Estimation of Ethylene glycol, Propylene glycol and Diethylene glycol in Levocetirizine dihydrochloride oral solution 0.5mg/mL by GC-FID

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Key words:

GC-FID, ethylene glycol, propylene glycol, diethylene glycol, oral solution, validation, system suitability, linearity, precision, accuracy, ruggedness.

Abstract:

The present study focuses on the development and validation of a gas chromatography-flame ionization detection (GC-FID) method to accurately quantify ethylene glycol (EG), propylene glycol (PG), and diethylene glycol (DEG) in the L-Cet Oral Solution, which contains Levocetirizine dihydrochloride at a concentration of 0.5 mg/mL. This method employs a straightforward, cost-efficient sample preparation technique, using a water-methanol solution as the diluent. Calibration standards for each analyte were formulated, and their concentrations in the oral solution were assessed under optimized chromatographic conditions. The method was subjected to validation according to International Council for Harmonisation (ICH) guidelines, evaluating critical parameters such as system suitability, specificity, linearity, precision, accuracy, and ruggedness. Linearity was observed for EG, PG, and DEG within the concentration range of 0.020–0.500%, with correlation coefficients exceeding 0.990, indicating strong linear relationships. Precision was assessed by conducting both intra-day and inter-day assays, yielding %RSD values that were well within acceptable limits. Ruggedness was verified by analyzing the samples using multiple instruments, columns, and analysts, all of which produced consistent results. Accuracy was evaluated by spiking samples with known concentrations of EG, PG, and DEG at the limit of quantification (LOQ), 100%, and 500% levels, with recovery values ranging from 98.0% to 102.0%. The method demonstrated no interference from the placebo or excipients, confirming its specificity. This validated method is highly reliable and can be employed for routine quality control testing of EG, PG, and DEG in pharmaceutical oral solutions, ensuring product safety and compliance with regulatory standards..

Aim: The primary objective of this research was to design and validate a rapid, cost-effective, and accurate method for the simultaneous quantification of ethylene glycol, propylene glycol, and diethylene glycol in L-Cet oral solution (Levocetirizine dihydrochloride 0.5 mg/mL). This was achieved using gas chromatography coupled with a flame ionization detector (GC-FID). A simple dilution of the sample with a water-methanol (1:1) solution was employed, providing a reliable approach for analysis. The method was performed on an Agilent 8890 GC-FID system, utilizing a DB-624 column (30 meters in length, 0.530 mm internal diameter, and a 3.0 µm film thickness) with nitrogen as the carrier gas. The flow rate was maintained at 4.7 mL per minute. The oven temperature program started at 80°C with a 1-minute hold, followed by an increase of 6°C per minute to 120°C, where it was held for 6.5 minutes, and then ramped up at 50°C per minute to a final temperature of 240°C, held for 15 minutes. The injector and detector temperatures were set at 240°C and 250°C, respectively. Retention times for ethylene glycol, propylene glycol, and diethylene glycol were found to be 5.24 minutes, 5.96 minutes, and 12.87 minutes, respectively, under these conditions.

Results and Discussion: The method developed for the quantification of EG, PG, and DEG was validated according to ICH guidelines. The validation process included rigorous assessment of system suitability, specificity, linearity, precision, accuracy, and ruggedness. System suitability tests demonstrated that the method consistently met performance criteria, with sharp, well-defined peaks for each analyte. Specificity was confirmed through testing with placebo and excipients, where no interfering peaks were observed, ensuring accurate identification and quantification of the target analytes.

Linearity was evaluated across six concentrations, ranging from 0.020% to 0.500% for each analyte, and the method demonstrated excellent linearity with correlation coefficients exceeding 0.990 for all compounds. This indicated a direct relationship between concentration and detector response. The precision of the method was evaluated through both intra-day and inter-day variability assessments. The %RSD values were found to be within acceptable limits, indicating that the method provided consistent results across multiple runs and over different days.

Ruggedness, a measure of the method's robustness under varied conditions, was assessed by performing the analysis with different instruments, columns, and analysts. Results remained consistent across all variations, further proving the reliability of the method. The accuracy of the method was tested by spiking known amounts of EG, PG, and DEG at the LOQ, 100%, and 500% levels. The recoveries ranged between 98.0% and 102.0%, confirming the method's ability to accurately measure the analytes at different concentration levels.

Overall, the method exhibited excellent performance across all validation parameters, making it suitable for the routine quality control of EG, PG, and DEG in pharmaceutical oral solutions. This is particularly important for ensuring that such solutions meet safety standards and comply with regulatory requirements.

Conclusion: The GC-FID method developed and validated in this study is both robust and reliable for the quantification of ethylene glycol, propylene glycol, and diethylene glycol in L-Cet oral solution. It provides a simple, rapid, and economical solution for routine quality control testing. The method's accuracy, precision, and ruggedness make it a valuable tool for ensuring the safety and regulatory compliance of pharmaceutical oral solutions. By using this method, manufacturers can guarantee that the levels of EG, PG, and DEG in their products are within acceptable limits, contributing to overall product safety and public health.

