

# Heinz Heinemann's Legacy at ExxonMobil: An Illustrious Career in Industrial Catalysis

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**Abstract** Heinz Heinemann contributed significantly to the field of heterogeneous catalysis over his 60 year career. As a scientist and later Catalysis Research Manager at ExxonMobil's (then Mobil's) Princeton Laboratory, he oversaw the development of many of the ZSM-5 processes for fuels and chemicals, most notably, a post-reforming process known as M-Forming. The M-Forming process development program justified Mobil's commercial development of ZSM-5, which in turn led to the rapid development of many other ZSM-5 processes including Methanol-to-Gasoline, Middle Distillate Dewaxing, xylene isomerization, and lubes dewaxing.

**Keywords** Heinemann · Industrial catalysis

## 1 Introduction

By the time Heinz Heinemann joined Mobil's Paulsboro, NJ Laboratory at the age of 56, he had already established himself as a significant presence in the field of

heterogeneous catalysis. However, it is unlikely that he could fully anticipate how much more productive that career was about to become. He was about to join a very capable catalysis R&D effort at a point where it was about launch several very highly successful catalytic process development programs. The majority of these emanated from the 1965 discovery of the zeolite ZSM-5.

## 2 Background

When Heinz Heinemann was hired by Mobil's Paul B. Weisz in 1969, he found an organization in the initial stages of the development of an exciting new process known as M-Forming. M-forming, which was discovered by Chen and Mower, used a ZSM-5 catalyst to convert paraffinic naphtha into higher octane alkylaromatics [1]. The process was believed to hold the potential for being a low cost octane enhancement process for reformate. To understand how the confluence of Heinz Heinemann's experience in reforming and Mobil's discovery of ZSM-5 contributed to the proliferation of Mobil's development of many zeolite catalyzed processes one should start with an examination of Heinz Heinemann's life and early career.

Born in Berlin, Germany in 1913, Heinz Heinemann attended the University and Technische Hochschule in Munich where he received Bachelors and Masters in Chemistry. He earned his PhD, in physical chemistry from the University of Basel, Switzerland in 1937 and emigrated to the United States in 1938.

From 1938 through 1941, Heinz worked for several small petroleum companies in Louisiana and Texas, at times teaching chemistry classes to women at small Texas colleges in the evening. He joined the Attapulugus Clay Company in 1941 where he rose to the level of research

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supervisor. It was during his career at Attapulgius that he first became interested in the area of heterogeneous acidic clay catalysts, bifunctional catalysis and catalytic reforming of naphtha [2]. In 1948, Heinemann joined the Houdry Process Corporation, where he became section manager of their research department.

Recruited to join the M. W. Kellogg Company in 1957, his initial position was vice president of research. He later rose to become director of Kellogg's chemical and engineering research. A capable industrial scientist and technical manager, he was best known in the North American catalysis community for his professional activities, which remained a passion of his throughout his career. Prior to joining Mobil in 1969, he co-founded the Catalysis Society of North America, the Philadelphia Catalysis Club, and the International Congress on Catalysis, serving as its president from 1956 to 1960. In the year prior to joining Mobil, he founded the journal, *Catalysis Reviews* (later *Catalysis Reviews—Science & Engineering*), serving as Executive Editor of the publication until 1984 [3].

### 3 Heinemann's Career at Mobil

By the time Heinz Heinemann joined Mobil's Paulsboro Laboratory in August of 1969, Mobil had already commercialized Selectoforming, its first shape selective zeolitic process [4]. Selectoforming, which was first commissioned at Mobil's Frontignan, France refinery in August 1967, was a Ni/erionite based catalytic process that selectively cracked the residual low octane n-paraffins remaining in reformate in order to further increase gasoline octane number.

Furthermore, ZSM-5, which had been discovered by G. R. (Bob) Landolt in 1965, was just beginning to be evaluated for catalytic applications [5]. Stan Lucki's and N. Y. Chen's initial experiments in late 1967 had provided evidence for shape selective paraffin cracking. Their work, together with major contributions by William Garwood, eventually led to the development of processes for catalytic dewaxing of distillates and lube base stocks [6].

