Electronic Supplementary Material (ESI) for ChemComm.

SUPPORTING INFORMATION

Step-by-step real time monitoring of a catalytic amination reaction

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Experimental

Tris(dibenzylideneacetone)dipalladium(0) ($Pd_2(dba)_3$), sodium 2′-dicyclohexylphosphino-2,6-dimethoxy-1,1′-biphenyl-3-sulfonate hydrate (sSPhos), aniline (99%), iodobenzene (98%), 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU) (98%), and HPLC grade methanol were purchased from Sigma-Aldrich and used as is unless specified otherwise. UHP200 Argon and HP300 4.8 Nitrogen were purchased from Airgas (Calgary, Canada) and used without further purification.

Preparation of reagents and solvents

All reagent stock solutions were prepared under an inert nitrogen atmosphere in a Schlenk flask or in a glovebox. $Pd_2(dba)_3$ stock solution was prepared using 0.0045 g $Pd_2(dba)_3$ dissolved in 4.0 mL tetrahydrofuran (dried/refluxed over CaH_2 and distilled under N_2) (1.2 mM Pd). sSPhos (sodium 2-dicyclohexylphosphino-2',6'-dimethoxybiphenyl-3'-sulfonate) stock was prepared by dissolving 0.0045g of the salt in 4.0 mL HPLC-grade methanol previously dried over CaH_2 (2.1 mM).

In a typical reaction, 20.0 mL of HPLC-grade methanol previously dried/refluxed over CaH_2 and freshly distilled under N_2, was transferred to a custom Schlenk flask fitted with a condenser,[1] sparged with nitrogen for 15 minutes, and connected to the mass spectrometer via PEEK tubing passed through a rubber septum. Heating was effected with an IKA C-MAG HS 7 stirring hotplate equipped with an ETS-D5 thermocouple and oil bath. The thermocouple was set to heat the oil bath to 80°C. All reagent stock solutions were prepared under an inert nitrogen atmosphere in a glovebox. An aliquot of sSPhos was injected into the flask, followed by $Pd_2(dba)_3$ to initiate the reaction. Iodobenzene was purified by washing 3 times with 10% HCl, followed by a freeze-pump-thaw. The remaining reagents were freeze-pump-thawed, and added stepwise via syringe.

Mass Spectrometry Analysis

All electrospray ionization mass spectra were recorded using a Waters Acquity Triple Quadrupole Detector equipped with a Z-Spray electrospray ionization source. The capillary voltage was held at 3.0 kV, cone voltage at 10.0 V, and extraction cone at 3.0 V. The MS cone voltage was optimized to eliminate in-source fragmentation of the catalyst. The desolvation gas flow rate was 500 L/hr, cone gas flow rate 100 L/hr, source temperature 80°C, desolvation temperature 210°C. The RF lens was set to an optimal voltage of 0.3 V. For full scan experiments, scan time was set to 10 s, with an inter-scan time of 0.1 s and a range of m/z 400-1000. Product ion scans of each intermediate were completed on the triple quadrupole instrument to optimize collision energy for each species such that the fragment ion was observed at its highest possible abundance, with the precursor ion simultaneously observed at a much lower abundance.

These optimized collision energies were then carried through to the MRM experiments, and these were performed with a collision energy between 5-35 V (species dependent) with an argon collision gas flow rate of 0.1 mL/hr. The full MRM parameter list is below in Table 1.

Table 1: MRM scan specifications for each intermediate.

Species	Precursor *m/z*	Product *m/z*	Product *m/z* Identity	Dwell Time (s)	Collision Energy (V)
[sSPhos]$^-$	489	375.4		0.2	35
[Pd(L)(NHPh)(Ph)]$^-$	764.5	595.1	[Pd(L)]$^-$	1.5	5
[Pd(L)(Ph)(I)]$^-$	799	127	[I]$^-$	1.5	20
[Pd(L)(dba)]$^-$	829	595.3	[Pd(L)]$^-$	1.5	25
[Pd(L)(NH_2Ph)(Ph)(I)]$^-$	892	799.2	[Pd(L)(Ph)(I)]$^-$	1.5	7

Calculation of Rate Constants

[Pd(L)(dba)]$^-$
slope = -0.3398, first order therefore $k = 0.3\ s^{-1}$.