Introduction

Ethylene glycol is a transparent, odourless, and colourless liquid with a sweet taste. It has a low vapor pressure at ambient temperature, reducing the risk of inhalation exposure. This compound is fully miscible with water, alcohol, and acetone, making it versatile in various

industrial applications [1]. Typically, ethylene glycol is synthesized through the hydrolysis of ethylene oxide, which results in the formation of this valuable compound. With its molecular formula $C_2H_6O_2$ and a boiling point of 197.3°C, ethylene glycol is commonly used in products such as antifreeze, de-icing solutions, plastics, solvents, and coolants [2,3]. Despite its utility, ethylene glycol poses significant toxicity risks, particularly due to its sweet taste, which may lead to accidental ingestion by children or animals. Once metabolized, it produces toxic byproducts such as glycolic acid and oxalic acid, which can lead to severe damage to the central nervous system, cardiovascular system, and kidneys.

Propylene glycol, another clear and colourless liquid, shares similar properties with ethylene glycol, including a mild sweetness and miscibility with water, acetone, and chloroform. Its chemical formula is $C_3H_8O_2$, and it has a boiling point of 188.2°C. This compound is widely used in pharmaceutical formulations, particularly as a solvent in oral, injectable, and topical preparations [4]. Propylene glycol is also a common ingredient in e-cigarette liquids, preferred over ethylene glycol due to its significantly lower toxicity levels.

Diethylene glycol is a hygroscopic, odourless liquid with the chemical formula $C_4H_{10}O_3$ and a boiling point of 244-245°C [5]. It is produced by reacting ethylene oxide with ethylene glycol and is fully miscible with water, alcohol, and acetone [6]. Due to its cost-effectiveness, diethylene glycol has occasionally been used as an illegal substitute for glycerol in pharmaceutical products, leading to cases of poisoning. Several poisoning incidents have been documented globally, primarily due to contamination in medicinal syrups with both ethylene glycol and diethylene glycol, resulting in acute renal failure and, in many cases, death. Regulatory bodies such as the U.S. Pharmacopeia and National Formulary (USP-NF) have introduced stringent limits on ethylene glycol and diethylene glycol to prevent such contamination, ensuring the safety of pharmaceutical products [7][8][9].

By employing a method like the one developed in this study, quality control measures can be strengthened to detect and prevent such harmful substances in pharmaceutical products.

Materials and Method

The section on "Materials and Methods" provides detailed insights into the chemicals, reagents, solution preparations, and chromatographic conditions utilized in the study for the simultaneous determination of ethylene glycol (EG), propylene glycol (PG), and diethylene glycol (DEG) in L-CET oral solution via GC-FID.

Chemicals and Reagents:

- **Standards**: Ethylene glycol, propylene glycol, and diethylene glycol were sourced from Oman Pharmaceutical Products Co. L.L.C.
- **L-CET oral solution**: Contains levocetirizine dihydrochloride (0.5 mg/mL).
- **Solvents**: LC-MS grade water (Fischer Chemical) and HPLC-grade methanol (Sigma-Aldrich) were used.

Solution Preparations:

- **Diluent**: A 50:50 (v/v) mixture of water and methanol.
- **Sample Solution**: 6000 mg of L-CET oral solution was diluted to 10 mL with the diluent.
- **Standard Stock Solution-1**: 100 mg of EG, PG, and DEG dissolved in 20 mL of diluent.
- **Standard Stock Solution-2**: 5 mL of Stock Solution-1 was diluted to 20 mL with diluent.
- **Standard Solution**: 1 mL of Stock Solution-2 diluted to 10 mL with diluent (concentration: 0.100%).

Chromatographic Study:

- **Instrument**: Agilent 8890 GC-FID with DB-624 column.
- **Carrier Gas**: Nitrogen, at a flow rate of 4.7 mL/min.

- **Temperature Program**:
  - 80°C for 1 minute, ramp 6°C/min to 120°C, hold 6.5 minutes.
  - Ramp 50°C/min to 240°C, hold 15 minutes.
- **Injection and Detection**: Injector at 240°C, detector at 250°C.
- **Retention Times**:
  - Ethylene glycol: 5.24 minutes.
  - Propylene glycol: 5.96 minutes.
  - Diethylene glycol: 12.87 minutes.

Method Validation:

- **System Suitability**: Assessed by calculating retention times, theoretical plates, and resolution.
- **Specificity**: No interference at retention times of EG, PG, and DEG in placebo/sample.
- **Linearity and Range**: Linear response ($r > 0.990$) over six concentration levels: 0.020% to 0.500%.
- **Precision**: Demonstrated via six replicate injections (%RSD presented in results).
- **Ruggedness**: Verified across different analysts, days, columns, and systems.
- **Accuracy**: Recovery of spiked samples within acceptable limits (reported in three concentration levels).

