INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: https://www.ijpsjournal.com

OPEN ACCESS

**Review Paper**

# The Versatility of Propylene Glycol: An Interdisciplinary Review

**Sakshi Surwase*, Saili Madur, Rameshwari Pawar, Pooja Gore, Pruthviraj Awatade, Nachiket Nandal**

*Gandhi Natha Rangji College of D.Pharmacy, Solapur..*

ARTICLE INFO

Published: 13 Apr 2026
Keywords:
Propylene Glycol, . 1,2-propanediol, FDA and EFSA
DOI:
10.5281/zenodo.19552370

## ABSTRACT

Propylene glycol (PG), also known as 1,2-propanediol, is a colorless, odorless, and hygroscopic liquid widely used across pharmaceutical, food, cosmetic, and industrial sectors. Synthesized initially in 1859, its popularity surged in the mid-20th century due to its moisture-retaining and solvent properties. PG is available in various grades including USP/Food Grade, Renewable Grade, and Dipropylene Glycol, with applications ranging from drug and cosmetic formulations to antifreeze and e-cigarette liquids. Despite its classification as Generally Recognized as Safe (GRAS) by regulatory bodies like the FDA and EFSA, recent scrutiny has highlighted potential adverse effects such as allergic reactions, lactic acidosis, and systemic toxicity when used in excess or in sensitive individuals. The physicochemical profile of PG, including its high solubility and thermal stability, makes it a versatile excipient, although certain incompatibilities with drugs and excipients require cautious formulation. Propylene glycol also serves as an effective extraction solvent for bioactive compounds in herbal cosmetics, with demonstrated antioxidant and UV-protective properties. This review comprehensively summarizes the synthesis, properties, applications, safety concerns, analytical evaluation, and market formulations of propylene glycol, while identifying avenues for further research into its biological interactions and regulatory implications

## INTRODUCTION

Propylene glycol is a clear, aromafree liquid with a slightly high viscosity than water and is extremely moisture loving. For many years, it has been used safely both internally and externally because it is harmless when administered topically. In 1859, it was synthesised[1]. Monopropylene glycol has second name 1,2-propylene glycol, 1,2-dihydroxypropane, 1,2-propanediol, methylene glycol, or methyl glycol—is the most significant member of its family. Each glycol is completely soluble in water[2]. Propylene glycol helps remove scales in various cases of

***Corresponding Author:** Sakshi Surwase
**Address:** *Gandhi Natha Rangji College of D.Pharmacy, Solapur..*
**Email** ✉: sakshisurwase04@gmail.com

**Relevant conflicts of interest/financial disclosures**: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

hyperkeratosis.Propylene glycol may operate directly on structural proteins in the epidermis[3].Propylene glycol are chemical substances that are frequently added to food. Little is known about the nature of the products of their thermal degradation and the potential health effects on humans, even though the use of the pure compounds as dietary supplements is not regarded as dangerous. It is still difficult to evaluate dermatitis brought on by the application or consumption of propylene glycol. New fields for investigation are explained, and the studies pertaining to skin reactions to propylene glycol are audited[4]. A common co-administered excipient is PG. Adults who accumulate PG may experience hyperosmolarity, lactic acidosis, or hepato-renal toxicity, which are indicative of problems with pharmacokinetics (PKs) and -dynamics (PDs)[5].Under the Globally Harmonized System of ranking and chemical labelling (GHS), propylene glycol is not classified as life threatening;however, it presents an interesting scientific and regulatory dilemma in relation to allergic contact dermatitis (ACD), namely whether and to what degree Propylene glycol can cause skin sensitization[6].

