



ISOPROPYL ALCOHOL



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Enjay Chemical Company

Foreword

For many years *Petrohol (Isopropyl Alcohol)* had been a valuable source book and reference work for information related to isopropyl alcohol. This book was followed by *Isopropyl Alcohol*, an expanded version of *Petrohol*. This second edition of *Isopropyl Alcohol* is a completely revised, reorganized and updated version of the first edition.

Information and data contained in the second edition of *Isopropyl Alcohol* came from industrial and technical journals, papers, patents, and the Enjay Chemical Laboratories. Every effort has been made to report these facts objectively and accurately. Interpretation of the facts and determination of their relation to problems at hand are left to the reader.

Enjay Chemical Company hopes this book will be of material aid to manufacturers, chemists, pharmacists, and research workers with a general interest in isopropyl alcohol. Numerous references have been included to assist those who wish a more extended treatment of the preparation, properties, and applications of isopropyl alcohol.

Acknowledgment

This edition of *Isopropyl Alcohol* is based on the first edition written by L. F. Hatch. It has been revised and updated by W. R. Fenwick with valuable assistance from A. J. Rutkowski of Enjay Laboratories.

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ISOPROPYL
ALCOHOL

ISOPROPYL ALCOHOL PRODUCTION*

Year	Isopropyl Alcohol Production (M)	Acetone Production from Isopropyl Alcohol (M)
1920.....	20.....	3
1930.....	45.....	20
1940.....	225.....	115
1950.....	850.....	390
1955.....	925.....	435
1960.....	1180.....	613
1961.....	1189.....	591
1962.....	1326.....	668
1963.....	1466.....	718
1964.....	1575.....	790
1965**	1640.....	825
1970**	1890.....	935

*Chemical & Engineering News, Vol. 42, No. 49, Dec. 7, 1964, p. 26

**C&EN estimates

Source: U. S. Tariff Commission

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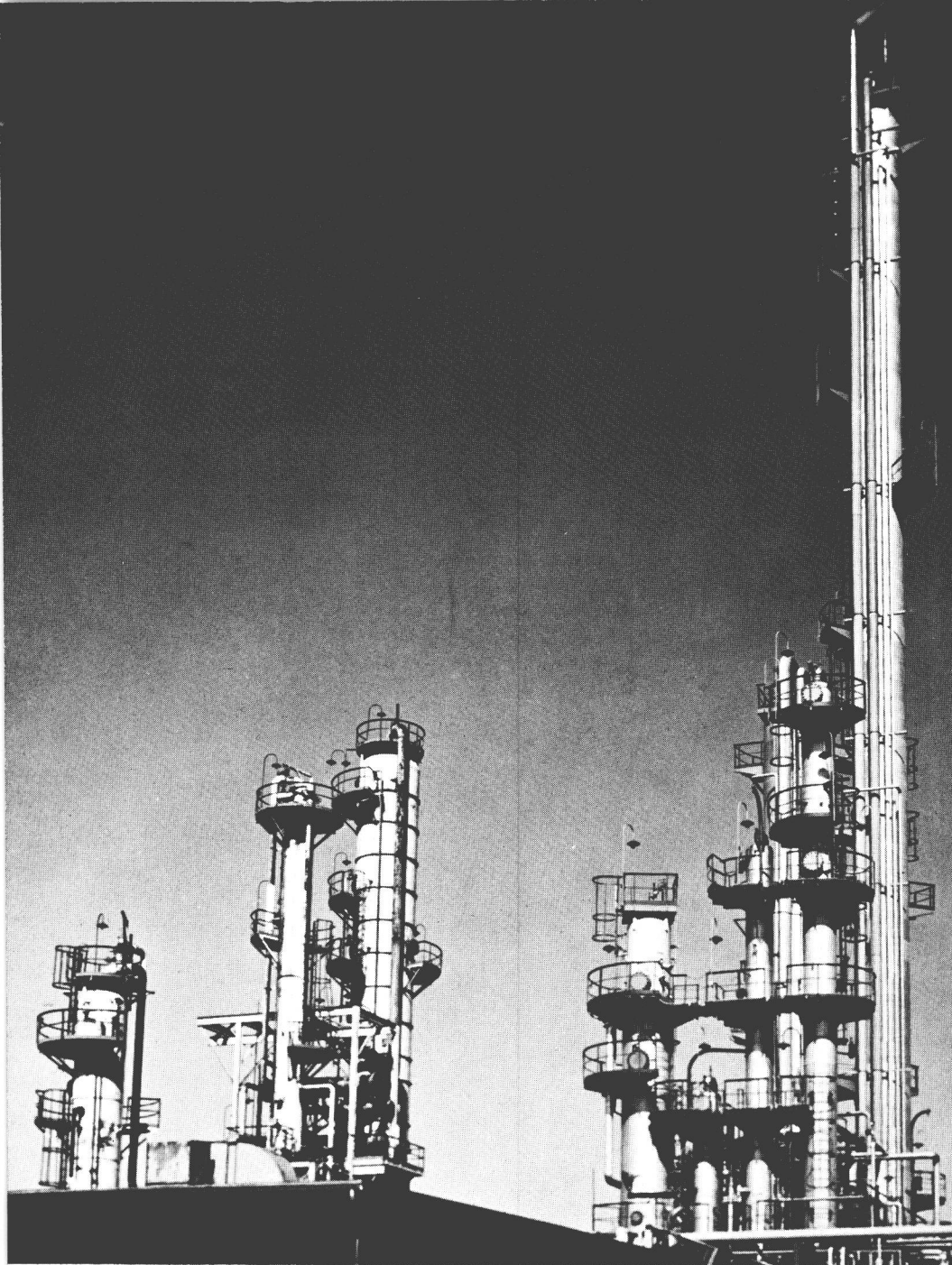
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Left to right: the Butyl finishing section, the MIBK unit and the Acetone-Ketone finishing sections at one of the Enjay chemical plants.