Conclusion:

The validated GC-FID method for simultaneous determination of EG, PG, and DEG is efficient, accurate, precise, and rugged, making it suitable for routine quality control of pharmaceutical formulations like L-CET oral solution.

This comprehensive analytical procedure, along with its validation per ICH guidelines, ensures reliability in the pharmaceutical industry for detecting glycols, ensuring patient safety, and maintaining product quality.

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Conflict of Interest:

No conflicts of interest were declared.

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Table No- 1 Chromatographic condition for analytical study

Column	DB-624, 30 m x 0.53 mm ID, 3.0µm (Part No: 125-1334)
Column Oven	Rate/min (°C) / Temp.°C / Hold - / 80 / 1 minutes 6 / 120 / 6.5 minutes 50 / 240 / 15 minutes
Control mode	constant flow
Flow rate	4.7 mL/minute
Carrier gas	Nitrogen
Injection volume	0.5 µL
Injection mode	Split
Split ratio	10:1
Liner	ultra inert, Low PSI drop, wool (p/n 5190-2295)
Front Inlet temperature	240°C
FID temperature	250°C
FID Make-up gas flow(N_2)	25 mL/minute
FID H_2 flow	40 mL/minute
FID Air flow	300 mL/minute
Data rate	20 Hz
Save	On
Syringe wash solvent- A & B	Diluent

Table No- 2: System suitability – Standard solution

Injection #	Ethylene glycol	Propylene glycol	Diethylene glycol
	Area	Area	Area
1	339173	469677	381163
2	339140	444158	360086
3	337234	454443	370582
4	337288	427136	351781
5	332985	442783	353616
6	332030	438681	351667
Mean	336308	446146	361483
SD	3078.63403	14525.26356	12036.76167
%RSD	0.9	3.3	3.3

Table No-3 Specificity – Results

Observation		
Name of Solution	% Interference	RT (Min)
Blank	No interference	NA
Ethylene glycol (EG)	No interference	5.24

Propylene glycol (PG)		No interference	5.96
Diethylene glycol (DEG)		No interference	12.86
Standard solution	Ethylene glycol (EG)	No interference	5.24
	Propylene glycol (PG)	No interference	6.13
	Diethylene glycol (DEG)	No interference	12.77
Placebo of L-Cet oral solution	Ethylene glycol (EG)	BQL	5.23
	Propylene glycol (PG)	BQL	5.94
	Diethylene glycol (DEG)	No interference	ND
Unspike Sample Solution	Ethylene glycol (EG)	BQL	5.23
	Propylene glycol (PG)	BQL	5.94
	Diethylene glycol (DEG)	No interference	ND
Spike Sample Solution	Ethylene glycol (EG)	No interference	5.22
	Propylene glycol (PG)	No interference	5.94
	Diethylene glycol (DEG)	No interference	12.85

ND- Not detected
BQL- Below quantification limit

Table No- 4: Linearity of Ethylene glycol		
Name of linearity solution	Concentration (%)	Mean area
LOQ Level	0.020	64469
Level-2 (0.050%)	0.051	208312
Level-3 (0.100%)	0.101	320674
Level-4 (0.200%)	0.203	643375
Level-5 (0.300%)	0.304	973771
Level-6 (0.500%)	0.506	1621409
Slope		3166250.679
Intercept		13333.824
Correlation coefficient		0.999

Table No- 5: Linearity of Propylene glycol		
Name of linearity solution	Concentration (%)	Mean area
LOQ Level	0.020	77391
Level-2 (0.050%)	0.050	261393
Level-3 (0.100%)	0.101	417012
Level-4 (0.200%)	0.201	829402
Level-5 (0.300%)	0.302	1228559
Level-6 (0.500%)	0.503	2033649
Slope		3995138.304
Intercept		24188.036
Correlation coefficient		0.999

Table No- 6: Linearity of Diethylene glycol		
Name of linearity solution	Concentration (%)	Mean area
LOQ Level	0.020	66666

Level-2 (0.050%)	0.051	219724
Level-3 (0.100%)	0.102	348107
Level-4 (0.200%)	0.204	686001
Level-5 (0.300%)	0.306	1043693
Level-6 (0.500%)	0.509	1763551
Slope		3422291.354
Intercept		8061.784
Correlation coefficient		0.999

Table No- 7: Method Precision – Unspiked sample

Date of Analysis	13/06/2024		
Instrument ID	QC/INS/246		
Column No.	ARND710		
Analyst	Satish. Samireddi		
Batch No.	4LS005A		
Sample ID#	EG (in %)	PG (in %)	DEG (in %)
1	0.005 (BQL)	0.004 (BQL)	ND
2	0.006 (BQL)	0.005 (BQL)	ND
3	0.006 (BQL)	0.005 (BQL)	ND
4	0.006 (BQL)	0.005 (BQL)	ND
5	0.006 (BQL)	0.004 (BQL)	ND
6	0.006 (BQL)	0.004 (BQL)	ND
Mean	0.006 (BQL)	0.005 (BQL)	-
SD	0.00041	0.00055	-
%RSD	6.8	11.0000	-

