POLYOXYMETHYLENE FROM FORMALDEHYDE AND ACETIC ANHYDRIDE
REPORT POM E11A

*Analysis developed by Intratec*

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ABSTRACT

This report presents a cost analysis of Polyacetal Resins (also known as Polyoxymethylene, POM) production from acetic anhydride and formaldehyde. The process examined is similar to the one owned by DuPont. In this process, starting formaldehyde (37 wt% solution) is concentrated to a purity higher than 99.9 wt% by means of two distillation steps and a treatment step. High purity formaldehyde is then polymerized in an inert cyclohexane medium. To enhance thermal stability, hydroxyl end groups are reacted with acetic anhydride.

The report examines one-time costs associated with the construction of a plant and the continuing costs associated with the daily operation of such a plant. The analysis assumes a United States-based plant capable of producing 110 kt of Polyoxymethylene per year and includes:

* Capital Investment, broken down by:
  - Total fixed capital required, divided in process unit (ISBL); infrastructure (OSBL), contingency and owner's cost
  - Working capital and costs incurred during industrial plant commissioning and start-up

* Operating cost, broken down by:
  - Variable operating costs (raw materials, utilities)
  - Fixed operating costs (maintenance, operating charges, plant overhead, local taxes and insurance)
  - Depreciation

* Raw materials consumption, products generation and labor requirements

* Process block flow diagram and description of industrial site installations (process unit and infrastructure)

This report was developed based essentially on the following reference(s):

(2) US Patent 2768994, issued to Du Pont in 1956

Keywords: Acetyl resin, polyoxymethylene (POM) resins, polymer of formaldehyde, DuPont, polyformaldehyde
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Plant Cost Breakdown Summary

Process Flow Diagrams & Equipment List

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ABOUT THIS REPORT

Study Objective

This report presents the economics of Polyacetal Resins (also known as Polyoxymethylene, POM) production from acetic anhydride and formaldehyde. The process examined is similar to the one owned by DuPont.

The primary objective of this study is to explain the cost structure of the aforementioned process, encompassing capital investment and operating cost figures.

The process design and economics in this report are based on an industrial facility with a capacity of 110,000 metric ton per year, a nominal capacity that is globally competitive.

In addition, the economic assessment, developed for the period [period], assumes the construction of a United States-based industrial facility that includes the infrastructure typically required for such a project.

Report Overview

This report is structured into eight main parts which follow a logical sequence. Each of these parts is described below.

By way of introduction, the first part – the current chapter – briefly explains the report itself, its structure and objective. Readers are encouraged to spend a few minutes reading this chapter, so as to make the most of the study.

In the second part, About Polyoxymethylene, the reader will learn the basics of Polyoxymethylene itself. This chapter also covers its applications and major production pathways.

The third part, Process Overview, presents basic aspects of the process studied: products generated, process inputs, and physico-chemistry highlights.

The fourth part, Industrial Site, describes an industrial plant based on the process under analysis, in terms of the process unit and infrastructure required. This technical analysis underlies the entire study.

The fifth part, Capital Investment, presents all capital costs associated with the process examined, from design and erection of an industrial site to plant startup.

Operating Costs of the process are examined in the sixth part. Ongoing costs related to the operation of a unit based on the process are studied, including operating fixed costs, operating variable costs and depreciation.

The seventh part, Product Value, targets to estimate the gate cost of the plant final product, by adding corporate overhead costs and a parcel that will guarantee an expected Return On Capital Employed (ROCE). It provides an idea of the minimum price at which the product may be sold, and how competitive it is.
The eighth part, *Process Economics Summary*, summarizes all economic figures presented throughout the report.

Finally, to address any questions or concerns about the methodologies and procedures adopted in the development of this report, the reader is referred to the eighth part, *Analysis Methodology*.

**How to Use this Report?**

The main purpose of this Report is to assist readers in a preliminary economic evaluation of the production process approached. It is a valuable support tool for a myriad of activities and studies, such as screening and assessment of investment options, preliminary evaluation of the economic potential of emerging production processes, rough assessment of the economic feasibility of industrial ventures, cost estimates double-checking, preliminary budget approval, research planning, and so on.

