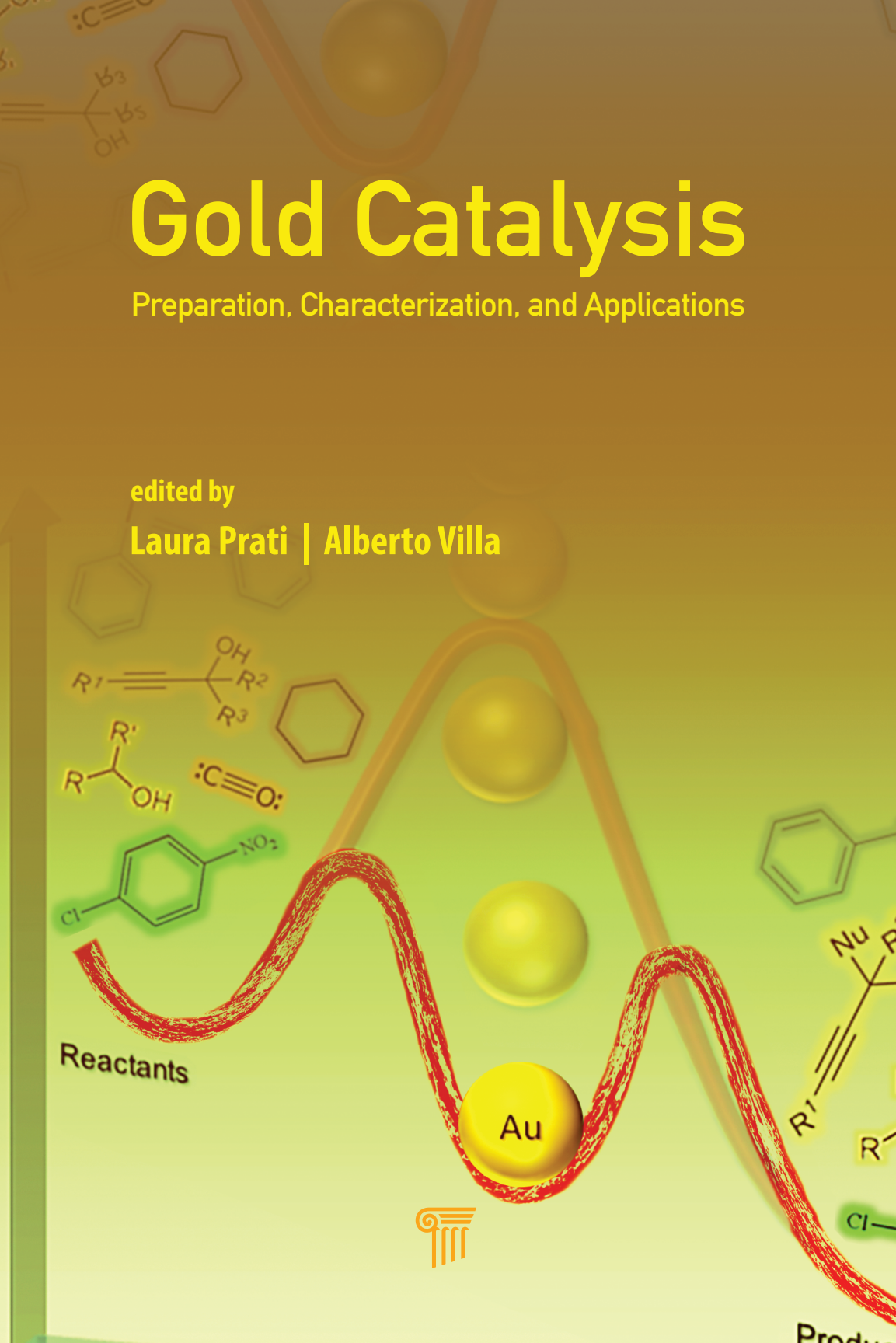
# Gold Catalysis

## Preparation, Characterization, and Applications

edited by
