

THE OXIDATION OF ETHYLENE

TO

ETHYLENE OXIDE

The purpose of this investigation was to determine the effect of the operating variables of type of reactor, catalyst, ethylene feed concentration, temperature, and oxygen concentration on the products of oxidation of ethylene to ethylene oxide and together with subsequent hydrolysis to A Thesis Abstract Submitted for Partial Fulfillment of the Requirements contained in

by Bernard Jacknin

for the Degree of Doctor of Philosophy in CHEMICAL ENGINEERING

The equipment used in a general flow diagram for the system. in silver catalyst activated by barium peroxide was employed and No. 3 Valencia mixture as the carrier according to Wiseman. For the analysis of ethylene oxide the procedure employed was a modification of that suggested by

Approved:

Committee:

/s/ Frank C. Vilbrandt
In Charge of Investigation

/s/ Frank C. Vilbrandt
Committee Chairman

/s/ Frank C. Vilbrandt
Head of Major Department

/s/ Philip Scherer
Committee Member

/s/ Earle B. Norris
Dean of Engineering

/s/ Nelson F. Murphy
Committee Member

/s/ C. Clement French
Director of Graduate Studies

/s/ Leonard McFadden
Committee Member

Virginia Polytechnic Institute Blacksburg, Virginia



THE OXIDATION OF ETHYLENE TO ETHYLENE OXIDE

by Bernard Jacknin

The purpose of this investigation was to determine the effect of the operating variables of type of reactor, catalyst, ethylene feed concentration, temperature, and contact time on the products of oxidation of ethylene to ethylene oxide; and together with subsequent hydrolysis to evaluate the commercial feasibility of the manufacture of ethylene glycol. The review of the literature contained 10 references.

The equipment employed was arranged as indicated in a general flow diagram for the system. A silver catalyst activated by barium peroxide was employed and prepared on No. 7 and No. 3 Valencia pumice as the carrier according to Wiseman. For the analysis of ethylene oxide the procedure employed was a modification of that suggested by Vaughan and Wiseman. The carbon dioxide content of the product gases was determined by absorption of the carbon dioxide by ascarite; moisture was removed by means of drierite.

Data and Results. A summation was made of operating conditions, yields and conversion in the air oxidation of ethylene in a fixed bed and fluidized bed reactor as a function of type of catalyst, contact time, reactor bath temperature, ethylene feed concentration, employing a barium peroxide activated silver catalyst coated on No. 3 and No. 7 Valencia pumice, uncoated pumice, and mixtures of these catalysts. It was found advisable to employ a 50% mixture of

catalyst-coated and uncoated carrier in the tests because of the tendency toward fusion of the catalyst particles when used alone as the reactor charge. An increase in the ethylene feed concentration from 3 to 9 per cent does not seem to appreciably affect either the conversion or yield.

ECONOMIC EVALUATION OF PROCESS

The data obtained from tests made with the fluidized bed reactor served as basis for the design of the oxidation unit. The oxidation was designed to be carried out with a feed gas containing three per cent ethylene, a reactor bath temperature of 235° C, a contact time of 1.69 seconds employing a 50 per cent mixture of silver catalyst-coated and uncoated No. 3 Valencia pumice. These conditions correspond to a yield and conversion of ethylene oxide of 60.0 and 5.66 per cent, respectively.

Capital Investment. It was designed for an annual capacity of 40 million pounds of ethylene glycol, plant operation being 250 days per year. For such a plant capacity the capital investment was found to be \$8,096,205, distributed as follows: building costs 11.4 per cent, equipment costs 29.9 per cent, working capital 13.9 per cent, initial catalyst cost 42.4 per cent and initial Dowtherm cost 2.4 per cent. Oxidation reactors accounted for 30 per cent of equipment costs.

Annual Costs. The annual costs for the plant were found to be \$4,937,168, distributed as follows: raw material costs 54.6 per cent, labor and supervision 2.9 per cent, maintenance 4.9 per cent, and fixed charges, management and distribution 37.6 per cent. The cost for ethylene, assumed three cents per pound, represents 33 per cent of the raw material costs or 45.5 per cent of the total annual costs.

Income. The annual income for the plant was found to be \$6,200,000 based on a selling price for ethylene glycol of \$0.155 per pound. No consideration was given to the sale of byproduct diethylene glycol in computing the annual income. Based on a selling price of \$0.17 per pound, sale of the byproduct would result in an increase in the income of one million dollars.

The net income, difference between the annual costs and annual income (without consideration of byproduct sale), was estimated at \$1,262,832 per year, or 15.6 per cent of the capital investment.