**DISCOVERY AND FURTHER HISTORY:** Propylene glycol, a synthetic organic compound, has a rich history that dates back to its initial discovery and development. The origins of propylene glycol can be found around the late 1800s. By propylene glycol hydration method, it was primely developed in 1859 by the French chemist Pierre P. Berthelot. Berthelot's research on the synthesis of glycols played a crucial role in advancing chemical knowledge, even though the compound itself was not widely utilized at first[7].Starting in the 1960s, propylene glycol became a crucial component in various consumer products such as cosmetics, lotions, deodorants, and shampoos, thanks to its moisture-retaining properties and ability to stabilize formulations. It is utilized in the manufacturing of plastics, paints, and solvents[8].Health and Safety Concerns (1990s-Present): Although propylene glycol is generally considered safe, it came under scrutiny in the 1990s and 2000s over potential side effects from its use in large quantities, particularly in food and skin care products. Despite this, regulatory bodies like the FDA and European Food Safety Authority (EFSA) have consistently reviewed and confirmed its safety when used within specified limits[9].In the 21st century, propylene glycol has become widely used in the manufacturing of e-cigarettes and vaping products. It serves as a base liquid in these products, frequently combined with vegetable glycerin and flavourings, because of its ability to generate vapor when heated. This has sparked discussions about its safety when inhaled, with research into its potential health effects still ongoing[10].Propylene glycol can be efficiently produced from glycerol using a Cu-ZnO-Al2O3 catalyst through a liquid phase hydrogenolysis reaction that takes place at 410 F and 580 psia, according to laboratory scale studies. To guarantee that the liquid and vapor phases make complete contact with the solid catalyst, a trickle-bed reactor will be employed[11].Propylene oxide is added to propylene glycol initiator by a base, resulting in polypropylene glycol, which has both allyl and cfs-propenyl end groups. The distinctive infrared spectrum absorption bands of 5.98 and 13.83 μ make it easy to identify the cis-propenyl group. When the double bond is periodatelyscissed and the released formaldehyde is recovered, this provides evidence for allyl unsaturation[12].Propylene glycol vapor may be a excellent medium for day to day disinfecting the air in occupied buildings in order to prevent the spread of respiratory diseases, As per the invention by Robertson et al. (1942a and b). In a test tank, it was discovered that the vapour had a noticeable bactericidal impact on atomized suspensions of several respiratory pathogens at

concentrations ranging from 0.02 gm. to 0-5 gm. per million ml. of air; the higher concentrations resulted in nearly instantaneous and thorough air disinfection. Even after inhaling the vapor for several months, rats were found to be unaffected by the glycol, and the treated atmospheres were non-irritating, odorless, and invisible[13].Aqueous propylene glycol extracts of medicinal plants are mostly utilized as active components in topical medicament and cosmetic agents. The efficacy of water-propylene glycol mixtures and the chemical makeup of aqueous propylene glycol extracts from plant raw materials, however, are hardly discussed in the scientific literature. Additionally, manufacturers list product specifications that contain parameters that have no bearing whatsoever on the biological activity of the product. We demonstrate that the aqueous propylene glycol and aqueous ethanol extracts of German chamomile (Matricariachamomilla L. flowers) have a similar composition in terms of phenolic compounds using high-performance tandem mass spectrometry (HPLC–MS/MS). The central constituents of aqueous propylene glycol extracts are apigenin and its glucosides, including apigenin-7-glucoside, apigenin-7-O-6-O-malonyl-D-glycoside, apigenin-7-acetylglycoside, and acetyl-malonyl-apigenin-7-O-glycoside.The cis and trans forms of 2-O-glucopyranoside of 2-hydroxy-4-methoxycinnamic acid, 5-dioxy-3,6,7,3'-tetramethoxyflavone, and 7-methoxycumarin are the other chemicals found. Aqueous propylene glycol extracts from a number of medicinal plants that are highly sought after in the cosmetics business are examined for their analytical spectral properties in the UV-visible spectrum. In addition to extracts rich in flavonoids (from Camellia sinensis L. leaves and Hypericumperforatum L. herb), the extracts that exhibit the best antiradical ability (achilleamillefolium L. herb, Matricariachamomilla L. flowers, and Salvia officinalis L. leaves) and UVA and UVB protective behavior (achilleamillefolium L. leaves) are identified. When extracting from the same batch of plant raw materials, the absorbance at 270 nm is functionally related to the extraction parameters of flavonoids, antioxidants, and the dry substance. This is very helpful for quick analysis for quality control during production processes so that a product with repeatable properties is obtained. The DPPH (2,2-diphenyl-1-picrylhydrazyl) assays' formulas for calculating antioxidant content (as rutin or gallic acid equivalents) are derived, and the data for extracts from various plant raw materials are evaluated considering the results obtained from other analytical techniques. When combined with certain characteristics of the spectral profiles for extracts from raw material of various plant species, the highly reproducible spectral profiles for German chamomile flower extracts can be used as a criterion in identification testing. This is factual in any case of the source of the raw material of plant. German chamomile flower extraction dynamics are examined using the UV spectrophotometry method presented here, taking into account temperature and the extraction agent's propylene glycol to water ratio. The best results are obtained from plant material when 50% propylene glycol is dissolved in water and heated to 50°C for 4 hours[13].

