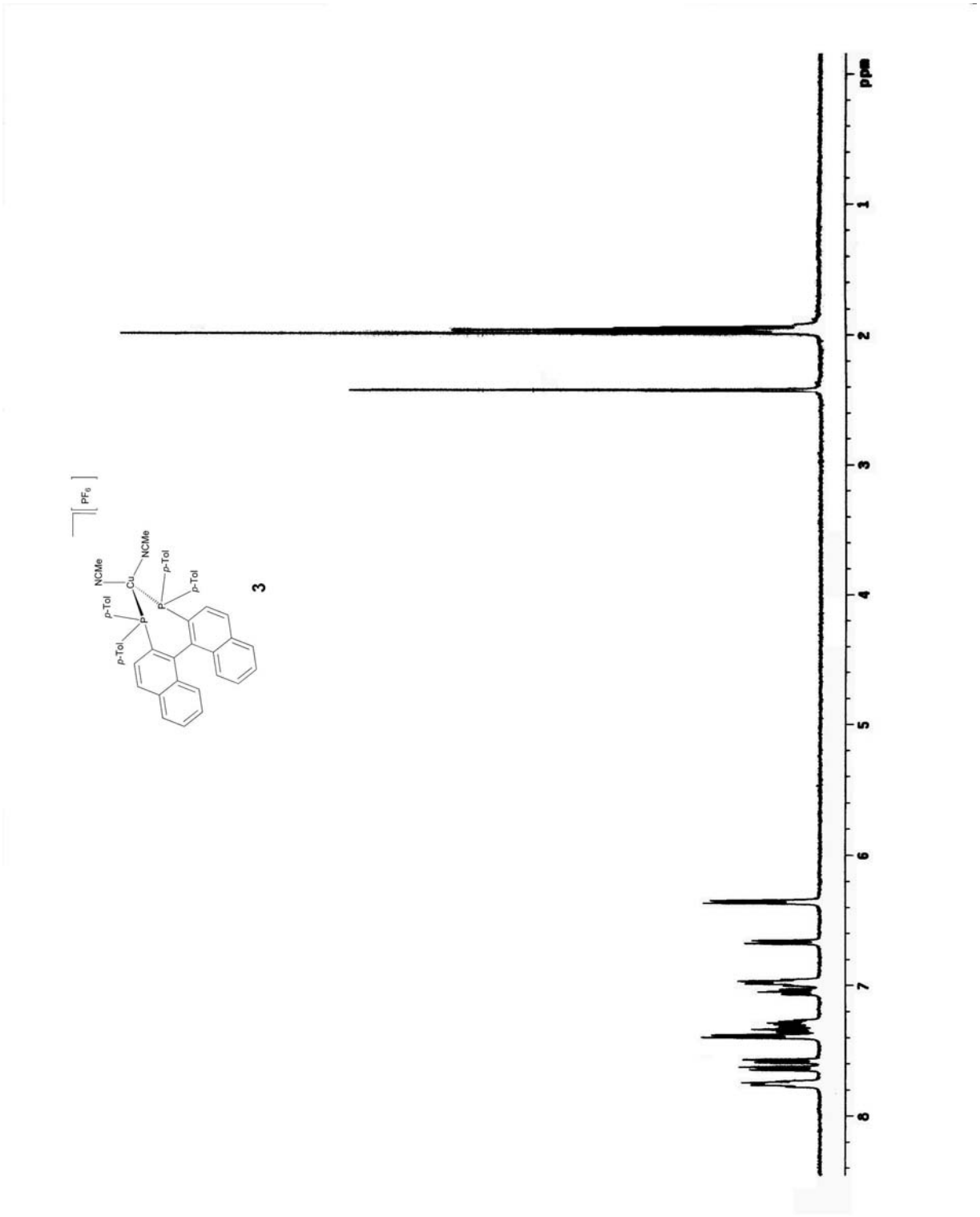
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