

Multiple C–H Bond Activation in Water as a Novel Approach Towards Hexa(heteroaryl)benzene Ligands

Miha Drev, Uroš Grošelj, Jurij Svete, Bogdan Štefane, Franc Požgan

Faculty of Chemistry and Chemical Technology, University of Ljubljana, Večna pot 113, SI-1000 Ljubljana, Slovenia
e-mail: miha.drev@fkkt.uni-lj.si



1. Introduction

Hexaarylbenzene (HAB) derivatives have been found as very attractive organic compounds due to their unique geometry and important role in the creation of liquid crystalline materials, molecular-scale devices¹, molecular receptors, light-harvesting architectures, nano-electronics and nonlinear optics².

2. Optimization of the reaction condition

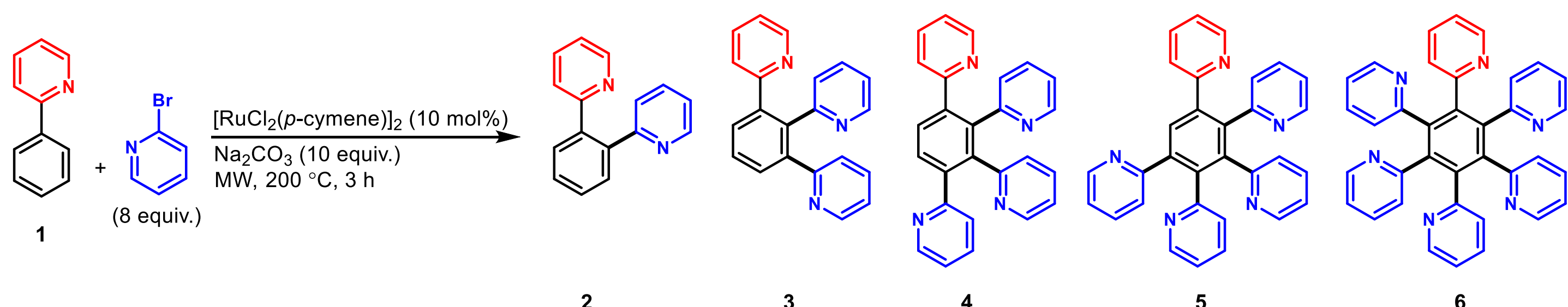


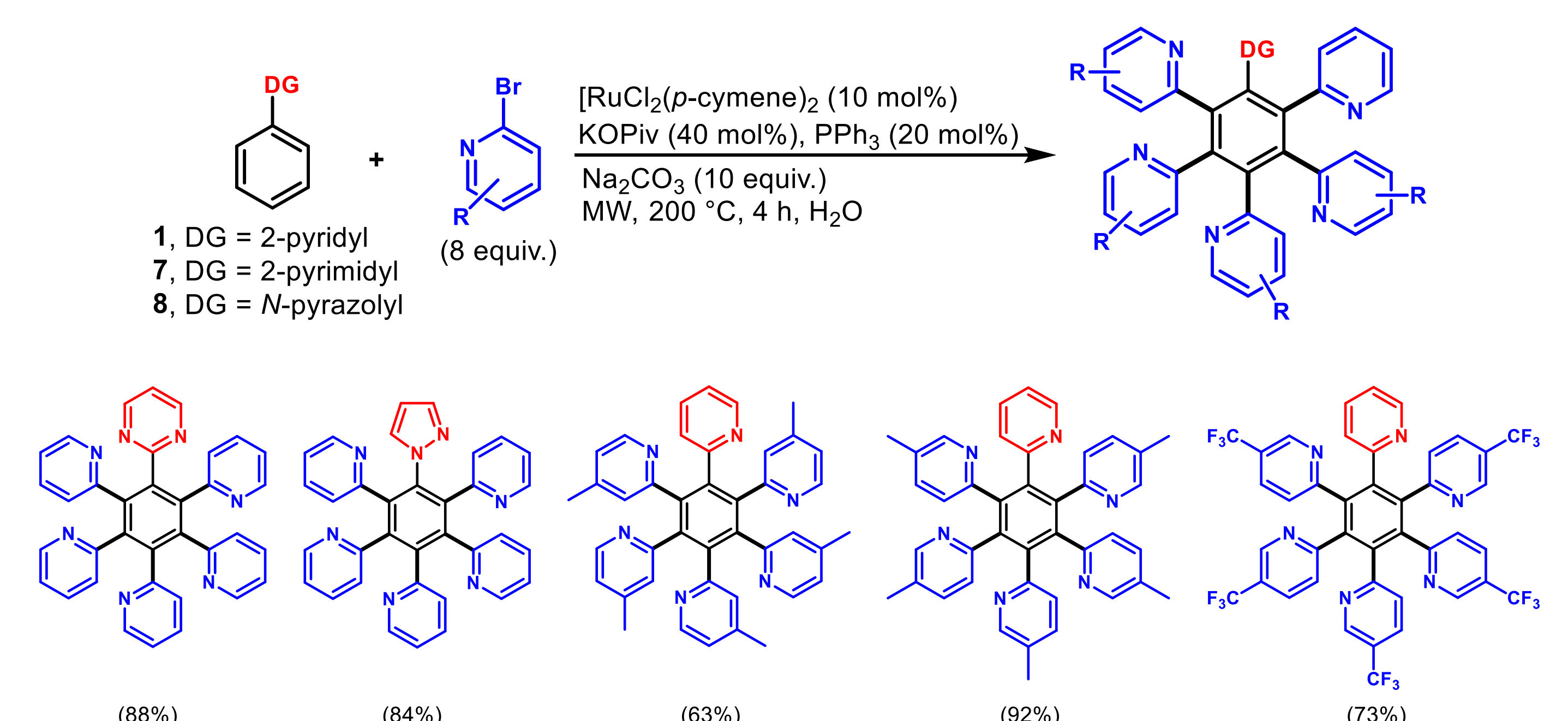
Table 1: Optimization of microwave-assisted C–H bond activation on phenylpyridine.