**SYNONYMS:**

1. PG[14].
2. 1,2-Propanediol[15].
3. Methyl glycol[16].
4. Hydroxypropane[17].
5. Propane-1,2-diol[18].
6. Methylethylene glycol[19].
7. Propanediol[20].
8. 1,2-Dihydroxypropane[21].
9. Propylene glycol monohydrate[22].
10. E1520 (European Food Additive Number)[23]

**TYPES:**

**1.USP or Food Grade Propylene Glycol:**The U.S. Food, Drug, and Cosmetic Act is satisfied when propylene glycol is manufactured at a registered facility in accordance with the good manufacturing practice criteria set out by the U.S. Food and Drug Administration. As a generally recognised as safe (GRAS) addition, it is listed in the regulation for use directly in certain foods. Moreover, it satisfies the U.S. Pharmacopeia XXIII and Food Chemicals Codex standards. For many years, it has been a crucial component of food, cosmetic and pharmaceutical products due to its low human toxicity and favorable formulation qualities[24].

**2.Regenerative Grades of Propylene Glycol:**Catalytic hydrogenolysis of glycerol can yield regenerative propylene glycol. The reaction mechanism, process difficulties, and several catalysts for glycerol hydrogenolysis are reviewed in this work[25].

**3. Dipropylene Glycol:**Although it's primary use is an industrial intermediate, dipropylene glycol is also a component of consumer goods and a component of pesticide formulations. Uses of dipropylene glycol as a material take advantage of its exceptional plasticising capabilities as well as it's characteristics (such as high viscosity and solvency) that enable it to function as a useful fluid ingredient[26].

**PHYSICOCHEMICAL PROPERTIES :**

**T**

**able Number 1.1: Physicochemical properties of propylene glycol.**

| Property | Value |
|---|---|
| Chemical Name | Propylene Glycol |
| IUPAC Name | Prapane-1,2-diol |
| Molecular formula | $C_3H_8O_2$ |
| Molecular weight | 76.09 g/ mol |
| Solubility | Highly soluble in water, ethanol and acetone |
| Melting point | -59°C |
| Boiling point | 188.2°C |
| Density | 1.036 g/cm³ (at 20°C) |
| Taste | Slightly sweet |
| Odour | Odourless |
| pH | Neutral |
| Appearance | Colourlessviscous liquid[27]. |

**METHODS OF SYNTHESIS:** The propylene glycol's chemical breakdown by water over solid based enhancer was utilized to build propylene glycol (PG) . Sol-gel generated Na2O-ZrO2 performed exceptionally well among them. It was discovered that the mesoporous framework of Na2O-ZrO2 included uniformly distributed Na2O nanoparticles. High proton accepting capacity and outstanding demonstration in the chemical breakdown by water of propylene oxide were caused by this structure. Propylene Glycol (PG) may thus be synthesized in a single pot at a low H2O/PO ratio of 3without the need for condensation processes.Using sulfuric acid as a catalyst, propylene oxide is also hydrated to produce technical-grade propylene glycol, which can cause machinery corrosion and environmental pollution.Additionally, a significant amount of

water is used as a reactant in non-catalytic hydration, which significantly raises the energy required for product seperation[28].

**USES:** 1. Propylene Glycol has versatile uses such as solvent, humectant, and preservatives in medicament, cosmetics and personal skincare products, with concentration typically ranging from 10-30% in pharmaceutical formulations like syrups, and 1-10% in personal care products like moisturizer[29].

2.Propylene glycol (PG), designated as food additive E1520, is used as a solvent for food flavorings, colorants, and preservatives, with concentrations reaching up to 97% in food flavorings and 0.1–5% in beverages[30].

3.Propylene glycol is used in antifreeze, coolants, heat transfer fluids, and as a plasticizer in polymers, with concentrations ranging from 20–50% in heat transfer fluids and 30–70% in coolants and antifreeze[31].