Readers must always bear in mind the nature of this report and the resulting limitations on how to properly use it. Limitations that apply to both technical data and economic assessment presented in this study are explained below.

**Technical Data**

The preliminary design of the process, presented in the part *Industrial Site*, is based on fast techniques that rely on reduced design efforts. The goal of such preliminary design is exclusively to represent the process in sufficient detail for supporting capital and production costs estimation within the accuracy expected: class 4 budgetary estimates. Therefore the technical data presented must not be confused with an actual conceptual process design, and must not be used as such.

**Economic Assessment**

The economic assessment presented in this report (parts *Capital Investment, Operating Cost, Product Value Analysis and Process Economic Summary*), developed for the period [insert], assumes the construction of a United States-based industrial facility. This means that capital and production costs estimates presented are based on several general assumptions (e.g. average market figures for raw materials, chemicals and utilities prices, labor costs, taxes and duties), believed to suitably portray local conditions for the period of analysis informed, on a country-level basis.

Accordingly, the economic assessment provided in this report is not meant to fit any specific industrial venture, which would involve a wealth of specific data and assumptions not herein considered.
EXECUTIVE SUMMARY

About Polyoxymethylene

Polyoxymethylene (a.k.a. POM, Polyacetal Resin, Polyformaldehyde) is a thermoplastic polymer fiber. For its crystalline packing, consisting of organized stacking chains, POM has a high strength, stability, stiffness and hardness, as well as low friction. These characteristics combined with resistance to chemicals and excellent dimensional stability make the polymer often a substitute for metal and it is widely used in the manufacturing of high-performance engineering materials and electronics.

POM is usually transported and stored in its pallet form, or as the final product already molded. It is not flammable and very little toxic, although it should be kept away from heat sources, since it might produce formaldehyde, which is flammable and has been labeled as a known carcinogen by the US National Toxicology Program.

POM homopolymers are used in automotive applications (e.g. fuel-system and seat-belt components, steering columns, window-support brackets); industrial applications (e.g. couplings, pump impellers, conveyor plates, gears); and consumer items (e.g. toys, garden sprayers, zippers).

POM copolymers, on the other hand, are employed in industrial/automotive applications (e.g. gears, cams, bushings, clips, lugs, door handles, window, cranks, housings) and food applications (e.g. milk pumps, coffee spigots, food conveyors).

Other applications of POM include its use as: engineering plastic; small precision molding component (in measuring/communication equipment); part in various electronical items (televisions, radios, computers, telephones, etc); and in manufacturing of oil/gas pipes and aerosol container for cosmetics.
Polyoxymethylene Production Process

The present analysis approaches Polyacetal Resins (also known as Polyoxymethylene, POM) production from acetic anhydride and formaldehyde.

The process under analysis comprises two major sections: (1) Formaldehyde Purification; and (2) Polymerization.

Formaldehyde Purification. The formaldehyde solution is passed through an anion-exchange unit for the removal of formaldehyde solution and then to a concentration column. The concentrated formaldehyde is sent to the Extraction Column, forming hemiformal by contact with cyclohexanol. A cyclohexanol-water mixture is routed to a decanter to recover cyclohexanol. The hemiformal is cracked to split off the formaldehyde monomer, which is directed to the Polymerization Reactor.

Polymerization. Formaldehyde is fed to a reactor and polymerized into POM, which precipitates as it is formed. The solid particles are separated from the solvent in a Vacuum Filter, are dried to remove volatile materials, and routed to the Acetylation Reactor. A liquid stream from the filter is sent to Solvent Recovery, which returns solvent to the Polymerization Reactor. An acetic anhydride stream is recovered, refined, and routed to the Acetylation Reactor, where hydroxyl groups on the polymer chain are converted to acetate groups. The product is routed to a Hot Nitrogen Dryer to remove residual acetic anhydride, which is recycled to Anhydride Recovery. The dried product is then sent to an extruder, to Blending Silos, and is then packed and stored.

Process Schematic Diagram
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