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Formaldehyde

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Report Abstract
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INTRODUCTION

Formaldehyde (HCHO) is found as a naturally occurring compound in plants and as a metabolic intermediate in mammalian cells. It is also produced during incomplete combustion of organics such as in vehicle exhausts and tobacco smoke.

Formaldehyde was first produced as an embalming agent and disinfectant. It is frequently used as an intermediate in the synthesis of other products, which find use in the manufacture of numerous consumer articles (such as laminated counter tops) and in industrial products (glues and construction materials, insulation and particle boards).

Formaldehyde is a clear, reactive gas under ambient conditions. It is usually marketed as a liquid solution, typically at 37 weight percent formaldehyde solution, combined with water and up to 15 percent methanol. Therefore, all production comparisons shown in this report are made on a 37 weight percent basis. However, higher concentrations are sold and are required for the production of some derivative products such as polyacetal resins. The market trend is to sell solutions at higher concentrations to reduce shipping costs. Stabilizers are usually required when shipping higher concentrations of formaldehyde solutions. As a solid, it is marketed as trioxane (CH_2O_3) its cyclic trimer; and as a polymer of 8 to 100 units paraformaldehyde (a solid mixture of linear polyoxymethylene glycols). The solid form (*para*-formaldehyde or trioxane), can be depolymerized back to relatively pure formaldehyde in the presence of a strong acid such as hydrochloric or sulfuric acid.

The formaldehyde market is mature and well established in the more developed economies of Western Europe and North America. Estimated global consumption in 2011 was well in excess of 30 million tons of formaldehyde. The major industry drivers being the construction, automotive, and furniture industries, as well as demand for consumer goods. The formaldehyde market is very susceptible to market fluctuations since its consumption is strongly linked to general construction industry growth.

There are environmental concerns related to formaldehyde production and use, and these are discussed in the report. The environmental issues have resulted in migration to and increased research in less toxic alternatives.

The environmental issues may impact formaldehyde consumption in the cosmetics market. Additionally, the toxicity of formaldehyde has also resulted in stricter conditions to control its emissions with the associated regulations and costs in all regions.

TECHNOLOGY

Methanol is the key feedstock required in the commercial production of formaldehyde. The methanol can be either produced on site or purchased. Air (oxygen) is required for oxidation and demineralized water for absorbing formaldehyde. Currently, the only production technologies for formaldehyde of commercial significance are based on the partial oxidation and dehydrogenation of methanol using a silver catalyst, or partial oxidation of methanol using a

metal (molybden/iron) oxide-based catalyst ("Formox" process). These two technologies are described in detail in the report (Section 3).

In the silver catalyst route, vaporized methanol with air and steam is passed over a thin bed of silver-crystal catalyst at about 600 to 700 °C. Formaldehyde is formed by the dehydrogenation of methanol. The heat required for the endothermic reaction is obtained by burning hydrogen contained in the off-gas produced from the dehydrogenation reaction. The silver catalyst process uses an excess of methanol. The main formaldehyde forming reactions for this process are shown below (dehydrogenation of methanol to formaldehyde and partial oxidation of methanol):

$$CH_3OH \rightleftharpoons HCHO + H_2 \qquad (\Delta H = +85\ kJ/mol)$$

$$CH_3OH + \tfrac{1}{2}O_2 \rightleftharpoons HCHO + H_2O \qquad (\Delta H = -157\ kJ/mol)$$

In the Formox process, a mixture of air and methanol is vaporized and passed into molybdenum and iron oxide catalyst-packed reactor tubes. Metal oxides in the catalyst are typically molybdenum (Mo) and iron (Fe). Small amounts of oxides of vanadium, cobalt, phosphorus, chromium and copper may also be included. The reaction that is responsible for producing formaldehyde in this process is vapor–phase oxidation of methanol with excess oxygen. The reaction takes place at temperatures of about 250 to 400 °C, is highly exothermic and generates heat to provide steam for turbines and process heating:

$$CH_3OH + \tfrac{1}{2}O_2 \rightleftharpoons HCHO + H_2O \qquad (\Delta H = -157\ kJ/mol)$$

A wide range of alternative feedstocks have been considered but not found to be economic. For example, a tiny amount of formaldehyde is produced from the non-catalytic oxidation of propane-butane mixtures. Formaldehyde can be produced from methane, but a mixture of products needs to be separated. It is also a byproduct of the oxidation of naphtha to acetic acid.

