VINYL ACETATE PRODUCTION FROM ACETIC ACID AND ETHYLENE
REPORT VAM E11A

Analysis developed by Intratec

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ABSTRACT

This report presents a cost analysis of Vinyl Acetate Monomer (VAM) from acetic acid and ethylene. The process examined is a typical vapor phase oxidation process. In this process, vapor acetic acid, ethylene and oxygen react in a catalytic multi-tube reactor, producing Vinyl Acetate. After separation/purification steps, VAM is obtained as the final product and unreacted ethylene and acetic acid are recycled back to the reactor.

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 with a capacity of 350 kt of Vinyl Acetate 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 9573877, issued to Celanese in 2017

Keywords: Ethenyl Acetate, Ethanoic Acid, Ethene, Oxidation, Vapor Phase, VAM
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ABOUT THIS REPORT

Study Objective

This report presents the economics of Vinyl Acetate Monomer (VAM) from acetic acid and ethylene. The process examined is a typical vapor phase oxidation process.

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 350,000 metric ton of Vinyl Acetate per year, a nominal capacity that is globally competitive.

In addition, the economic assessment, developed for the period Q1 2017, 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 Vinyl Acetate, the reader will learn the basics of Vinyl Acetate itself. This chapter also covers its applications and major industrial process 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
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 industrial 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 industrial 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 operating 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 2017 Q1, assumes the construction of a United States-based industrial facility. This means that capital and operating 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 Vinyl Acetate

Vinyl Acetate (a.k.a. VAM, Vinyl Acetate Monomer, Ethenyl Acetate) is an organic compound, an important vinyl ester, used in the manufacture of many polymers and resins. It is a colorless liquid with a sweet, fruity smell, soluble in most organic solvents, but only slightly soluble in water.

On an industrial scale, the dominant production route of Vinyl Acetate is based on the reaction of ethylene with acetic acid and oxygen in the gas phase on heterogeneous catalysts containing palladium.

Being a flammable liquid, vinyl acetate monomer should be stored under nitrogen and away from ignition sources, heat, oxidizing materials, and chemicals that can generate free-radicals, so as to avoid uncontrolled polymerization. Vinyl acetate is transported in practically all quantities: small containers, drums, tankers, tank cars, and ships. Stabilizers are usually added for transportation.

The greatest demand for Vinyl Acetate is associated with the production of polymers and copolymers, mainly poly(vinyl acetates), used in papermaking, textiles, sealants, binders and coatings; ethylene vinyl acetate, used as a film, in the hot-melt coatings and adhesives; as PVC-alternative; and ethylene–vinyl alcohol, used in food packing and medical applications.
Vinyl Acetate Production Process

The present analysis approaches Vinyl Acetate Monomer (VAM) from acetic acid and ethylene.

The process under analysis comprises three major sections: (1) Reaction; (2) Separation; and (3) Purification.

Reaction. Make-up and recycle acetic acid passes through a vaporizer, along with fresh and recycle ethylene. The feed stream, containing excess of ethylene over acetic acid, is mixed with oxygen, preheated and fed to multi-tube reactors. The reaction occurs over palladium and gold catalysts. Heat is removed by evaporative cooling on reactors shell. At the end, 8 - 10 wt% of ethylene and 15 - 35 wt% of acetic acid are converted to vinyl acetate. Water, CO2 and small quantities of ethyl acetate, ethylidene diacetate, and glycol acetates are the main byproducts.

Separation. The reactor effluent is cooled and fed to the predehydration column, where a crude VAM stream is withdrawn from the bottom and stored. The overhead stream is separated into an organic phase, recycled to the column, and an aqueous phase, directed to a decanter downstream. Uncondensed gases are washed by acetic acid; the solution formed is routed to the crude VAM tank, while gases from the scrubber are recycled to the reaction. Part of such gases is washed with water for removing residual acetic acid, also directed to the crude VAM tank. After water wash, gases are directed to an absorption column, for CO2 removal by a potassium carbonate solution.

Purification. In the azeotropic column, a VAM-water mixture is distilled and fed to a decanter, along with the aqueous phase separated in the predehydration. Here an organic phase containing VAM is separated and directed to the light-ends column, while an aqueous phase is routed to the wastewater column, which separates residual VAM from wastewater. Ethyl acetate is withdrawn and discharged, and acetic acid is recycled to the vaporizer. The light ends column stripes off acetaldehyde and other volatiles from the crude vinyl acetate. Finally, residual acetic acid and heavy-ends are removed in the pure VAM column, yielding a vinyl acetate with 99.9 wt%.

Process Schematic Diagram