Table No- 8: Method Precision – Spiked sample

Date of Analysis	13/06/2024		
Instrument ID	QC/INS/246		
Column No.	ARND710		
Analyst	Satish. Samireddi		
Batch No.	4LS005A		
Sample ID#	EG (in %)	PG (in %)	DEG (in %)
1	0.095	0.098	0.095
2	0.096	0.097	0.094
3	0.095	0.098	0.095
4	0.092	0.094	0.092
5	0.093	0.096	0.094
6	0.091	0.093	0.091
Mean	0.094	0.096	0.094
SD	0.00197	0.00210	0.00164
%RSD	2.1	2.2	1.7

Table No-9: Intermediate Precision – Unspiked sample

Date of Analysis	29/06/2024		
Instrument ID	QC/INS/186		
Column No.	170		
Analyst	Vara prasad Kagita		
Batch No.	4LS005A		
Sample ID#	EG (in %)	PG (in %)	DEG (in %)

1	0.005 (BQL)	0.004 (BQL)	ND
2	0.005 (BQL)	0.004 (BQL)	ND
3	0.005 (BQL)	0.003 (BQL)	ND
4	0.004 (BQL)	0.004 (BQL)	ND
5	0.004 (BQL)	0.004 (BQL)	ND
6	0.004 (BQL)	0.004 (BQL)	ND
Mean	0.005 (BQL)	0.004 (BQL)	-
SD	0.00055	0.00041	-
%RSD	11.000	10.206	-

Table No-10: Intermediate Precision – Spiked sample			
Date of Analysis	29/06/2024		
Instrument ID	QC/INS/186		
Column No.	170		
Analyst	Vara prasad Kagita		
Batch No.	4LS005A		
Sample ID#	EG (%)	PG (%)	DEG (%)
1	0.096	0.093	0.096
2	0.095	0.092	0.096
3	0.091	0.090	0.095
4	0.089	0.088	0.094
5	0.088	0.086	0.093
6	0.084	0.084	0.090
Mean	0.091	0.089	0.094
SD	0.00451	0.00349	0.00228
%RSD	5.0	3.9	2.4

Table No-11: Precision & Intermediate comparison (Unspiked sample)				
Date of analysis	12/06/2024		29/06/2024	
Instrument ID	QC/INS/246		QC/INS/246	
Column No.	ARND710		170	
Analyst	Satish. Samireddi		Vara prasad. Kagita	
B. No.	4LS005A		4LS005A	
Sample ID#	Ethylene glycol			
	Content (in %)		Content (in mg)	
	Precision	Int. Precision	Precision	Int. Precision
1	0.005 (BQL)	0.005 (BQL)	0.065 (BQL)	0.059 (BQL)
2	0.006 (BQL)	0.005 (BQL)	0.076 (BQL)	0.060 (BQL)
3	0.006 (BQL)	0.005 (BQL)	0.077 (BQL)	0.057 (BQL)
4	0.006 (BQL)	0.004 (BQL)	0.072 (BQL)	0.054 (BQL)
5	0.006 (BQL)	0.004 (BQL)	0.077 (BQL)	0.053 (BQL)
6	0.006 (BQL)	0.004 (BQL)	0.070 (BQL)	0.048 (BQL)
Mean	0.006 (BQL)	0.005 (BQL)	0.073 (BQL)	0.055 (BQL)
SD	-	-	-	-
% RSD	-	-	-	-
Overall Mean	-		-	
Overall SD	-		-	
Overall %RSD	-		-	

Table No-12: Precision & Intermediate comparison (Unspiked sample)		
Date of analysis	12/06/2024	29/06/2024

Instrument ID	QC/INS/246		QC/INS/246	
Column No.	ARND710		170	
Analyst	Satish. Samireddi		Vara prasad. Kagita	
B. No.	4LS005A		4LS005A	
Sample ID#	Propylene glycol			
	Content (in %)		Content (in mg)	
	Precision	Int. Precision	Precision	Int. Precision
1	0.004 (BQL)	0.004 (BQL)	0.052 (BQL)	0.044 (BQL)
2	0.005 (BQL)	0.004 (BQL)	0.057 (BQL)	0.047 (BQL)
3	0.005 (BQL)	0.003 (BQL)	0.060 (BQL)	0.043 (BQL)
4	0.005 (BQL)	0.004 (BQL)	0.058 (BQL)	0.050 (BQL)
5	0.004 (BQL)	0.004 (BQL)	0.052 (BQL)	0.047 (BQL)
6	0.004 (BQL)	0.004 (BQL)	0.052 (BQL)	0.047 (BQL)
Mean	0.005 (BQL)	0.004(BQL)	0.055 (BQL)	0.046 (BQL)
SD	-	-	-	-
% RSD	-	-	-	-
Overall Mean	-		-	
Overall SD	-		-	
Overall %RSD	-		-	