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INTRODUCTION

Isopropyl alcohol has several names and a great variety of uses. Its I.U.C. name is 2-propanol (propane-2-ol); its common name is isopropyl alcohol. However, the name "isopropanol" has become widely used within industry because of its simplicity. Isopropyl alcohol may also be called dimethylcarbinol, but this name is seldom used. It is a colorless, stable, secondary alcohol with many chemical and solvent properties similar to those of ethyl alcohol. In many applications the similarities permit use of isopropyl alcohol as a replacement for ethyl alcohol. The differences offer opportunities for new uses and new products.

Isopropyl alcohol's most important use is still for the production of acetone. However, production of acetone through cumene as the raw material could affect isopropyl alcohol use in this area^a. But the use of isopropyl alcohol to produce other compounds, as well as expanded applications in other areas, is expected to maintain a stable growth pattern.

Isopropyl alcohol serves as a solvent and extracting agent, as an antistalling agent in gasoline, and as a de-icing agent in various applications. It is also used in cosmetics, drugs, and various pharmaceuticals, and in a wide variety of miscellaneous applications. The table contains an alphabetical list of isopropyl alcohol uses—some well established and others suggested by the literature reviewed in this book.

Isopropyl alcohol's bitter taste, its inability to produce exhilaration, and its undesirable after-effects make a denaturant unnecessary. Therefore it can be manufactured and marketed free of government control and taxation—an advantage not enjoyed by ethyl alcohol.

Table 1: Uses of Isopropyl Alcohol

A	B
Abrasive cleaners	Bath salts manufacture
Accelerators, rubber	Beer manufacture, antifreeze
Acetate, isopropyl	Blackhead lotion
Acetic acid extraction	Breaking-in oils
Acetone production	Bromides
Additive manufacture	
Adhesives	C
Aerosols	Capsicum, extraction
After-shave lotions	Caulking compounds
Aircraft cleaners	Cellophane coating,
Alkaloid extraction	solvent for lacquer
Antifreeze preparations	Cements, synthetic rubber
Automotive chemicals	Chloride, isopropyl

a. Oil, Paint & Drug Reporter, Chemical Profile, September 30, 1963

Cholesterin solvent
Cleaning compounds
Coagulant; sugar, starches
Cooling agent for frozen foods
Cutting oils

D

Defoaming agent
De-icing; carburetors,
windshields, airplanes
Deodorant formulations
Detergents, light duty liquid
Disinfectant solutions
Drying; laboratory, instruments,
metallurgical, film
Dye leveling
Dye stuffs