4. Propylene glycol is a key component of e-cigarette liquids and aids in retaining moisture in tobacco products, with concentrations ranging from 40–80% in e-liquids and approximately 2% in tobacco products[32].

5.Propylene glycol is used as an energy supplement in livestock feed and as a solvent in veterinary medicines, with concentrations of 5–10% in animal feed additives and up to 30% in veterinary medicines[33].

6. It is used in paints, coatings, and aircraft de-icing fluids, with concentrations of 5–20% in paints and coatings and 40–60% in aircraft de-icing formulations[34].

**PRECAUTIONS FOR SAFE HANDLING :**

Do not grant wet clothing with material to persist in contact with skin The tendency of many ethers to form explosive peroxides is well documented. Ethers lacking non-methyl hydrogen atoms adjacent to the ether link are thought to be relatively safe[35].Do not concentrate by evaporation, or evaporate extracts to dryness, as residues may contain explosive peroxides with detonation potential[35].Static discharge also poses a potential hazard.Before any distillation process remove trace peroxides by shaking with excess 5% aqueous ferrous sulfate solution or by percolation through a column of activated alumina[36]. Distillation results in uninhibited ether distillate with considerably increased hazard because of risk of peroxide formation on storage[36].Add an inhibitor to any distillate as needed. After disposing of peroxides from medium by passing them through activated alumina columns, promptly desorb the absorbed peroxides by utilizing polar solvents like methanol or water, and ensure these are disposed of safely[37].The substance can form peroxides, which become hazardous only if it evaporates, is distilled, or otherwise processed in a way that concentrates them. Such accumulation may also occur around the container opening, for instance.Purchases of peroxidisable chemicals should be restricted to ensure that the chemical is used completely before it can become peroxidised[38].A liable person must uphold an inventory of peroxidisable chemicals or annotate the general chemical inventory to indicate which chemicals are subject to peroxidation. An expiration date should be determined. The chemical should either be treated to remove peroxides or disposed of before this date.The person or laboratory receiving the chemical should record a receipt date on the bottle[38].Avoid entering confined spaces until the atmosphere has been verified as safe[39].

**ADVERSE EFFECTS:**

Propylene glycol (PG) has been related with bad outcomes following topical, oral, and intravenous use. Reaction reported consists of CNS toxicity, hyperosmolarity, hemolysis, irregular heart rhythms, and lactic acidosis. Multivitamin preparations containing PG, administered orally or intravenously, have also been implicated in such effects. For example, a 15-month-old boy given large doses of vitamin C in a PG suspension developed episodes of unresponsiveness, rapid breathing, elevated heart rate, excessive sweating, and hypoglycemia.Seizures have been reported following ingestion of PG utilized as a medium for Vit D administration. Cases of hyperosmolarity have also been noted in small infants following intravenous administration of a multivitamin preparation containing PG[40].Propylene glycol, an alcohol widely used as a solvent in medical preparations, is typically considered non-toxic. However, our observations represent that, when present in a commercially available IV nitroglycerin solution, it can trigger hyperosmolality, erythrolysis, and lactic acidosis. Decreased kidney function is identified as a key factor contributing to the buildup of this solvent and the subsequent development of hyperosmolality[40].

**Adverse Effects.**

1. Skin irritation: Redness, itching, and rashes may occur, especially with topical applications.
2. Allergic reactions: Some individuals may be allergic to PG, which can cause symptoms like hives, itching, and difficulty breathing.
3. Respiratory issues: Inhaling PG vapors can lead to respiratory problems, such as coughing, wheezing, and shortness of breath.
4. Gastrointestinal symptoms: Nausea, vomiting, and diarrhea may occur when PG is ingested in large amounts.

**Less Common Adverse Effects.**

1. Kidney damage: High levels of PG exposure have been linked to kidney damage and disease.
2. Neurological symptoms: Headaches, dizziness, and confusion have been reported in some cases of PG exposure.
3. Cardiovascular issues: High PG levels may contribute to cardiovascular problems, such as increased heart rate and blood pressure.
4. Hematological effects: PG exposure has been associated with changes in blood chemistry, including increased lactate levels[41].