However, it was the M-Forming chemistry, initially discovered in 1967, that first elicited the greatest amount of excitement within the company [7]. Beginning in the mid-60s, the U.S. Government was seriously considering

regulation of lead as an octane enhancer for gasoline. At the same time automobile engines were moving to higher compression ratios, leading to increased octane demand. M-Forming reacted paraffins with aromatics in naphtha by cracking the longer chain paraffins into olefins which then readily alkylated the single ring aromatics. The result was a high octane, alkylaromatic rich gasoline that was very similar to reformate, but did not require the higher hydrogen pressures, and most importantly, did not require a noble metal.

It was Heinemann's past experience with reforming and his reputation as a creative catalytic scientist that convinced Mobil that he could make a significant contribution to the development and commercialization of M-forming. Paul Weisz had been familiar with Heinemann's work with Mills, Milliken and Oblad on bifunctional catalysis [8]. In fact, Heinemann had first become interested in the catalysis of reforming naphthas in 1945, and was able to devote a large portion of his time to the catalytic chemistry while at Houdry Process Company beginning in 1948. He contributed to the development of Houdry's advanced reforming process, initially known as Iso-Plus and later as Houdryforming.

To quote from Heinemann's Houdry Award Address in 1975 [2],

“Among the many areas of heterogeneous and homogeneous catalysis with which I have been connected at one time or another, there is one to which I have returned repeatedly—catalytic reforming of naphthas.”

Heinz Heinemann's background in Houdryforming allowed him to appreciate the significance of Chen's discovery of M-Forming. He worked with Chen and several other Mobil scientists to identify the advantages of M-forming over Selectoforming and Houdryforming as post-reforming processes (Table 1).

It readily became clear that M-Forming could produce higher yields of high octane gasoline than either Houdryforming or Selectoforming, primarily because it facilitated the alkylation of aromatics with cracked products rather than allowing the cracked products to be lost as light gas [9]. Longer chain and lower octane paraffins were more readily converted to alkylaromatics (Fig. 1).

**Table 1** Comparison of post-reforming processes at equal octane number improvements [9]

	Houdry-forming	Selecto-forming	M-Forming
Temperature (°F)	950–1,025	600–850	600–800
Pressure (psig)	600	200–400	200–400
Res. octane No. of reformate	84	86	90
Product res. octane No.	91	93	97
C5+, vol% of reformate	82	85	86

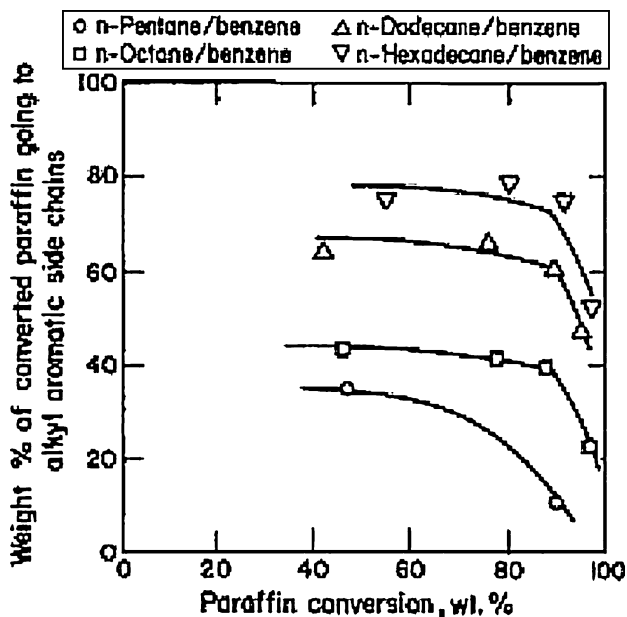


Fig. 1 Conversion of n-paraffins to alkyl aromatic side chains. ZSM-5 catalyst, 600°F, 700 psig, 1/1 wt. blend, severity controlled by space velocity [7]

