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Review on Economics for Propylene Glycol and Plant Design

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Abstract: *One of the most promising processes for biomass conversion to chemicals is the hydrogenolysis of glycerol to propylene glycol. Conventional hydrogenolysis operations, on the other hand, are frequently carried out at high H2 pressures and temperatures, resulting in high energy demands, rapid catalyst deactivation, and possible safety issues during H2 handling. The energy and atom efficiency of catalytic transfer hydrogenolysis (CTH) are both high. For the CTH of glycerol, we investigated a number of new solid catalysts. Detailed studies on energy optimization, tech- economic analysis, and environmental impact for both processes have been undertaken as part of this endeavors. The most important discovery is that the CTH process requires substantially less energy and capital expenditure. In the case of transfer hydrogenolysis, CO2 emissions per unit of propylene glycol are substantially lower. The findings of this research could be valuable in the development and deployment of novel hydrogenolysis technologies for additional energy and environmental applications. In laboratory scale studies, a Cu-ZnO-Al2O3 catalyst was shown to effectively generate propylene glycol from glycerol utilizing a liquid phase hydrogenolysis process at 410 F and 580 psia. To achieve complete contact of the liquid and vapor phases with the solid catalyst, a trickle-bed reactor will be used. This research intends to scale up this reactor model, which has only been tested in bench scale so far. This process is expected to produce 100 million pounds of propylene glycol per year, according to the design specifications. Propylene glycol (PG) is a very versatile chemical that is utilized in a wide range of industrial applications, including transportation, building, and food and pharmaceutical manufacturing. Propylene glycol of pharmaceutical (USP) grade is at least 99.5 percent pure by weight and is utilized in health-related items such as food, personal care products, cosmetics, and medications. PG from propylene oxide is the principal method for producing propylene glycol in the current context. Other ways for producing Propylene glycol, such as PG from lactic acid and Propylene glycol from glycerol, are also employed. Because of the rising demand for propylene glycol, new ethylene manufacturing methods are required. Due to the major study of producing Propylene glycol with strong selectivity and conversion, the direct conversion of propylene oxide to Propylene glycol technique has been under active research over the past 15-20 years. Our project's goal was to assess all three ways of production and construct a facility for the most efficient procedure.*

Keywords: Glycerol, Propylene Glycol, Hydrogenolysis, Cu-ZnO-Al2O3, CTH.

I. INTRODUCTION

Propylene glycol (also known as 1,2-propanediol) is a very versatile chemical that is utilized in a wide range of industrial applications, including transportation and construction, as well as food and pharmaceutical manufacturing. Propylene glycol of pharmaceutical (USP) grade is at least 99.5 percent pure by weight and is utilized in health-related items such as food, personal care products, cosmetics, and medications. The FDA closely regulates USP grade propylene glycol due to its very sensitive applications, and producers must adhere to tight rules to maintain the quality and purity of their product. Propylene glycol, which is used in aircraft de-ice, antifreeze, and braking fluid, is at least 95% pure and is a significant participant in the transportation business. It's also a key ingredient in unsaturated polyester resins (UPRs), which are used to manufacture fiber glass reinforced plastics in the building sector (1).

In this context, hydrogenolysis of polyols to glycols and alcohols could provide alternate synthetic routes and reduce the need for energy-intensive conversion processes involving hydrocarbons. Hydrogenolysis of glycerol, a biodiesel by-product,

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can create propylene glycol (PG), 1,3-propanediol, ethylene glycol (EG), and propanol's, which can be used in antifreezes, polyesters, medicines, and solvents, among other things. This is one of the most popular topics, with substantial research being conducted in both academia and industry. Glycerol hydrogenolysis, on the other hand, is frequently carried out at high temperatures and pressures (>230°C, >4 MPa). Actually, this method is still significantly reliant on fossil-derived H2, with inefficient investments in H2 compression, recycling, and process equipment manufacturing (2).

Catalysed transesterification is a typical method for producing biodiesel. As a result of this type of reaction, for every 9 tons of biodiesel generated, another ton of glycerol is produced as a by-product, lowering glycerol costs globally. The more biodiesel produced the more glycerol is produced as a by-product. Lower glycerol prices have an impact on biodiesel production because it can be sold after purification. The ability to increase the profitability of biodiesel manufacturing plants by generating added value products utilize glycerol as a raw material source would have a significant impact for the biofuels sector, making it nearly as profitable as Petro fuels. Contributing to the establishment of circular economy biorefineries by increasing the availability of carbon-neutral commodity chemicals (3).

The method for producing propylene glycol described here is divided into three sections: a pre-treatment section, in which crude glycerol purchased from biodiesel manufacturers is desalted by electrode ionization for feed to the reactor; a reactor section, which contains a trickle-bed reactor packed with an alumina-supported catalyst for glycerol reaction; and a separation section, in which the product is purified to 99.5 percent purity (USP grade). Overall, this approach outlines a viable, unique method of producing propylene glycol while lowering the negative environmental effects of previous methods. It is expected to become a standard industrial process in the near future (1).