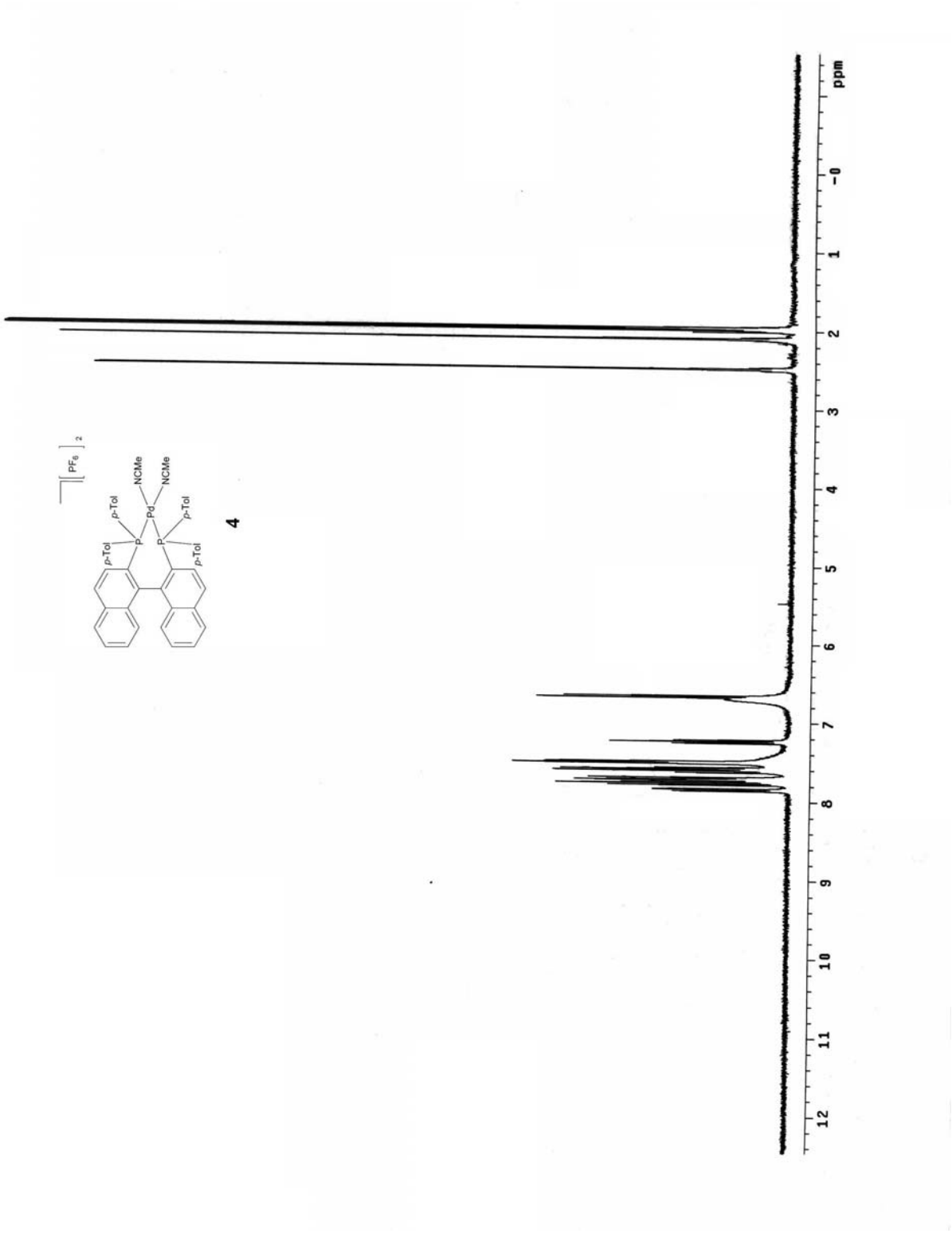
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