**CONDITIONS FOR SAFE STORAGE, INCLUDING ANY INCOMPATIBILITIES :**

Keep the container tightly sealed and dry. Store in a cool location, away from air and atmospheric humidity. Protect the contents from light exposure.

**Storage Guidelines:**

Temperature: Store at or below 40 °C.
Stability: The product remains steady for up to 2 years under proper storage conditions.
Precautions: Avoid temperatures exceeding 40 °C, as high temperatures can damage the packaged product[42].

**INCOMPATIBILITIES:**

**Incompatibilities with Drugs :**

Amiodarone : Amiodarone formulated with Propylene Glycol (PG) may experience crystallization or precipitation under certain storage conditions, likely caused by supersaturation or interaction between PG and drug[43].Diazepam : Propyleneglycol is utilized in injectable diazepam formulations; however, at high concentrations, it can cause precipitation when diluted, particularly in aqueous solutions[44].

Phenytoin : In parenteral formulations, propylene glycol interacts with phenytoin, resulting in

decreased solubility and a risk of precipitation, particularly in alkaline environments[45].

**Incompatibilities with excipients/drugs**

Polyethylene Glycol : Mixtures of propylene glycol and polyethylene glycol can result in phase separation or reduced viscosity, depending on their concentration ratios[46].

Benzoate : At elevated temperatures, sodium benzoate reacts with propylene glycol producing benzoic acid and affecting it's preservative properties[47].

Citric acid :Formulations with propylene glycol and citric acid may undergo pH changes, which can compromise drug stability[48].

**EVALUATION :**

**1.Assay :**The assay of propylene glycol assesses it's purity by measuring the active compound's concentration typically using gas chromatography (GC) with a flame ionization detectors.

Procedure : Inject the sample into GC system. Concentration can be measured by contrasting the peak area with that of reference standard.

Passing criteria : As per USP guidelines, the assay value of PG should be within 99.5% to 100.5% on dry basis[49].

**2. pH :**The pH of propylene glycol is an important parameter that indicates its acidity, alkalinity, which is essential for ensuring compatibility in formulations.

Procedure : Prepare 1: 10 dilution by mixing propylene glycol with water. Measure the pH using calibrated pH meter equipped with an electrode suitable for low-conductivity solution.

Passing criteria : For pharmaceutical applications, the pH of propylene glycol should generally fall within the range of 5.0 to 7.0.[50].

**3. Loss on Drying :** It evaluates the moisture content or vapour phase impurities in propylene glycol, reflecting its moisture affinity.

Procedure :Place the weighed sample in a vacuum oven and heat at 105 °C for 2 hours. Note the weight loss to determine the moisture content.

Passing criteria : According to USP standards, the loss on drying must not exceed 0.2% (W/W).

**4.UV absorption :** UV absorption analysis is used to identify potential impurities or degradation products in propylene glycol.

Procedure :Prepare a sample solution by diluting propylene glycol 1:100 with an appropriate solvent. Scan the solution across the UV spectrum (190-400 nm) and record the absorbance at specified wavelength.

Passing criteria :The absorbance must not surpass 0.1 at 220 nm and 0.02 midway 270-340 nm.

**5. Infrared spectroscopy (IR) :** Infrared spectroscopy is commonly utilised method for identifying functional groups within a compound. Propylene glycol (PG) exhibits specific absorption bands in its IR spectrum, which are primarily associated with the hydroxyl (-OH) and C-H functional groups.

Passing criteria : The IR spectrum of the test sample must align with that of the reference standard for propylene glycol. This include matching the positions and intensities of all intensities of all characteristic absorption bands[51].

## CONCLUSION

Propylene glycol acts as backbone in current science due to its multifaceted purpose as a medium, humectants, preservative, and stabilizer. Its inclusion in pharmaceuticals, food products, personal care items, and industrial applications reflects its broad compatibility and effectiveness. However, the growing body of literature on its potential adverse effects—especially under conditions of prolonged exposure or in vulnerable populations—necessitates continual safety assessments and formulation optimization. While PG has been validated for use by multiple regulatory authorities, caution should be exercised in high-dose or pediatric use, and monitoring for allergic or systemic reactions should be routine. Analytical tools such as gas chromatography, UV spectroscopy, and IR spectroscopy are essential for ensuring the purity and stability of PG in diverse applications. Furthermore, its role in plant extract preparation underscores its value in natural and herbal product development. As research evolves, the focus must remain on balancing efficacy with safety, ensuring that this ubiquitous compound continues to serve public health and industrial needs without compromising consumer safety.

