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"Handbook of Advanced Methods and Processes in Oxidation Catalysis: From Laboratory to Industry"

Edited by Daniel Duprez (University of Poitiers, France) and Fabrizio Cavani (University of Bologna, Italy), Imperial College Press, UK, 2014, 1020 pages, ISBN: 978-1-84816-750-6, £149.00, US$225.00

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"Handbook of Advanced Methods and Processes in Oxidation Catalysis", edited by Daniel Duprez and Fabrizio Cavani, aims to give an overview of catalytic oxidation methods. It is divided in two parts, covering total and selective oxidation, and draws on the experience of a number of academic and industrial scientists. It is a broad and generally useful book which fulfils its aims, being intended for the technical parts of the chemical industry as well as the academic community. This book is particularly interesting in that it clearly describes the very diverse applications and importance of oxidation catalysis within the chemical industry. These applications are manifested in the production of speciality chemicals as well as large bulk chemical processes. It also shows the rapid growth and development of oxidation catalysis in recent years.

The first ten chapters on total oxidation regard hydrocarbon oxidation, soot, liquid phase techniques and five chapters on volatile organic compounds (VOCs) including plasma processes and chlorinated VOCs. The remaining 18 chapters regard selective oxidations and include industrial perspectives of varying degrees of interest as well as reactor technologies and experimental tools and techniques. This breadth of scope makes it a great resource but also ensures that the reader will only be interested in the detail of some parts of the book.

Only the parts of the book which are mainly concerned with platinum group metal (pgm) catalysts have been reviewed as these are of most interest.

Total Oxidation

Chapter 1 regards the oxidation of carbon monoxide and hydrocarbons in exhaust gas treatments and is authored by Jacques Barbier Jr and Daniel Duprez (University of Poitiers). This is a fairly detailed and informative chapter with 83 references and describes the kinetics and mechanisms around three-way catalysts using platinum, palladium and rhodium; however, the science is relevant to oxidation promoters in fluid catalytic cracking (FCC).

Chapter 8 is authored by Unni Olsbye (University of Oslo, Norway) and regards the catalytic combustion and partial oxidation of hydrocarbons to syngas. The author starts from the basics and thermodynamics of these transformations, then moves on to partial oxidation reactions catalysed by base and noble metals. Nickel is active, cheap and abundant but easy to oxidise

and the presence of metal oxide leads to combustion. Coke formation is a problem that can be mitigated by the use of rare earth metals or basic oxides, as well as the use of noble metals; an interesting observation was that pgms can operate under conditions that are thermodynamically favourable for the formation of graphite. The final part of the chapter regards catalytic combustion, in which the relative ease of combustion of hydrocarbons, the ignition temperature for each metal and the impact of particle size on the combustion is discussed. It appears that there is an optimum particle size in which Pt is present both as an oxide and as metal. Chemical looping is also briefly discussed, but with very little detail.

Selective Oxidation

Chapter 11 by Edouard Mamedov and Khalid Karim (Saudi Basic Industries Corporation (SABIC) Technology & Innovation Center, Saudi Arabia) discusses the selective oxidation of ethane to acetic acid and of ethylene to vinyl acetate monomer (VAM). For the former, they describe the development of a Pd-doped mixed oxide and for the latter they describe the use of palladium-gold on silica including references to three patents. They also discuss mixed metal oxides for oxidative dehydrogenation of propane. The impression was that they used a complex empirical approach, but no incisive fundamental insights were developed.

Chapter 12 by Gerhard Mestl (Clariant R&D, Germany) deals with the development of selective oxidation catalysts at Clariant. The theme is a reliance on high-throughput testing to identify leads and an interesting insight was how they use catalyst particulates in their high-throughput screening. Hardly any formulations are described, which detracts from the interest.

Chapter 16 by Paul L. Alsters (DSM Innovative Synthesis BV, The Netherlands) *et al.* is a wide-ranging contribution that describes the use of oxidation catalysis in the synthesis of a number of products such as vitamin C and quinones from various phenols and the cobalt-catalysed toluene side-chain oxidation.

Chapter 22 by Nikolaos Dimitratos and Graham Hutchings (Cardiff University, UK) and Jose A. Lopez-Sanchez (The University of Liverpool, UK) deals with supported metal nanoparticles in liquid-phase oxidation reactions. This is a topic which is likely to be of increasing importance in the future and this particular contribution is very welcome. The first topic covered is ruthenium for the oxidation of benzyl alcohol to benzaldehyde in solution and this is very interesting not because of the transformation, which is just a probe reaction, but for the discussion on the nature of the active catalytic species. The authors then describe Pd based catalysts for similar transformations, which appear to be structure sensitive since decarbonylations tend to occur on (111) planes whilst hydrogenations occur on all of the crystal faces. This type of insight should be behind any rational design of catalysts. The authors then discuss size-controlled Au catalysts, Pt catalysts and bimetallic catalysts.

Chapter 24 by Francisco Ivars and José M. López Nieto (Universidad Politécnica deValencia, Spain) deals with the oxidation of light alkanes and begins with an interesting comparison of the feed required to produce one ton of ethylene: 3.3 tons of naphtha compared to 1.7 tons of ethane. The only industrially established oxidation of alkanes is butane to maleic anhydride which is, surprisingly, easier with butane than with 1-butene. Most of the examples given are based on mixed oxide catalysts, whilst the application of pgms is limited to the partial oxidation of methane to syngas.

Chapter 27 by Miguel Menéndez (University of Zaragoza, Spain) discusses membrane technologies for catalytic oxidations and is a useful addition to the book. These are mainly mixed oxide but the application of pgms may be advantageous in these systems.

Finally Chapter 28 by Gianpiero Groppi, Alessandra Beretta and Enrico Tronconi (Politecnico di Milano, Italy) discusses the use of structured catalytic reactors for selective oxidations. One of the key points made in this chapter is that there is a significant gas-phase component to reactions occurring above 500ºC which indicates that catalyst design becomes less important at these temperatures. It is a lengthy chapter of 45 pages and 141 references, which would be a useful resource for those with an interest in the field since it starts from the basics and includes engineering concepts.

Concluding Remarks

Perhaps a downside of various (industrially written) chapters is that they describe their own companies' technologies, but do not make much reference to, or comparison with, competing or alternative technologies and so, in many instances a true comparison and evaluation is difficult to make. In general most of the

technologies and processes described are up to date and relevant; there are some instances where dated information is used. Overall it is a useful and detailed reference book. It also contains a large number of references which readily enables the reader to find more detailed and in-depth information on specific topics he/she may require.

Acknowledgement

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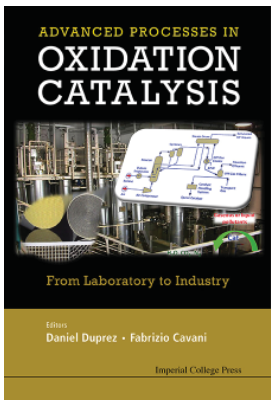

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The Reviewer

Ronan M. Bellabarba graduated from the University of Hull, UK, in 1996 and completed a DPhil in organometallic chemistry at the University of Oxford, UK, in 2000. After a couple of post-docs he joined Sasol Technology, UK, in 2002 and in June 2014 he moved to Johnson Matthey Chemical Catalysts, a Johnson Matthey Process Technologies business, as PGM Technology Manager.