Table No-13: Precision & Intermediate comparison (Unspiked sample)				
Date of analysis	12/06/2024		29/06/2024	
Instrument ID	QC/INS/246		QC/INS/246	
Column No.	ARND710		170	
Analyst	Satish. Samireddi		Vara prasad. Kagita	
B. No.	4LS005A		4LS005A	
Sample ID#	Diethylene glycol			
	Content (in %)		Content (in mg)	
	Precision	Int. Precision	Precision	Int. Precision
1	ND (BQL)	ND (BQL)	ND (BQL)	ND (BQL)
2	ND (BQL)	ND (BQL)	ND (BQL)	ND (BQL)
3	ND (BQL)	ND (BQL)	ND (BQL)	ND (BQL)
4	ND (BQL)	ND (BQL)	ND (BQL)	ND (BQL)
5	ND (BQL)	ND (BQL)	ND (BQL)	ND (BQL)
6	ND (BQL)	ND (BQL)	ND (BQL)	ND (BQL)
Mean	ND (BQL)	ND (BQL)	ND (BQL)	ND (BQL)
SD	-	-	-	-
% RSD	-	-	-	-
Overall Mean	-		-	
Overall SD	-		-	
Overall %RSD	-		-	

ND- Not detected
BQL- Below quantification limit

Table No- 14: Precision & Intermediate comparison (Spiked sample)		
Date of analysis	13/06/2024	29/06/2024
Instrument ID	QC/INS/246	QC/INS/246
Column No.	ARND710	170

Analyst	Satish. Samireddi		Vara prasad. Kagita	
B. No.	4LS005A		4LS005A	
Sample ID#	Ethylene glycol			
	Content (in %)		Content (in mg)	
	MP	IP	MP	IP
1	0.095	0.096	1.181	1.196
2	0.096	0.095	1.194	1.190
3	0.095	0.091	1.192	1.139
4	0.092	0.089	1.145	1.113
5	0.093	0.088	1.161	1.102
6	0.091	0.084	1.138	1.056
Mean	0.094	0.091	1.169	1.133
SD	0.00197	0.00451	0.02407	0.05393
% RSD	2.1	5.0	2.1	4.8
Overall Mean	0.092		1.151	
Overall SD	0.00370		0.04400	
Overall %RSD	4.0		3.8	

Table No- 15: Precision & Intermediate comparison (Spiked sample)				
Date of analysis	13/06/2024		29/06/2024	
Instrument ID	QC/INS/246		QC/INS/246	
Column No.	ARND710		170	
Analyst	Satish. Samireddi		Vara prasad. Kagita	
B. No.	4LS005A		4LS005A	
Sample ID#	Propylene glycol			
	Content (in %)		Content (in mg)	
	MP	IP	MP	IP
1	0.098	0.093	1.229	1.161
2	0.097	0.092	1.218	1.152
3	0.098	0.090	1.230	1.120
4	0.094	0.088	1.175	1.101
5	0.096	0.086	1.200	1.074
6	0.093	0.084	1.164	1.052
Mean	0.096	0.089	1.203	1.110
SD	0.00210	0.00349	0.02808	0.04291
% RSD	2.2	3.9	2.3	3.9
Overall Mean	0.092		1.156	
Overall SD	0.00464		0.05948	
Overall %RSD	5.0		5.1	

Table No- 16: Precision & Intermediate comparison (Spiked sample)		
Date of analysis	13/06/2024	29/06/2024
Instrument ID	QC/INS/246	QC/INS/246
Column No.	ARND710	170
Analyst	Satish. Samireddi	Vara prasad. Kagita
B. No.	4LS005A	4LS005A
Sample ID#	Diethylene glycol	
	Content (in %)	Content (in mg)

	MP	IP	MP	IP
1	0.095	0.096	1.187	1.196
2	0.094	0.096	1.169	1.202
3	0.095	0.095	1.184	1.194
4	0.092	0.094	1.147	1.174
5	0.094	0.093	1.172	1.157
6	0.091	0.090	1.137	1.122
Mean	0.094	0.094	1.166	1.174
SD	0.00164	0.00228	0.02006	0.03053
% RSD	1.7	2.4	1.7	2.6
Overall Mean	0.094		1.170	
Overall SD	0.00191		0.02500	
Overall %RSD	2.0		2.1	

Table No- 17: Accuracy of Ethylene glycol

Name of Solution	Preparation	Amount recovered (%)	Amount added (%)	% Recovery	% Mean and % RSD Recovery level	
Accuracy at LOQ level	1	0.019	0.020	95.0	Avg	93.3
	2	0.019	0.020	95.0	SD	2.88675
	3	0.018	0.020	90.0	%RSD	3.1
Accuracy at Specification level (0.100%)	1	0.095	0.100	95.0	Avg	95.3
	2	0.096	0.100	96.0	SD	0.57735
	3	0.095	0.100	95.0	%RSD	0.6
Accuracy at Higher level (0.500%)	1	0.487	0.501	97.2	Avg	95.9
	2	0.474	0.501	94.6	SD	1.30128
	3	0.481	0.501	96.0	%RSD	1.4