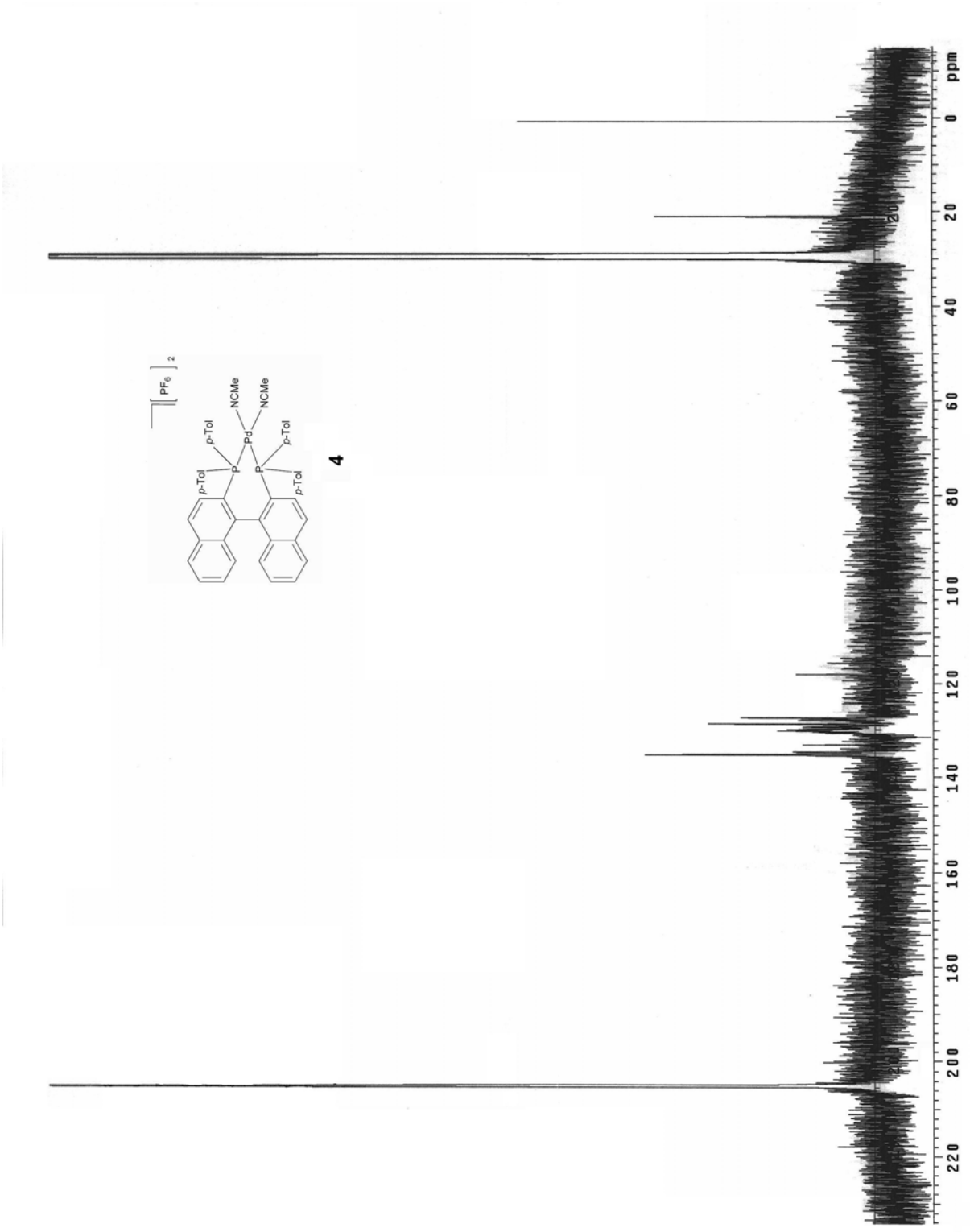
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