Entry	Additive (mol%)	Solvent	Conv. ^a (%)	2/3/4/5/6 ^a
1	–	H ₂ O	92	14/17/9/7/53
2	KOPiv (20)/PPh ₃ (10)	H ₂ O	97	2/3/3/7/85
3 ^b	KOPiv (20)/PPh ₃ (10)	H ₂ O	100	20/19/15/18/28
4	KOPiv (40)/PPh₃ (20)	H₂O	100	0/0/0/0/100; 6 (70%)^c(97%)^d
6 ^e	KOPiv (40)/PPh ₃ (20)	H ₂ O	100	13/13/10/34/30
7	KOPiv (40)/PPh ₃ (20)	1,4-dioxane	100	8/7/8/15/62
8	KOPiv (40)/PPh ₃ (20)	NMP	80	47/23/14/4/12

Reagents and conditions: **1** (0.25 mmol), 2-bromopyridine (2 mmol), [RuCl₂(*p*-cymene)]₂ (0.025 mmol), Na₂CO₃ (2.5 mmol), solvent (1 mL), argon. ^aConversion and ratio determined by ¹H NMR analysis. ^b5 mol% of [RuCl₂(*p*-cymene)]₂ used. ^cIsolated yield by radial chromatography. ^dPerformed on 1 mmol of **1** and isolated yield by precipitation from EtOAc. ^eConventional heating at 200 °C. MW = microwave heating