E

Emulsion breaking
Engine cleaners
Essential oils solvent
Esters preparation of:
acetate
formate
lactate
myristate
palmitate
Ether (isopropyl) synthesis
Extractions; drugs, flavors

F

Fabric coatings
Fats, purifying
Fish Protein concentrates
Flotation agents, xanthate
Foam depression
Food products, preparation
Foot lotions
Fuel cells
Fumigants
Fungicides

G

Germicides
Ginger solvent
Glass cleaners
Glazes, candy
Grease removers
Gum inhibitors

H

Hair preparations
(sprays, tonics, dyes)
Histological preparations
Horticultural sprays
Household chemicals
Hydrogen peroxide manufacturer

I

Industrial cleaners
Inhibitors; corrosion, oxidation
Inks
Insecticides

J

Jellies—gum tragacanth

K

Kara gum solutions
Kelp extraction
Ketene
Ketones

L

Lacquer, nitrocellulose
(latent solvent)
Leather cleaner
Leather softeners
Leg makeup
Liniments
Lubricating oils

M

Metal cleaners
Metal polish
Motor cleaners

N

Naphtha recovery
Natural resins (solvent)
Nitrocellulose wetting

O

Oil emulsions
Oil recovery

P

Paint removers
Paints
Paper manufacture
Pectin extraction
Perfumes
Permanent wave lotion
Petroleum dewaxing
Pharmaceutical preparations,
nonofficial
Photographic products and
processes
Pigments, dispersing agent
Pitch emulsions
Plastics manufacture
Precipitating asphalts and waxes
Precipitating proteins
Prevent water separation
Promote root growth
Protective coatings
Protective creams and lotions
Purifying foods
Purifying salts
Purifying sulfonates
Pyrethrum extraction
Pyroligenous liquors

R

Reaction medium
Reagent, laboratory
Recovery processes
Refrigerant
Removing sludges
Resin solvent
Rubber cements
Rubbing alcohol
Rug cleaner
Rust preventatives

S

Scalp cleanser
Scalp medicine
Scouring wool
Shampoos
Shellac
Shock absorber fluid
Shoe dye
Sizings
Skin sterilization
Soaps
Soldering flux
Spice extractant
Spotting fluids
Steel manufacture
Sterilization
Sugar processing
Sulfonates
Suntan lotion
Sutures
Synthetic rubber

T

Tablet manufacture
Textile wash
Theater spray
Theatrical makeup
Thinners
Thymol
Tinctures
Toilet water

U

Urea

V

Vanillin
Varnishes
Vitamin assay
Vitamins

W

Warning agent for noxious gases
Washing precipitates

Waterproofing
Wetting agents
Wetting tablet granulations
White oil manufacture
Window cleaners
Windshield de-icer
Wool wax

Y

Yarns, finishing
Yeast defoaming agent

Z

Zein Resin extraction
Zein varnishes

1 PREPARATION OF ISOPROPYL ALCOHOL

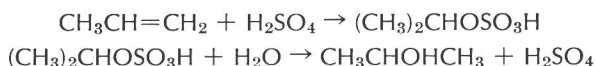
HISTORY

The first systematic study of the preparation of isopropyl alcohol was reported by Berthelot in 1855¹. His synthesis was based on the reaction between propylene and sulfuric acid to form isopropyl hydrogen sulfate, and the subsequent hydrolyzing of this sulfate to form the alcohol and sulfuric acid. This basic principle is used today for the production of isopropyl alcohol.

The first pilot plant for this process was built by Melco Chemical Company in 1919². Shortly after, the Standard Oil Company of New Jersey secured rights to the process and by December, 1920, was producing isopropyl alcohol at its Bayway refinery. Isopropyl alcohol is generally considered to have been the first petrochemical.