Table No- 18: Accuracy of propylene glycol

Name of Solution	Preparation	Amount recovered (%)	Amount added (%)	% Recovery	% Mean and % RSD Recovery level	
Accuracy at LOQ level	1	0.022	0.020	110.0	Avg	100.0
	2	0.020	0.020	100.0	SD	10.00000
	3	0.018	0.020	90.0	%RSD	10.0
Accuracy at Specification level (0.100%)	1	0.098	0.100	98.0	Avg	97.7
	2	0.097	0.100	97.0	SD	0.57735
	3	0.098	0.100	98.0	%RSD	0.6
Accuracy at Higher level (0.500%)	1	0.539	0.505	106.7	Avg	105.9
	2	0.536	0.505	106.1	SD	0.86217
	3	0.530	0.505	105	%RSD	0.8

Table No- 19: Accuracy of Diethylene glycol

Name of Solution	Preparation	Amount recovered (%)	Amount added (%)	% Recovery	% Mean and % RSD Recovery level	
Accuracy at LOQ level	1	0.023	0.020	115.0	Avg	106.7
	2	0.021	0.020	105.0	SD	7.63763

	3	0.020	0.020	100.0	%RSD	7.2
Accuracy at Specification level (0.100%)	1	0.094	0.099	94.9	Avg	94.6
	2	0.093	0.099	93.9	SD	0.57735
	3	0.094	0.099	94.9	%RSD	0.6
Accuracy at Higher level (0.500%)	1	0.486	0.500	97.2	Avg	97.0
	2	0.482	0.500	96.4	SD	0.52915
	3	0.487	0.500	97.4	%RSD	0.5