With a significant amount of Heinemann’s help, the M-Forming process development was accelerated and progressed to a commercial trial at Mobil’s Frontignan, France refinery in March–April 1972. The trial was a

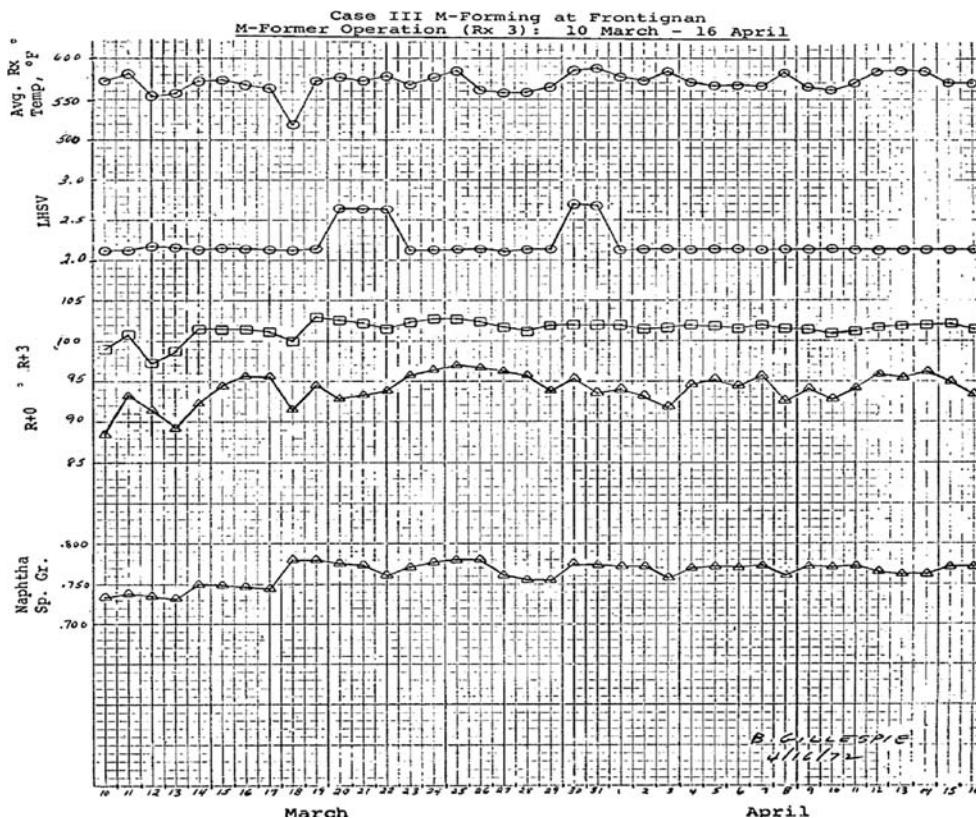
technical success and produced the target octanes and yields over the course of the 2 month trial. Most notably, the catalyst exhibited very little deactivation (Fig. 2). Additional ZSM-5 catalyst was produced for a subsequent trial Mobil’s Wilhelmshaven, Germany refinery.

The anticipated octane shortfall was slow to develop, however, as other processes, most notably fluid catalytic cracking using new zeolite (Rare Earth exchanged X and Y) catalysts began producing higher octane gasoline. Also, the anticipated phase down of leaded gasoline did fully materialize until 1974. The incentives for post-reformate treatment declined mainly because of the undesirable gasoline loss. The M-Forming process never was further deployed and existing Selectforming reactors began to be shut down.

The catalyst that was manufactured for the Wilhelmshaven refinery trial became the basis for the commercial demonstration of Mobil’s first xylene isomerization process (MVPI) at its Naples, Italy refinery.

