

PREFACE

The use of catalysts in chemical and refining processes has increased rapidly since 1945, when oil began to replace coal as the most important industrial raw material. Even after working for more than 35 years with catalysts, I am still surprised to consider the present size of the catalyst business and to see how many specialist companies supply different operators. Now that each segment of the industry is so specialized no single organization is able to make all of the catalyst types that are required. The wide range of catalysts being used also means that it is difficult to keep pace with the details of every process involved. Unfortunately, there are few readily available comprehensive descriptions of individual industrial catalysts and how they are used. This is a pity, since catalysts play such an important part in everyday life.

Modern catalyst use was unimaginable a hundred years ago because catalysts were still chemical curiosities. The use of catalytic processes simply increased with the demand for new products and gradual improvements in engineering technology. Only now is it becoming true to say that catalyst design, which originally relied on luck and the experience of individuals, is becoming a more exact science. New construction materials have made plant operation more efficient and led to the development of better processes and catalysts. It is no coincidence that the two major wars of the twentieth century saw the rapid expansion of a more sophisticated chemical industry. Currently, some new catalysts are evolving from previous experience while others are being specifically designed to satisfy new consumer demands. This is demonstrated by the introduction of catalysts to reduce automobile exhaust emissions in response to environmental regulations. This has been one of the major catalyst growth areas of the past 20 years and the use of catalysts to control various industrial emissions is similarly important.

The demand for catalysts is still increasing particularly in the Far East, as expansion of the chemical and refining industries keeps pace with the increase in world population. As a consequence, the number of catalyst suppliers is still growing. All have the experience needed to produce large volumes of catalysts successfully and can give good advice on process operation, but different catalysts for the same applications are not always identical.

Ownership of key patents for catalysts and catalytic processes has led to licenses being offered by chemical and engineering companies. For this reason precise catalyst compositions are not often published, and while commercial products may seem to differ only in minor details, in a particularly efficient manufacturing process these can certainly improve performance. There are no catalyst recipe books, and details regarded as company secrets are hidden in the vague descriptions of a patent specification.

Competition among suppliers in a market where customers may only place large orders every few years has encouraged overcapacity in order to meet emergency requirements. At the same time, low selling prices and the high costs of introducing new products have reduced profitability. The recent spate of catalyst joint ventures reflects this.

Availability of reliable products must be guaranteed so that a customer's expensive plant will not have to close down or operate at a loss. Security of supply is clearly a major factor in catalyst selection. Indeed, for many years it was a strategic or political necessity as well as being of commercial importance. For instance, during the ColdWar era, most of Eastern Europe and China had to rely on their own domestic production capacity. At the same time, the big chemical companies in the United States and Europe, which had traditionally produced their own catalysts, began to buy the best available commercial products.

Since Sabatier published *Catalysis in Organic Chemistry* in 1918 many process reviews have been written on the industrial applications of catalysts and they provide a good deal of historical background. Lack of detail has meant, however, that catalyst compositions are not often included. In any case, earlier reviews are usually out of print and can only be found with difficulty from old library stock. Up-to-date information is badly needed.

Catalysts could, by definition, operate continuously, but those used industrially may lose activity very quickly. Some catalysts can then be regenerated at regular intervals by burning of carbon deposited during operation. Others have to be replaced following permanent poisoning by impurities present in the reacting gases. To avoid the necessity for parallel reactors or unscheduled interruptions to replace spent catalyst, efficient operating procedures have had to be devised for online regeneration or the removal of poisons from feedstock. The use of additional catalysts or absorbents to protect the actual process catalysts has become an important feature of operation. Catalysts are also deactivated by overheating. This sinters either the active catalyst or the support and occurs if the operating temperature is at the limit of catalyst stability, particularly in the presence of trace impurities in feedstock. Other problems can result from increasing pressure drop through the catalyst bed, if dust is entrained with process gas or if the catalyst itself slowly disintegrates.

It may therefore be necessary to replace catalysts many times during the life of plant equipment. Stability despite the presence of poisons becomes an important feature of the selection procedure to avoid unscheduled plant closures. Proper catalyst reduction may also be a critical step prior to operation to ensure optimum performance in the shortest possible time. This is not always easy and efforts have therefore been made to use prereduced catalysts and even to regenerate spent catalysts externally to restore as much of the original activity as possible. It should never be assumed that catalyst operation is straightforward. It

is often a nightmare. And effort spent in solving problems or making improvements is time consuming. The provision of an efficient technical service has thus become an indispensable element of the catalyst business.

It is hoped that this extensive survey of industrial catalysis will stimulate a wider general interest in the subject.

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