

# Abstract

Mass spectrometry, ion spectroscopy, NMR and quantum-chemical calculations are commonly combined to study the structures, properties and reactivity of intermediates in metal-catalyzed reactions. However, our ability to identify the main species present in solution by electrospray ionization mass spectrometry (ESI-MS) and to confirm whether these species are indeed reactive intermediates involved in the study reactions remains limited. Thus, we developed a new method combining isotope labeling with kinetic data extraction for the identification and analysis of intermediates in reaction mixtures termed delayed reactant labeling (DRL). Accordingly, this thesis is divided into 5 Chapters. Chapter 1 gives an overview of ESI-MS as a tool for studying the mechanisms of metal-catalyzed reactions, focusing on gold chemistry. Chapter 2 describes the experimental (ESI-MS, ion spectroscopy and gas chromatography) and theoretical (DFT) methods used in this thesis and the corresponding instrumentation. Chapter 3 details the development of the delayed reactant labeling (DRL) as a technique for studying reaction kinetics by mass spectrometry and examples how it was used to investigate problems in the following chapter. Chapter 4, shows that a Au(I) complex can act as a strong base in a solution containing water via the formation of a digold hydroxide complex  $[(L)_2Au_2OH]^+$  (L= ligand). This complex activates acetone to form digold-acetonyl complexes  $[(L)_2Au_2(CH_2COCH_3)]^+$ . The formation of digold hydroxide is the essential first step towards the formation of the digold acetonyl complex, as shown by experiments with Au(I) catalysts bearing different ligands and by the effect of counter ions. The role of gold-gold interactions is fundamental for acetone activation, and DFT calculations suggested that the reaction mechanism of the C–H activation reaction involves a dimer of gold complexes bound via gold–gold interactions. Chapter 5 reports the results from our investigation into intermediates of water addition to alkynes catalyzed by Au(I). Whether monoaurated or diaurated intermediates are involved in this transformation has long been a subject of debate. Yet, by studying this reaction with different alkynes, we successfully showed that these two intermediates are actually species with a very similar or the same kinetics in solution. Kinetic analysis, by both DRL and gas chromatography of the overall reaction, showed a first-order reaction rate variation as a function of the gold catalyst concentration, thereby further supporting a reaction mechanism which proceeds exclusively via monoaurated neutral  $\alpha$ -gold ketone intermediates. Therefore, our experimental paradigm based on DRL enhances the robustness of ESI-MS in identifying reaction intermediates while simultaneously assisting in solving scientific controversies.