

Homogeneous computational catalysis: the mechanism for cross-coupling and other C-C bond formation processes

Feliu Maseras

Institute of Chemical Research of Catalonia (ICIQ), 43007 Tarragona, Catalonia, Spain

The last years have witnessed substantial advances in the application of computational chemistry to the determination of the complex reaction mechanisms operating in homogeneous catalysis, thanks mostly to the development of new computational methods and to the ever increasing power of modern computers. In this presentation we will summarize some of our recent results for transition metal-catalyzed reactions of C-C bond formation [1-5], where we have applied standard DFT and DFT/MM computational techniques.

Cross-coupling reactions are among the most widely used methods for the formation of carbon-carbon bonds, and are thus a fundamental tool in organic synthesis. Most cross-coupling processes respond to the general formula:



where R and R' are organic groups and X is a good leaving group. These reactions are usually catalyzed by transition metal complexes, often containing palladium. The Y group is usually attached to R' through an electropositive atom. The nature of Y decides the particular name of the cross-coupling reaction. The optimal reaction conditions depend heavily on the Y group, and the detailed mechanisms are difficult to access from purely experimental techniques. We have applied our computational approaches to the study of the mechanism of the Suzuki-Miyaura (where R'-Y is an organoboronic acid) [1, 2] and Stille (where R'-Y is an organotin species) [3] reactions.

Arylation reactions lead also to the formation of C-C bonds. They are related to cross-coupling processes because they respond to the general equation presented above, with R equal to aryl and Y equal to hydrogen. The reaction mechanism is however different, and the least understood aspect has been traditionally the nature of the C-H activation step. Our computational studies on the problem have helped the identification of this step as a proton abstraction process by an external base [4, 5].

The joint application of theoretical and experimental chemistry to the clarification of complex reaction mechanisms opens the way to the development of better reaction conditions, and to the design of more efficient catalysts.

References

- 1 A. A. C. Braga, N. H. Morgon, G. Ujaque, F. Maseras; *J. Am. Chem. Soc.*, **127**, 9298 (2005).
- 2 A. A. C. Braga, G. Ujaque, F. Maseras; *Organometallics*, **25**, 3647 (2006).
- 3 A. Nova, G. Ujaque, F. Maseras, A. Lledós, P. Espinet; *J. Am. Chem. Soc.*, **128**, 14571 (2006).
- 4 D. García-Cuadrado, A. A. C. Braga, F. Maseras, A. M. Echavarren; *J. Am. Chem. Soc.*, **128**, 1066 (2006).
- 5 D. García-Cuadrado, P. de Mendoza, A. A. C. Braga, F. Maseras, A. M. Echavarren; *J. Am. Chem. Soc.*, **129**, 6880 (2007).