BASIC REACTIONS

Basic reactions in the production of isopropyl alcohol are the formation of isopropyl hydrogen sulfate and the subsequent hydrolysis to isopropyl alcohol and sulfuric acid:



In the production of isopropyl alcohol, some diisopropyl sulfate is also formed by the reaction of propylene with some of the isopropyl hydrogen sulfate produced in the initial reaction:



The diisopropyl sulfate may, in turn, hydrolyze to form isopropyl hydrogen sulfate and isopropyl alcohol:



Or the diisopropyl sulfate may react with isopropyl alcohol to form isopropyl hydrogen sulfate and diisopropyl ether:

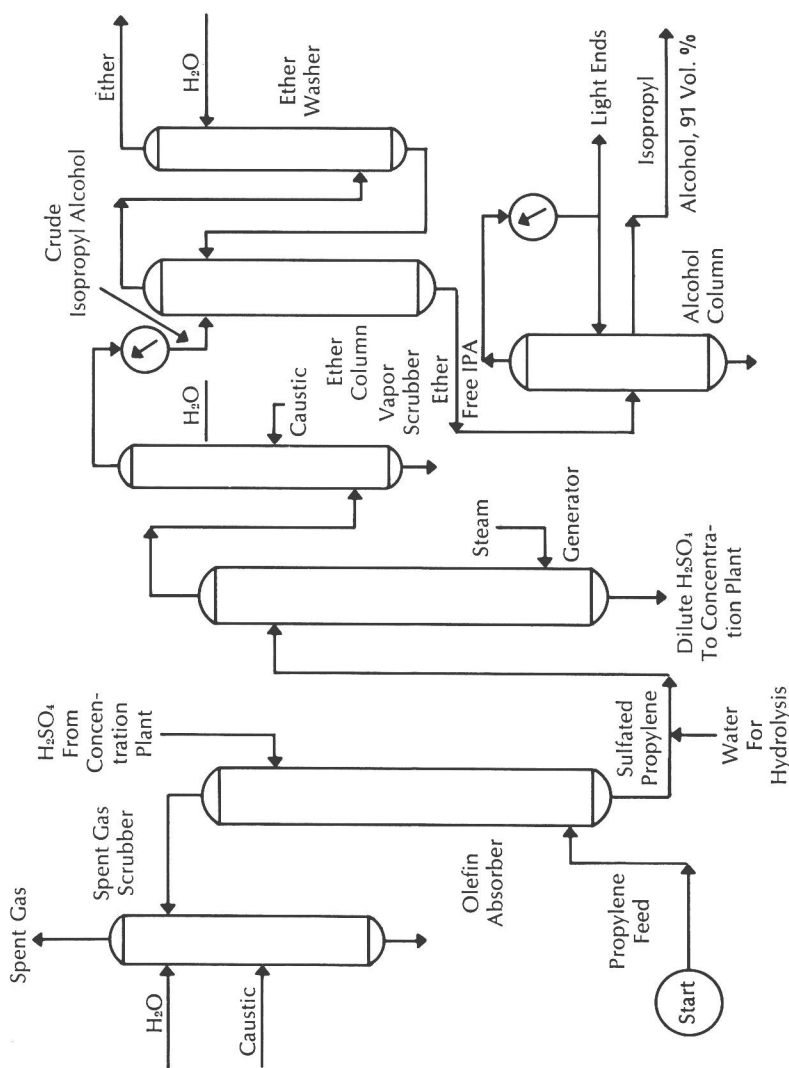


PREPARATION

Various methods may be used to bring about these reactions and various conditions will favor the desired reactions. In one of the original commercial processes, propylene was introduced into the bottom of a packed absorption tower maintained at 21 to 27°C. Sulfuric acid (85%), the continuous phase in the column, passed down the column counter-current to

1. Berthelot, M., *Ann. Chim. et Phys.*, 43(3), 399 (1855).

2. Ellis, C., *The Chemistry of Petroleum Derivatives*, Reinhold, New York, 1937, vol. II, p. 346.



the gaseous propylene mix. Because the reaction was exothermic, external cooling was required. Conversion to isopropyl hydrogen sulfate was approximately 50 per cent.

Ethylene, which may have been in the feed gas, did not react under these mild conditions (21 to 27°C. and 85% H_2SO_4). Any higher-molecular-weight olefins present were reacted along with the propylene.