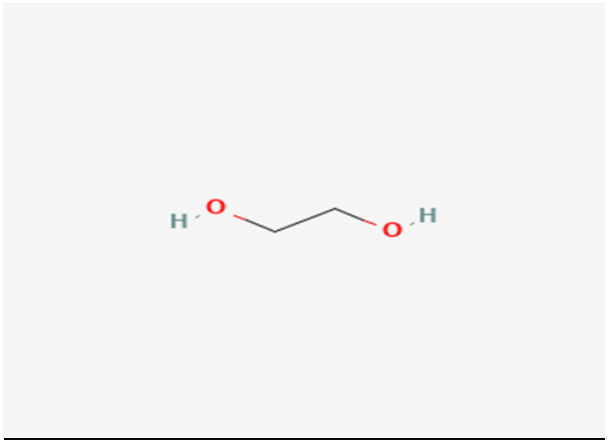

Figure 1 Chemical structure of Ethylene glycol

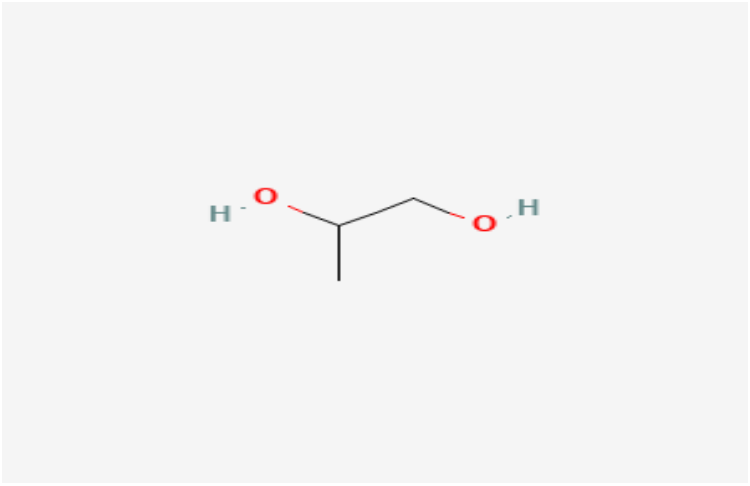

Figure 2 Chemical structure of Propylene glycol

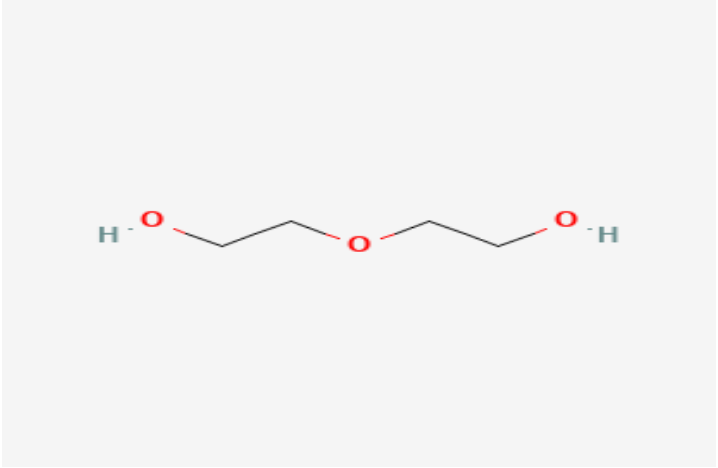

Figure 3 Chemical structure of Diethylene glycol

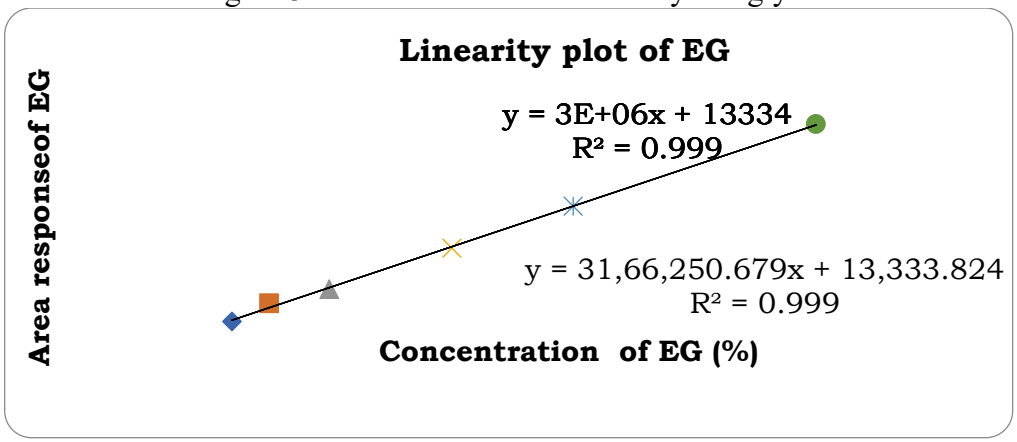

Figure 4: Linearity of Ethylene glycol