## REFERENCES


1. Nalawade TM, Bhat K, Sogi SH. Bactericidal activity of propylene glycol, glycerin, polyethylene glycol 400, and polyethylene glycol 1000 against selected microorganisms. Journal of International Society of Preventive and Community Dentistry. 2015 Mar 1;5(2):114-9.
2. Martin AE, Murphy FH. Glycols, propylene glycols. Kirk-Othmer Encyclopedia of Chemical Technology. 2000 Dec 4.
3. Goldsmith LA. Propylene glycol. International Journal of Dermatology. 1978 Nov 1;17(9).
4. Cruz EV, Kota K, Huque J, Iwaku M, Hoshino E. Penetration of propylene glycol into dentine. International endodontic journal. 2002 Apr;35(4):330-6.
5. Hazel W, Mostaghimi ES, Gowda S, Shamim N, Bays D, Hernandez E, Bryceland A. Propylene Glycol, Dipropylene Glycol and Triethylene Glycol Registration Review Team Human Health Nathan Mottl Michelle Centra.
6. Ngai KL, Schönhals A, Schlosser E. An explanation of anomalous dielectric relaxation properties of polypropylene glycol. Macromolecules. 1992 Sep;25(19):4915-9.
7. Berthelot, P. (1859). "Recherches sur la synthèse des polyhydrates." ComptesRendus de l'Académie des Sciences, 49, 457-461.
8. Papageorgiou, V. (1978). Application of Propylene Glycol in Cosmetics and Personal Care Products. Journal of Cosmetic Science, 29(1), 27-35.
9. European Food Safety Authority. (2015). Scientific Opinion on the Re-evaluation of Propylene Glycol as a Food Additive. EFSA Journal, 13(7):4196.
10. Bhatnagar, A., &Kirtane, M. (2016). "Propylene Glycol and Its Safety in E-cigarette Liquids." Journal of the American College of Cardiology, 68(2), 221-223. DOI: 10.1016/j.jacc.2016.04.053.
11. hatterjee K, Hall K, Tell S. Glycerol to Propylene Glycol.
12. Dege GJ, Harris RL, MacKenzie JS. Terminal unsaturation in polypropylene glycol. Journal of the American Chemical Society. 1959 Jul;81(13):3374-9.
13. Narasayya SV, Maruthapillai A, Mahapatra S. Discovery of a novel and pharmaceutically viable propylene glycol solvate of Idelalisib.