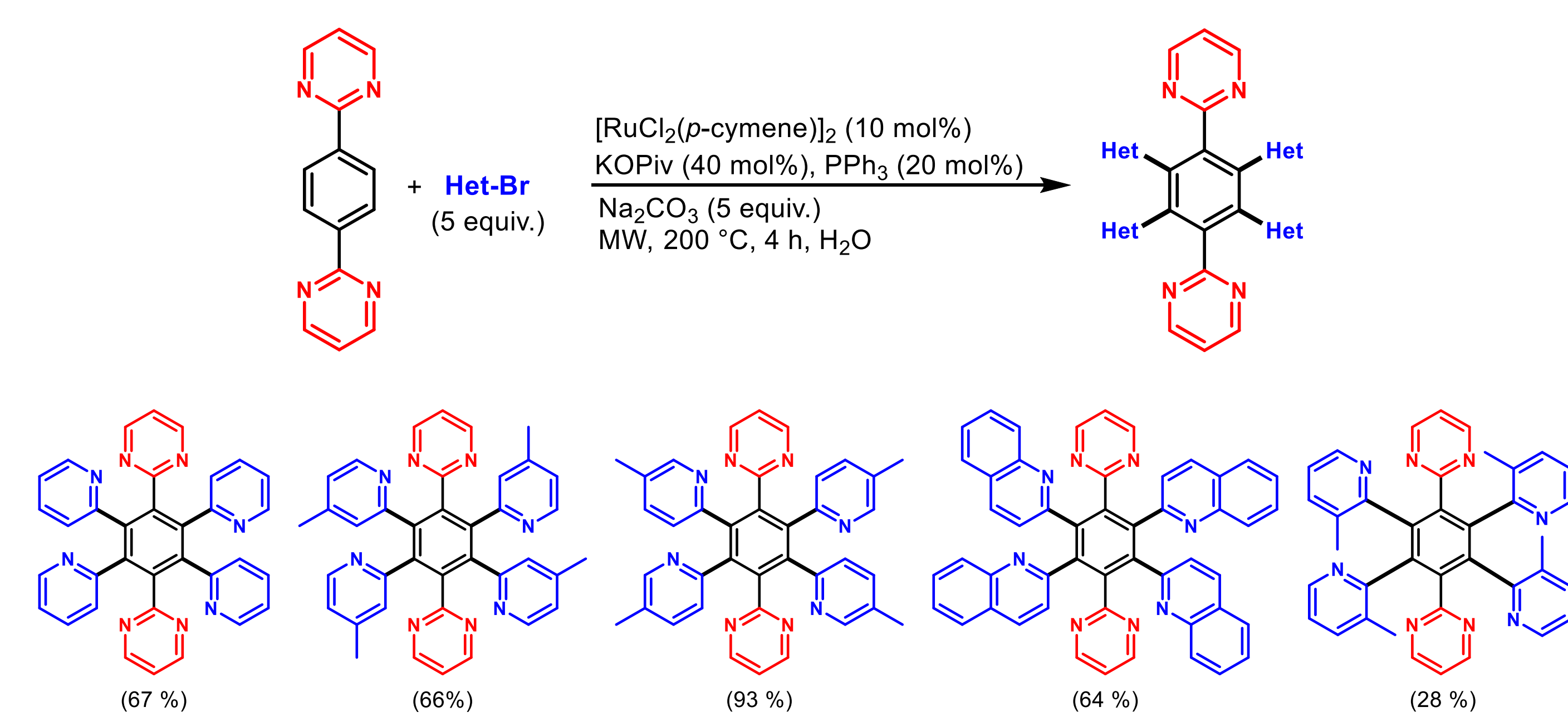
We initiated our study with the reaction of 2-phenylpyridine (**1**) with an excess of 2-bromopyridine (8 equiv.) in the presence of a base Na₂CO₃ and 10 mol% of [RuCl₂(*p*-cymene)]₂ at 200 °C for 3 h in water under microwave heating which gave a mixture of multiarylated products with predominant formation of hexa(2-pyridyl)benzene (**6**). The penta-arylation selectivity significantly improved by employing a combination of KOPiv (20 mol%) and PPh₃ (10 mol%) while lowering the Ru(II) catalyst loading to 5 mol% dramatically affected selectivity. Finally, we were pleased to find that the catalyst system comprising [RuCl₂(*p*-cymene)]₂ (10 mol%), KOPiv (40 mol%), and PPh₃ (20 mol%) gave the best result, furnishing the product **6** with quantitative selectivity.

3. Iterative C–H activation of heteroarylbenzenes.



Reaction conditions: **1**, **7**, or **8** (0.25 mmol), bromopyridine (2 mmol), [RuCl₂(*p*-cymene)]₂ (0.025 mmol), Na₂CO₃ (2.5 mmol), KOPiv (0.1 mmol), PPh₃ (0.05 mmol), H₂O (1 mL), argon, MW 200 °C, 4 h.

4. Tetra-C–H arylation of bispyrimidylbenzene.



Reaction conditions: 1,4-di(2-pyrimidyl)benzene (0.25 mmol), Het-Br (1.25 mmol), [RuCl₂(*p*-cymene)]₂ (0.025 mmol), Na₂CO₃ (1.25 mmol), KOPiv (0.1 mmol), PPh₃ (0.05 mmol), H₂O (1 mL), argon, MW 200 °C, 4 h.