Variation in methanol pricing affects not only the production cost of formaldehyde, but also that of downstream derivative products. Brief process descriptions are given for the following major downstream derivative products:

- Phenol-formaldehyde (PF) resins
- Urea-formaldehyde (UF) resins
- Melamine-formaldehyde (MF) resins

PROCESS ECONOMICS

The report includes detailed cost of production estimates for producing a 37 weight percent formaldehyde solution by the following processes:

- Metal oxide (Fe/Mo) catalyst
- Silver catalyst without methanol recycle (complete conversion)
- Silver catalyt with methanol recycle (incomplete recycle)

Cost of production estimates have been developed on China, USGC, and Western Europe location bases. A sensitivity analysis to assess the impact of variation in methanol price on formaldehyde cost of production is included.

The report also includes detailed cost of production estimates for formaldehyde resin plants producing the following:

- Phenol-formaldehyde resin (USGC location basis)
- Urea-formaldehyde resin (USGC location basis)
- Melamine-formaldehyde resin (USGC location basis)

The detailed cost tables given in this report include a breakdown of the cost of production in terms of raw materials, utilities consumed (electrical energy, cooling water, fuel etc.), direct and allocated fixed costs, by unit consumption and per metric ton and annually, as well as contribution of depreciation to arrive at a cost estimate. Capital costs are broken down according to inside battery limits (ISBL), outside battery limits (OSBL), other project costs, and working capital.

COMMERCIAL MARKET REVIEW

Formaldehyde is the major end-use derivative of methanol globally. It accounted for 32 percent of the global methanol demand in 2009, and in 2011 this has contracted to about 27 percent of global demand as new end-uses such as conversion to olefins has increased.

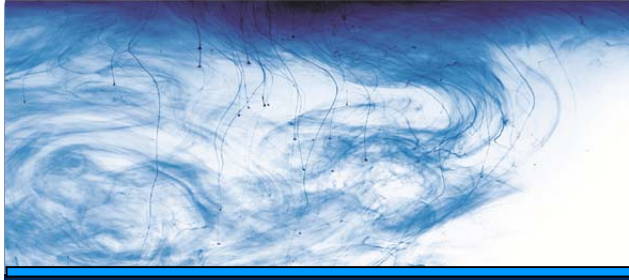
Formaldehyde's main end-use is in the production of resins such as urea-formaldehyde (UF), melamine formaldehyde (MF), and phenol formaldehyde (PF), which are predominantly used in producing glues for use in plywood and chipboard/particle board production. These are linked to furniture and the construction industry, therefore its growth is linked to general economic growth.

Approximately 70 percent of the global formaldehyde construction production is used in resins UF, MF and PF.

Other uses include acetylenic chemicals (via conversion of formaldehyde to butanediol), methylene diphenyl diisocyanate (MDI) for polyurethanes, polyacetal resins, hexamine and paraformaldehyde. Super-plasticizers such as sulfonated melamine-formaldehyde condensates (SMF) and sulfonated naphthalene-formaldehyde condensates (SNF) are also produced.

Urea commercial end-use applications are discussed in the report, as well as a regional supply, demand, and trade analysis

- Global supply, demand and trade data is given and discussed
- In addition, supply, demand and trade data is given and discussed according to key regions, i.e., North America, South America, Western European, Central and Eastern Europe, Middle East and Africa, and Asia Pacific
- A list of production plants in each of the key regions above is given showing specific plant capacities, owning company, location and annual tonnage produced



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