II. Process Background

Propylene glycol is an organic chemical that is used in the manufacture of polyester and as a de-icing base solution. Apart from that, propylene glycol is a liquid material that can absorb water. Propylene glycol has numerous applications in our daily lives. Propylene glycol is most commonly employed as an antifreeze in the chemical, food, and pharmaceutical industries when leakage could result in contact with food. Propylene glycol is also a safe food additive that helps pharmaceuticals, cosmetics, and food products retain moisture by absorbing excess water. Propylene glycol is also utilized in food as a coloring and flavoring agent. Propylene glycol can be used to create fake smoke or fog, for example, in firefighting training purpose. Propylene glycol is a clear, colorless liquid that is slightly syrupy at room temperature. Propylene glycol is an odorless and tasteless chemical that can also exist as a vapor in the air.

Apart from cosmetics and personal care, propylene glycol has the most uses in the food industry, according to (Market Research Future, 2019). Propylene glycol is in high demand in the pharmaceutical, automotive, and building and construction industries. Propylene glycol is used in a variety of industries, including unsaturated polymer resin and end- use industries such as food, personal care, pharmaceuticals, and detergents. As a result, as illustrated in Figure 1, propylene glycol is in great demand in the industry (4).

The propylene glycol market grows every year, as illustrated in (Ameri Research Inc., 2017). Because propylene glycol is widely utilized, its demand is rising, particularly in the manufacture of unsaturated polyester resin, followed by the manufacture of personal care products. Figure 2 depicts the annual increase in propylene glycol demand. The price of propylene glycol is expected to rise from 2017 to 2024 (5).

III. Market Study & Demand

In the projection period of 2021 to 2028, the propylene glycol market is predicted to increase at a rate of 6.1 percent. The propylene glycol market study examines the present growth, which is being fuelled by the expansion of several end-user industries. Propylene glycol is a viscous, colourless, hydroscopic liquid with a slight pleasant taste and a low level of toxicity. Propylene oxide and water react chemically to produce this substance. The expanding automotive sector in various nations, as well as the growing demand for petroleum-based propylene glycol, are likely to propel the propylene glycol market forward throughout the forecast period. obstruct the propylene glycol market's growth during the timeline. This propylene glycol market report details recent developments, trade regulations, import-export analysis, production analysis, value chain optimization, market share, impact of domestic and localized market players, analyses opportunities in terms of emerging revenue pockets, changes in market regulations, strategic market growth analysis, market size, category market growths, application niches and dominance, product approvals, product launches, geographic analysis, and more. Contact Data

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Bridge Market Research for an Analyst Brief to learn more about the propylene glycol market. Our team will assist you in making an informed market decision to achieve market growth (6).

IV. MARKET SIZE & SCOPE

The propylene glycol market is segmented on the basis of source, grade and end use industry. The growth amongst the different segments helps you in attaining the knowledge related to the different growth factors expected to be prevalent throughout the market and formulate different strategies to help identify core application areas and the difference in your target markets

On the basis of source, the propylene glycol market is segmented into petroleum-based propylene glycol, bio-based propylene glycol. Petroleum-based propylene glycol is further sub segmented into propylene oxide. Bio-based propylene glycol is further sub segmented into glycerine and sorbitol. 2. On the basis of grade, the propylene glycol market is segmented into antifreeze and functional fluids, unsaturated polyester resin, food and beverage, pharmaceuticals and cosmetics, plasticizers, liquid detergents. Antifreeze and functional fluids is further sub segmented into hydraulic and brake fluid, aircraft de-icing fluid, automotive coolants and heat transfer fluid. Unsaturated polyester resin is further sub segmented into reinforced thermoset and non-reinforced thermoset. Reinforced thermoset is further sub segmented into sheet moulding compounds, reinforced plastic laminates and electrical components. Non-reinforced thermoset is further sub segmented into synthetic marble casting and gel coats. Food and beverage fluids is further sub segmented into dairies. Pharmaceuticals is further sub segmented into dental care and therapeutic drugs and medicines. Cosmetics is further sub segmented into skincare. Plasticizers is further sub segmented into phenolic resin and cellophane film. Liquid detergents is further sub segmented into household and dishwashing and industrial soaps and cleaning fluids. 3. On the basis of end use industry, the propylene glycol market is segmented into building and construction, pharmaceuticals and cosmetics, transportation and food and beverage. Transportation is further sub segmented into aerospace, automotive and marine

The market demand is expected to reach an estimated volume of 3.5 million metric tons by 2026. The demand is driven by the growing personal and household care industries in almost all the regions like the Asia Pacific, North America, and Europe, among others. The demand growth in these markets is also supporting the growth of the propylene glycol market. The Asia Pacific region is a significant consumer market, accounting for more than 40% of global consumption. China is the primary consumer market within the region. The Asia Pacific region is also a leading supply market and is the net exporter of the product. However, if the intra trade to regions like Thailand, Korea, China, and Singapore is excluded, then the Asia Pacific becomes a net importer of propylene glycol. The region is likely to increase its imports from the United States and the Middle East in the coming years due to planned capacity reduction in the forecast period. North America is a major exporter to the Asia Pacific due to the rising demand for unsaturated polyester resins in the region. The United States is the leading exporter in North America, with most of its exports of propylene glycol being bound towards the Republic of Korea, China, and Brazil. Europe is a significant market for the product, with Germany being the major exporting country within the region. The demand is rising within the region due to the growing demand for functional fluids. The region is also witnessing an increasing import demand for industrial grade propylene glycol (PGI). The demand for PGI increases sharply during winters, owing to the demand from de-icing and anti-freeze segments. Europe also exports to China and the Republic of Korea, where the demand is growing rapidly (7).

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