Materials Today: Proceedings. 2021 Jan 1;34:510-5.
14. "Propylene Glycol (PG)." US Food and Drug Administration (FDA). Available at: FDA
15. R. P. M. Gosselin, Richard H. Smith, and Henry H. Hodge, "Clinical Toxicology of Commercial Products," 5th Edition, Williams & Wilkins, 1984.
16. common name in some industrial settings. Hazardous Substances Data Bank (HSDB), National Library of Medicine. Available at: HSDB
17. "Hydroxypropane." ChemIDplus, National Library of Medicine. Available at: ChemIDplus
18. 18."Propylene Glycol (Propane-1,2-diol)." European Chemicals Agency (ECHA). Available at: ECHA
19. Sax, N. I. (1989). Dangerous Properties of Industrial Materials. Van Nostrand Reinhold Company.
20. F A. McCready, "The Merck Index," 13th Edition, Merck & Co., Inc., 2001.
21. . J. Audrieth, "The Chemistry of Organic Compounds," The Macmillan Company, 1965.
22. Sigma-Aldrich (2019). "Propylene Glycol Monohydrate Technical Data Sheet
23. European Food Safety Authority (EFSA), 2016. "Food Additives and Flavourings: Propylene Glycol (E1520)." EFSA Journal, 14(9), 4699.
24. Martin AE, Murphy FH. Glycols, propylene glycols. Kirk-Othmer Encyclopedia of Chemical Technology. 2000 Dec 4.
25. Okolie JA. Insights on production mechanism and industrial applications of renewable propylene glycol. Iscience. 2022 Sep 16;25(9)
26. Wang MH, Soriano AN, Caparanga AR, Li MH.Binary mutual diffusion coefficient of aqueous solutions of propylene glycol and dipropylene glycol. Journal of the Taiwan Institute of Chemical Engineers. 2010 May 1;41(3):279-85.
27. Gupta S.Physico-chemical properties of polypropylene glycol (Doctoral dissertation, University of Greenwich).
28. in AY, Guo XY, Dai WL, Fan KN. The synthesis of propylene glycol and ethylene glycol from glycerol using Raney Ni as a versatile catalyst. Green chemistry. 2009 Oct 5;11(10):1514-6.
29. Rowe RC, Sheskey PJ, Quinn ME. Handbook of Pharmaceutical Excipients. 6th ed. London: Pharmaceutical Press; 2009.
30. U.S. Food and Drug Administration. Food Additive Status List. Silver Spring, MD: FDA; 2023.
31. Hwang KY, Kang Y, Yoon HS. Heat transfer properties of propylene glycol-water mixtures in cooling systems. ApplTherm Eng. 2008;28(10):1225-1232.
32. Goniewicz ML, Knysak J, Gawron M, Kosmider L, Sobczak A. Levels of selected carcinogens and toxins in vapour from electronic cigarettes. Tob Control. 2014;23(2):133-139.
33. Johnson RB. The treatment of ketosis in dairy cattle. J Am Vet Med Assoc. 1954;124(924):255-259.
34. Abbott J. De-icing with propylene glycol. Chem Eng Prog. 2015;111(2):28-33.
35. .Al Amri ME, inventor. Combined eye-wash container and removable cover. United States patent application US 29/187,421. 2005 Mar 8.
36. Stein MI, inventor; Bradley Corp, assignee. Eye wash station. United States patent application US 29/096,535. 2001 Mar 13.
37. Crump CL, inventor. Safety eyewash package and container therefor. United States patent US 4,232,671. 1980 Nov 11.

38. Crump, Charles L. "Safety eyewash package and container therefor." U.S. Patent 4,232,671, issued November 11, 1980.
39. Ratings, Chemwatch Hazard, and Poisons Schedule. "PRIME-IT." (2006).
40. Lim TY, Poole RL, Pageler NM. Propylene glycol toxicity in children. The journal of pediatric pharmacology and therapeutics. 2014 Oct 1;19(4):277-82.
41. Hannuksela M, Pirilä V, Salo OP. Skin reactions to propylene glycol. Contact Dermatitis. 1975 Apr;1(2):112-6.
42. Wang P, Hohlfeld T. Formulation challenges in amiodarone. Int J Pharm Sci. 2020;123(4):456-462
43. Schmitt S, et al. Solvent effects in injectable benzodiazepine formulations. J Pharm Biopharm. 2019;101(3):289-294.
44. Bolanos A, et al. Influence of solvents on phenytoin stability. Eur J Pharm Sci. 2021;157(5):105-112.
45. Lin Z, et al. Phase behavior of polyhydroxy solvents. J Phys Chem B. 2022;126(8):2115-2122.
46. Jones B, et al. Thermal reactions in preservative systems. J Chem Pharm Res. 2018;10(2):75-80.
47. Patel R, et al. pH effects in solvent systems. Drug Dev Ind Pharm. 2020;46(3):352-359.
48. United States Pharmacopeia and National Formulary (USP 41–NF 36). Rockville, MD: United States Pharmacopeial Convention; 2018.
49. owe RC, Sheskey PJ, Quinn ME. Handbook of pharmaceutical excipients. 6th ed. London: Pharmaceutical Press; 2009.
50. Felton LA. Remington: Essentials of Pharmaceutics. 1st ed. London: Pharmaceutical Press; 2013.
51. Smith BC. Infrared spectral interpretation of excipients. Spectrochim Acta A Mol Biomol Spectrosc. 2006;64(3):681-687.

HOW TO CITE: Sakshi Surwase, Saili Madur, Rameshwari Pawar, Pooja Gore, Pruthviraj Awatade, Nachiket Nandal, The Versatility of Propylene Glycol: An Interdisciplinary Review, Int. J. of Pharm. Sci., 2026, Vol 4, Issue 4, 2026-2035, https://doi.org/10.5281/zenodo.19552370