Hydrolysis can be effected in a lead-lined dilution tank by the addition of two to three volumes of water or steam to give a 20 per cent acid concentration. Crude isopropyl alcohol is obtained from this hydrolysis mixture by steam distillation. The dilute alcohol is concentrated by rectification to its constant-boiling mixture, which is 91 volume per cent alcohol. Amyl and sec-butyl alcohols present in the concentrate are removed by a mineral oil wash. Isopropyl alcohol may be further purified by treatment with oxidizing agents such as chlorine or sodium hypochlorite.

Figure 1 represents a generalized flow diagram for the synthesis of isopropyl alcohol.

PATENTED METHODS OF PRODUCTION

Patent literature reflects many modifications to this generalized process for isopropyl alcohol production^{3, 4, 5, 6, *}. More inclusive patents, which cover the hydration of various olefins, frequently contain information on the hydration of propylene^{7, 8, 9, 10, 11}. Other patents describe various methods of feed purification¹², special operating conditions^{13, 14}, and similar modifications.

Ledwoch, Moos, and Schultze¹⁵, Itakura¹⁶, and Katuno¹⁷ have investigated the relationships of pressure, temperature, acid concentration, and reaction time and the nature and quantity of the products formed in the reaction of propylene with sulfuric acid. Hydrolysis of propylene-sulfates to isopropyl alcohol has been studied by Schrage and Amick¹⁸. Kazarnovskii and Kozlov (et al.) have investigated various methods for analyzing and reducing the amount of

*This chapter does not contain a complete patent survey. Those cited are representative of the patents in the area.

3. Direccion General de Yacimientos Petroliferos Fiscales, Arg. Pat. 55,341 (1943).
4. Howlett, J., and Wood, W. L., Distillers Company, U. S. Pat. 2,533,808 (1950); C. A. 45, 4261f (1951); Brit. Pat. 642,905 (1950); C. A. 45, 7135h (1951); Can. Pat. 513,390 (1955); Fr. Pat. 964,194 (1950).
5. Smith, B. I., Standard Oil Development Company, U. S. Pat. 2,541,673 (1951); C. A. 45, 5711f (1951); Brit. Pat. 652,624 (1951); C. A. 46, 1023c (1952); Can. Pat. 522,620 (1956); Fr. Pat. 968,179 (1950); Ger. Pat. 938,547 (1956).
6. Amick, E. H., Standard Oil Development Company, U. S. Pat. 2,609,400 (1952); C. A. 48, 2757a (1954); Brit. Pat. 715,483 (1954); C. A. 50, 1074a (1956); Fr. Pat. 1,048,480 (1953).
7. E. I. du Pont de Nemours and Company, Brit. Pat. 448,457 (1936).
8. Schneider, H. G., and Archibald, F. M., Standard Alcohol Company, Can. Pat. 402,544 (1942).
9. Guinot, H. M., U. S. Pat. 2,345,114 (1944); C. A. 38, 3664^g (1944).
10. Groombridge, W. H., and Page, R., U. S. Pat. 2,365,264 (1944); C. A. 39, 4082^a (1945); Brit. Pat. 563,885 (1944); C. A. 38, 3124^g (1944); Can. Pat. 443,785 (1947).
11. Hunter, W., Celanese Corporation of America, U. S. Pat. 2,529,553 (1950); C. A. 45, 2966a, (1951); Brit. Pat. 606,608 (1948); C. A. 43, 4692i (1949).
12. Giraitis, A. P., and Fuqua, M. C., Standard Oil Development Company, U. S. Pat. 2,657,243 (1953); C. A. 48, 12165g (1954).
13. Schneider, H. G., and Mistretta, V. F., Standard Oil Development Company, U. S. Pat. 2,473,224 (1949); C. A. 43, 6645g (1949).
14. Mention, M., and Alheritiere, L., Usines de Melle, Fr. Pat. 1,135,432 (1956); C. A. 51, 12955c (1957).
15. Ledwoch, K. D., Moos, J., and Schultze, G. R., Erdol u. Kohle, 6, 687 (1953).
16. Itakura, T., J. Chem. Soc., Japan, 63, 1400 (1942); C. A. 41, 3041g (1947).
17. Katuno, M., J. Chem. Soc., Japan, 43, 5B (1940).
18. Schrage, R. W., and Amick, E. H., Jr., Ind. Eng. Chem., 42, 2550 (1950).