While the M-Forming process had a limited commercial lifetime, it did enable Mobil to justify the commercial scale-up of ZSM-5 zeolite crystal. As the first ZSM-5 catalyzed process to require ton quantities of ZSM-5, the process motivated the establishment of a first of its kind zeolite and catalyst manufacturing plant at Mobil’s Beaumont Chemical Specialty Plant. The knowledge developed through zeolite crystallization scale-up (e.g.,

Fig. 2 M-Forming trial at Frontignan, France refinery March 10–April 16, 1972. Performance curves Top average reactor temperature; LHSV, hr-1; Research Octane No. +3 ppm Pb (R + 3); Research Octane No. +0 ppm Pb (R + 0); Bottom specific gravity of gasoline



pressure crystallizers and organic directing agent handling) led to the development of a wide range of ZSM-5 based catalysts which could be tailored for new processes under development.

Heinz Heinemann was promoted to Manager of Catalysis Research at Mobil's Princeton Laboratory in 1972. There he helped to direct the development of a wide variety of ZSM-5 based processes including Methanol-to-Gasoline (MTG) and M2-Forming, a novel dehydrocyclization process. He was also closely associated with other Mobil processes being developed in the New Jersey laboratories in the 1972–1978 period including several xylene isomerization processes, toluene disproportionation, catalytic dewaxing and initial forays into the use of ZSM-5 for catalytic cracking. His experience as a manager and his knowledge of aromatic processes helped to accelerate the development of several Mobil processes.

Ultimately, Heinz Heinemann was closely associated with the development of fourteen commercial catalytic processes throughout his career. Ten of these occurred during the 9 year period (1969–1978) when he worked at Mobil Research and Development.

#### 4 Epilog

Heinz Heinemann retired from Mobil Research and Development Corporation in 1978 and immediately joined Lawrence Berkeley Laboratory as a Senior Scientist.

There continued to carry out research on new catalytic processes for the production of gaseous and liquid fuels. He retired from his position as Senior Scientist at Lawrence Berkeley Laboratories in 1995. At the age of 82, he continued working as a Distinguished Scientist in the Washington, DC, office of the Lawrence Berkeley National

Laboratory, serving as a liaison between the Laboratory and the U.S. Department of Energy.

Heinz Heinemann died on November 23, 2005 at the age of 92. His 60 year career in catalysis was incredibly prolific. He was inventor or co-inventor on 75 patents and published more than technical 150 papers. Heinemann received the E. V. Murphree Award in Industrial Engineering Chemistry of the American Chemical Society, the E. J. Houdry Award in Applied Catalysis of the Catalysis Society, the Homer H. Lowry Award in Fossil Energy given by the U.S. Department of Energy, a Distinguished Scientist Award of the Department of Energy, a Distinguished Lectureship Award of the American Institute of Chemical Engineers, and the Philadelphia Catalysis Club Award. He was also a member of the National Academy of Engineering.

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#### References

1. Chen NY, Garwood WE, Heck RH (1987) *Ind Eng Chem Res* 26:706
2. Heinemann H (1977) *Catal Rev Sci Eng* 15:1–53
3. Bell AT, Klier K (2006) *Catal Rev* 48(1):1
4. Chen NY, Maziuk J, Schwartz AB, Weisz PB (1968) *Oil Gas J* 66(47):154
5. Chen NY, Degnan TF Jr, Smith CM (1994) *Molecular transport and reaction in zeolites*. Wiley, New York
6. Chen NY, Garwood WE, Dwyer FG (1989) *Shape selective catalysis in industrial applications*. Marcel Dekker, New York
7. Garwood WE, Chen NY (1980) In: ACS National meeting, Houston, TX, March 23, 1980. *Div Pet Chem* 25(1):84 (Preprints)
8. Mills GA, Heinemann H, Milliken TH, Oblad AG (1953) *Ind Eng Chem* 45:134
9. Heinemann H (1981) *Catal Rev Sci Eng* 23(1,2):315