CARBON DIOXIDE CAPTURE, STORAGE AND UTILIZATION

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PREFACE

Carbon dioxide (CO_2) emissions are the main cause of the greenhouse effect. CO_2 Capture and Storage (CCS) is an effort to reduce CO_2 emissions. There are some technologies to capture CO_2 in industry, namely Pre-combustion, Post combustion and Oxy-fuel combustion technologies. The Zero Emissions Petrol Vehicle (ZEPV) concept is one of the possibilities to eliminate CO_2 emissions from the transportation sector.

Reactions between CO_2 and H_2, such as methanol synthesis and methanation, could play an important role to overcome these emissions. The low methanol yield, both selectivity and conversion, is the main problem in the methanol synthesis. Methanation could be considered as another alternative process because the recent research showed that the yield in methanation process is high, the conversion of CO_2 to CH_4 was nearly 100%.

The book is divided into two sections dealing with hydrogenation of CO_2 and technology of CO_2 capture, storage, and utilization. This book is aimed at undergraduate and master students and those beginning a research career in CO_2 capture, storage, and utilization. It covers most of the main themes in hydrogenation of CO_2. The sources of CO_2 are from combustion engine, especially in the transportation sector.

Finally, I would like to express thanks to several people for their involvement with this book. I am grateful to a number of people who read the manuscript; thanks are especially to Prof. Reginald Mann, Prof. Paul Sharratt and Dr. Philip Martin for their helpful comments.

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CHAPTER ONE
INTRODUCTION

Increased impact of a high CO_2 concentration in the atmosphere on the environment through the greenhouse effect has been of acute concern to the global community and many efforts are being made to control and reduce this emission. For example, several researches have looked at zero emission vehicles, such as battery driven cars (Electric Vehicles, EVs), hydrogen fuelled cars, Zero Emissions Membrane Piston Engine System (ZEMPES) and Zero Emission Petrol Vehicle (ZEPV), to reduce CO_2 emission in the transportation sector.

The ZEPV uses conventional petrol (which retains existing infra-structure) and a conventional internal combustion engine (ICE), but by closed cycle combustion (CCC), it is possible to store / sequester liquefied carbon dioxide on board. This carbon dioxide will be traded in at the filling station, returned to a “refinery” and catalytically converted back to petrol via methane/methanol using the methanol to gasoline (MTG) process. As well as being perfectly clean at the street level, this approach presents the possibility of sustainable transport using renewable sources of energy (Brewer 2000). Both ZEPV and ZEMPES used a highly pure O_2 “locally” separated for fuel combustion in the engine (Dutton 2003; Yantovski et al. 2004) with temperature control via admixed CO_2 to provide the same moderating effect as N_2.

Hydrogenation of CO_2 has received much attention since global warming, mainly caused by the increase in CO_2 emission, was recognised to be one of the most serious problems in the world. Methanol synthesis has been considered to play an important role in the reduction of CO_2 emissions. By using the MTG process, methanol is available to be converted to gasoline/petrol.

The apparently low conversion and selectivity of CO_2 is a problem in this hydrogenation. According to some previous studies, the main cause of the lower conversion is the presence of water on the active site of the Cu catalyst. Water tends to oxidize the active Cu during the reaction and was adsorbed on the active site of the Cu catalyst and inhibited adsorption of CO_2 and H_2 for the next catalytic reaction(Joo et al. 1999). The CO formation, as a by product, is the contributor to the lower selectivity in methanol synthesis from

CO_2 (Sahibzada et al. 1996). However, the sum carbon selectivity of CO and methanol in methanol synthesis was always greater than 99%. Conversion of the by product CO to methanol could greatly increase the selectivity in methanol synthesis.(Sahibzada et al. 1996).

By 100% CO_2 to CH_4 conversion(Kai et al. 2005), gasoline production from CO_2 via methane (CH_4) and methanol could be considered as another alternative process. So, there are presently four possible chemical pathways to produce gasoline from the recycled CO_2: direct CO_2 hydrogenation, the Camere process, the H_2O-CO_2 electrolysis and the methanation process. The energy recycle penalty (η), the extra energy needed to produce the energy equivalent of gasoline, is still used to analyse these chemical pathways. For the ideal case the energy recycle penalty for methanation process, 84 %, is bigger than that for direct CO_2 hydrogenation (38%) and the Camere process (45%) but is significantly smaller than for the H_2O-CO_2 electrolysis (135%).