Laura Prati | Alberto Villa



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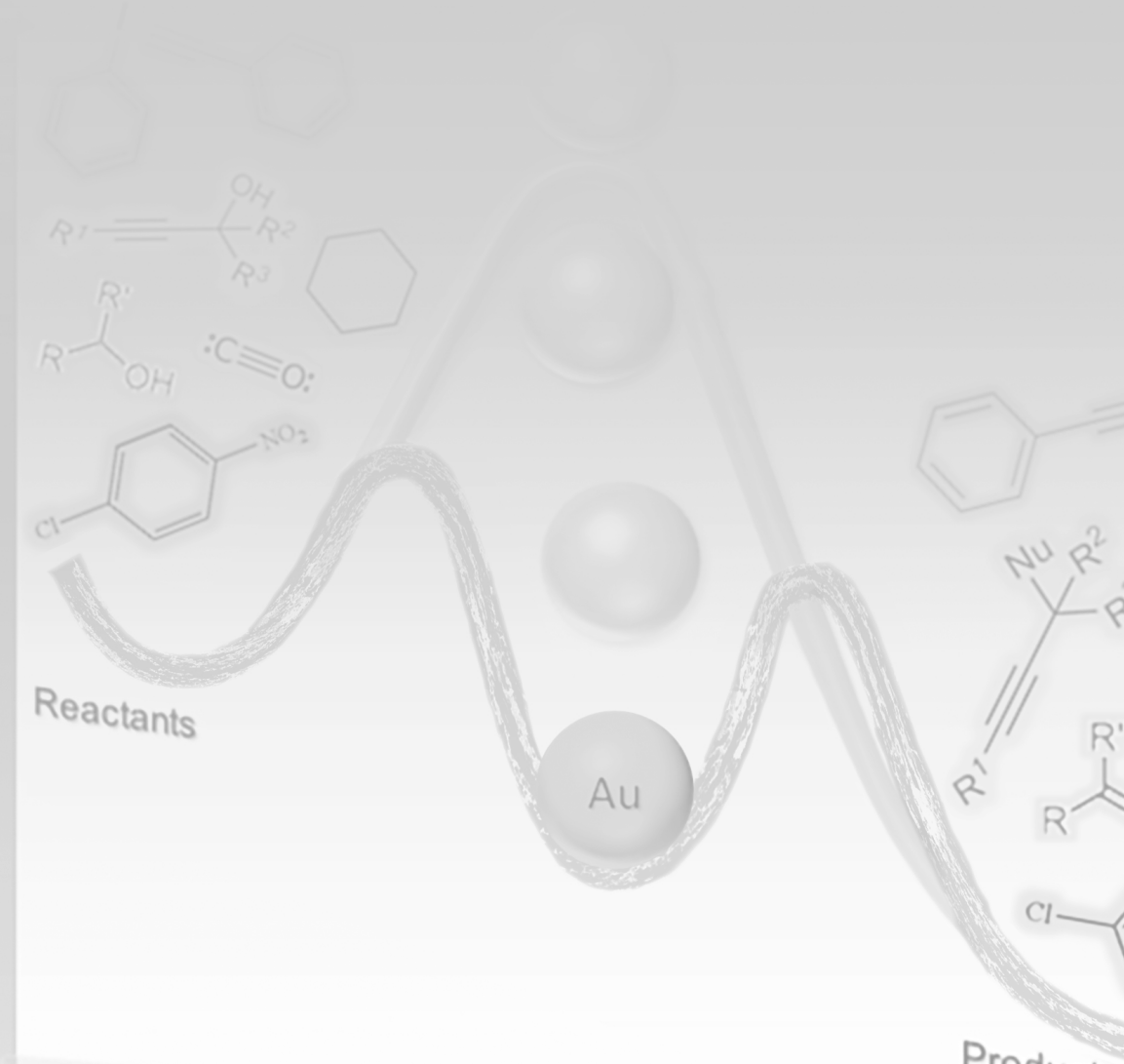