5. Complexation of hexa(2-pyridyl)benzene

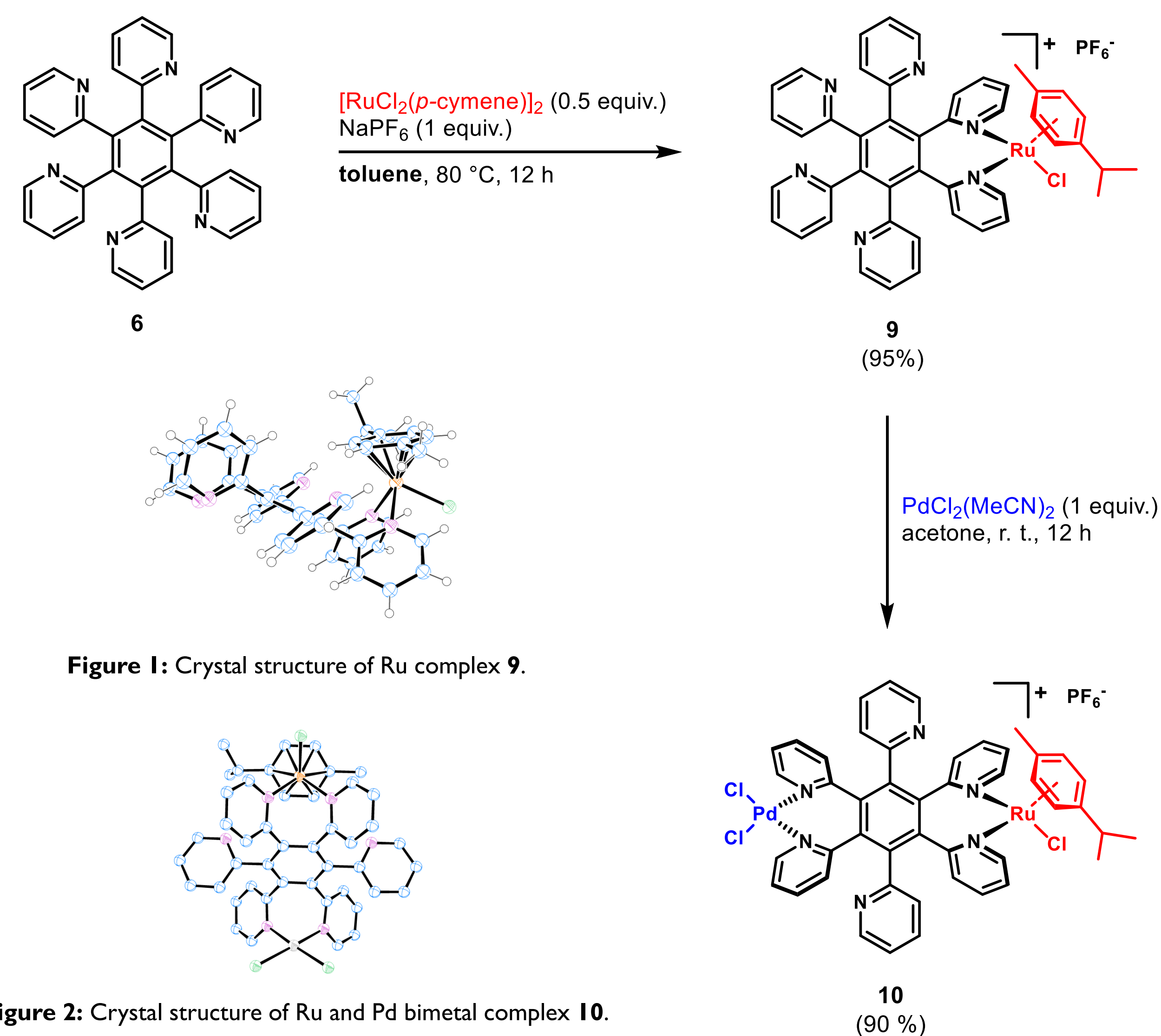


Figure 1: Crystal structure of Ru complex **9**.

Figure 2: Crystal structure of Ru and Pd bimetal complex **10**.

We preliminary explored coordination ability of HHABs to form multinuclear complexes with selected transition metals. The reaction of **6** with [RuCl₂(*p*-cymene)]₂ and NaPF₆ in toluene at 80 °C resulted in the formation of a cationic Ru(II) complex **9** with one coordinated ruthenium atom binding two vicinal pyridine nitrogen atoms. Furthermore, the reaction between monoruthenium complex **9** and a PdCl₂(MeCN)₂ as precursor in acetone at room temperature lead to bimetallic complexes **10**.

6. Conclusion

We developed an effective and highly selective method for the synthesis of hexa(heteroaryl)benzenes and showed that compound **9** can coordinate Ru(II) as well as Pd(II) in a single bimetallic complex.

7. References

- Vij, V.; Bhalla, V.; Kumar, M. *Chem. Rev.*, **2016**, *116*, 9565
- Lungerich, D.; Reger, D.; Hölzel, H.; Riedel R.; Martin, M. M. J. C.; Hampel, F.; Jux, N. *Angew. Chem. Int. Ed.*, **2016**, *55*, 5602