[Pd(L)(Ph)(I)]$^-$
slope = -4.3132, pseudo-first-order therefore: $k' = 4.3132(0.0898\ M)$ =/> $0.3873\ s^{-1}$

[Pd(L)(Ph)(I)(NH_2Ph)]$^-$
slope = -3.768, pseudo-first-order therefore: $k' = 3.768(0.1095\ M)$ =/> $0.4126\ s^{-1}$

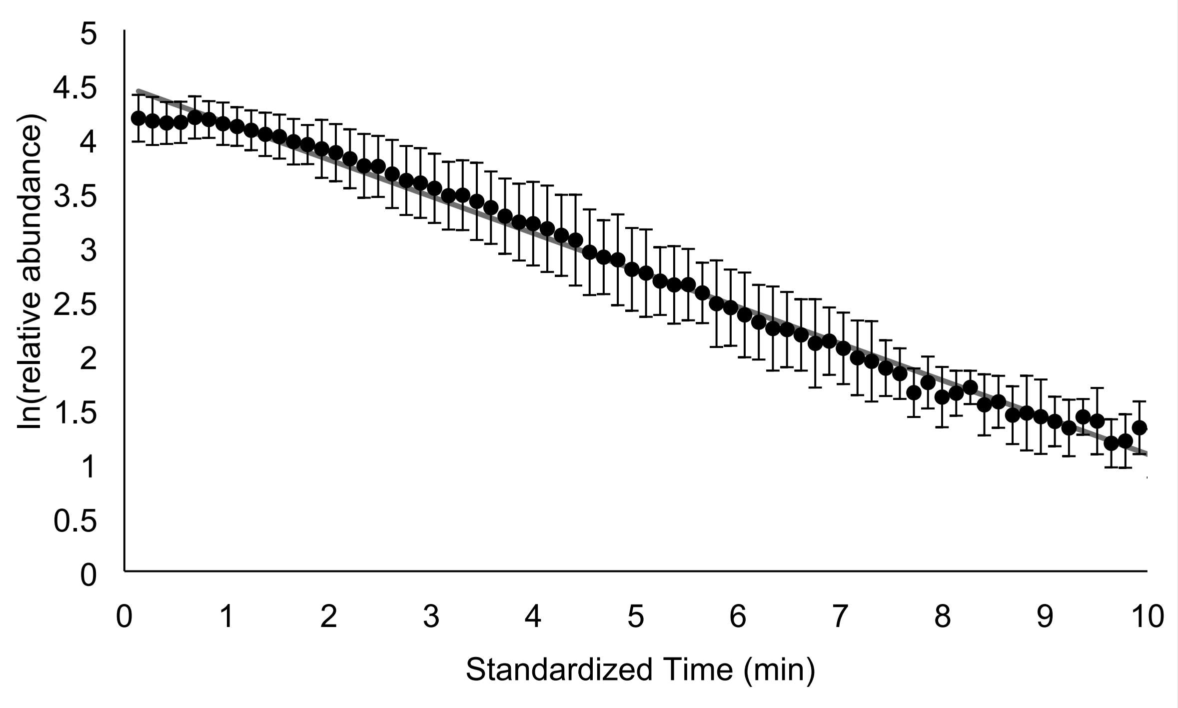

Figure S1: Kinetic plot of ln(relative abundance) vs. standardized time, where relative abundance refers to the $[Pd(sSPhos)(dba)]^-$ species (n=3). Time has been standardized such that t=0 represents addition of $Pd_2(dba)_3$. Kinetic plots for $[Pd(L)(Ph)(I)]^-$ and $[Pd(L)(Ph)(I)(NH_2Ph)]^-$ were constructed in the same fashion.

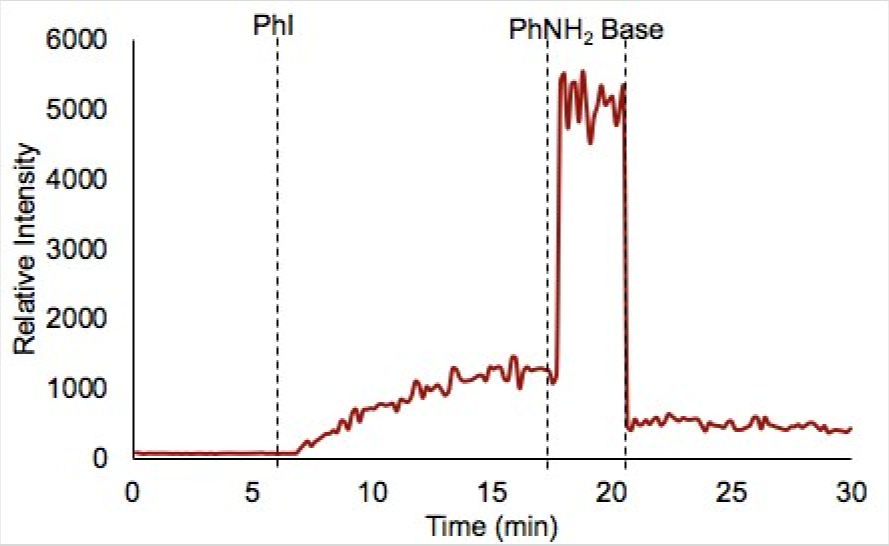

Figure S2: Single ion monitoring scan in positive ion mode, monitoring of the addition of PhI to a solution of Pd(SPhos)(dba), resulting in the formation of $[Pd(SPhos)(Ph)]^+$ (*m/z* 595).

References

1 G. T. Thomas, L. MacGillivray, N. L. Dean, R. L. Stoddard, L. P. E. Yunker and J. S. McIndoe, *Int. J. Mass Spectrom.*, 2019, **441**, 14–18.