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# Preface

Gold has always been recognized as a metal with special properties. Since ancient times gold has been used as a jewel, as a decorative material, or as a metal with therapeutic actions. More recently a new field of application of this extraordinary metal appears related to its characteristics as a catalytic material. Indeed, since the discovery in 1988 of its activity in two fundamental reactions—the oxidation of CO to $CO_2$ (Haruta) and the hydrochlorination of ethylene (Hutchings)—many studies and a constant growth of literature citations deal with this metal.

The discovery and the subsequent success of gold as a catalytically active metal were due to the discovery of suitable methods of obtaining finely dispersed nanoparticles. This is the main reason why the preparation for obtaining an active gold-based catalyst is so important. Gold is a metal with a relatively low melting point, especially if compared to the most used palladium and platinum. Therefore, it is difficult to disperse gold, especially at the nanoscale, the useful dimension in catalysis. The difficulties and trials devoted to obtaining highly dispersed gold catalysts are discussed in the first part of this book (Chapters 1–5) by experts of recognized reputation in this specific field. In particular Chapter 1 deals with the deposition-reduction method, which constitutes the historical method for gold catalyst synthesis. Chapter 2 presents the basis of one of the emerging techniques (sol immobilization) based on the use of preformed gold nanoparticles, whereas Chapter 3 deals with nascent nanoparticles trapped on a matrix (SMAD). A different approach for controlling the particle growth with the use of exotemplates is reported in Chapter 4. Many other methods that have led to excellent catalytic results are summarized in Chapter

5, which gives a comprehensive overview of the currently available methodologies.

The second part of the book is dedicated to characterization, where both surface and bulk techniques are presented. Actually there is not a single technique able to answer all the questions related to the possible correlation between structure and activity or disclose the real structure of gold catalysts under operative conditions. This section helps to understand the possibilities that different techniques offer from both a structural and a reactivity point of view. Structural problems solved by transmission electron microscopy (Chapter 6) and X-ray photoelectron spectroscopy (Chapter 7) related to gold catalysts are presented by experts in the field. Moreover, insights into the comprehension of real active sites are shown by the use of the interaction between gold active sites and molecular probes. It is the case of infrared studies (Chapter 8) as well as selective chemisorption (Chapter 9) that is able to provide information about the chemical activity of the systems.

The third part of the book is obviously devoted to the main gold catalytic applications, and we proudly present contributions of the founders of this chemistry, Prof. Masatake Haruta and Prof. Graham J. Hutchings, together with other leading exponents in the field. From Chapter 10 to Chapter 14 updated and still challenging applications of heterogeneous gold catalysts are shown: CO oxidation (Chapter 10), a well-studied reaction not yet completely understood; C–H activation (Chapter 11), a challenging application not only for gold but also where gold could be peculiar; oxidation reactions in the liquid phase (Chapter 12), where gold catalysts showed enhanced properties compared to classical oxidation catalysts; coupling reactions (Chapter 13), where gold catalysts represent one of the few examples of really heterogeneous catalysts; and hydrogenation reactions (Chapter 14), where gold is able to impart to the catalyst peculiarities in terms of selectivity.

The last chapter (Chapter 15) differs from the others because it presents the catalytic uses of gold in the homogeneous phase. The chapter is presented by one of the most important figures in the field, Prof. Hashmi, and it is a good source of information on the potentiality of gold, even for nonexperts in the field of homogeneous catalysis.

As the editors we believe that all the contents of this book constitute a valuable contribution in understanding not only why gold attracted so much interest in the catalysis scientific community but also why gold has become so popular in quite recent years. We would like to warmly thank all the authors for their excellent contributions, making this book useful for both researchers already involved in gold catalysis and the ones who would like to approach this field.

**Laura Prati**
**Alberto Villa**