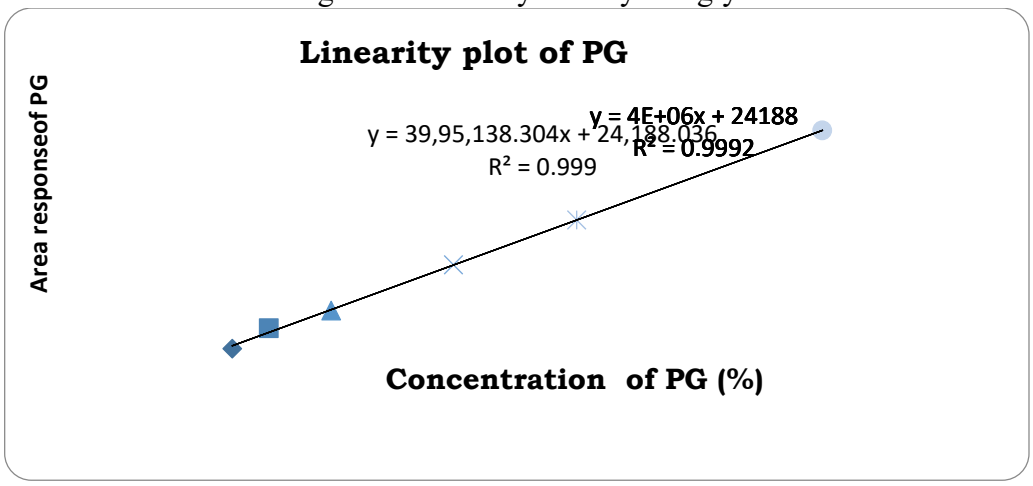

Figure 5: Linearity of Propylene glycol

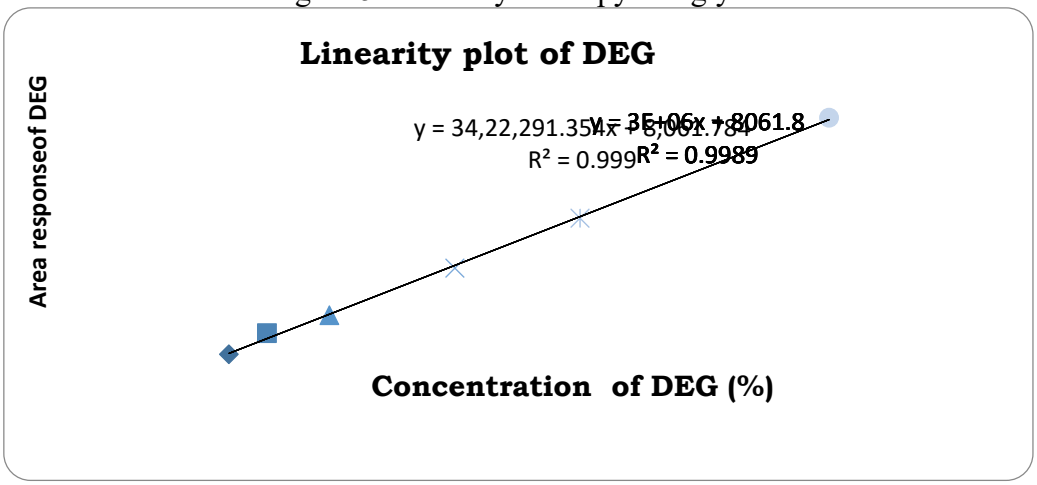

Figure 6: Linearity of Diethylene glycol

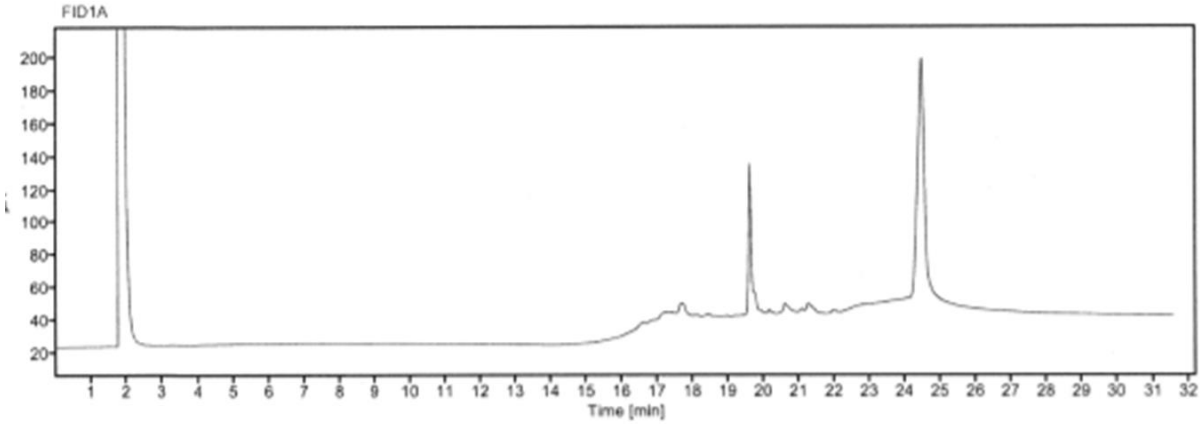

Figure 7 Blank Chromatogram

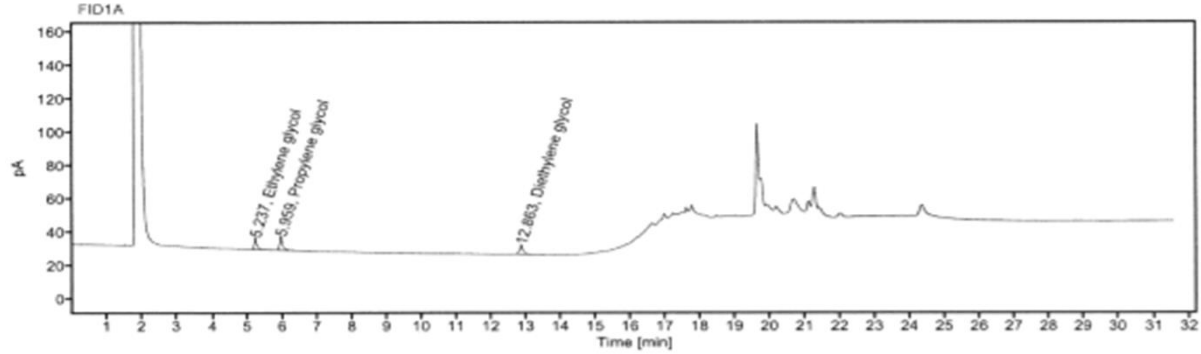

Figure 8 Standard Chromatogram

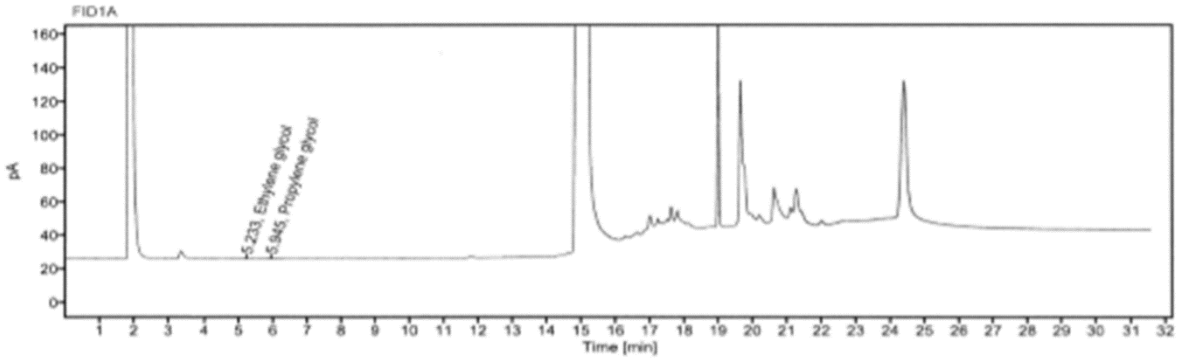

Figure 9 Sample Chromatogram

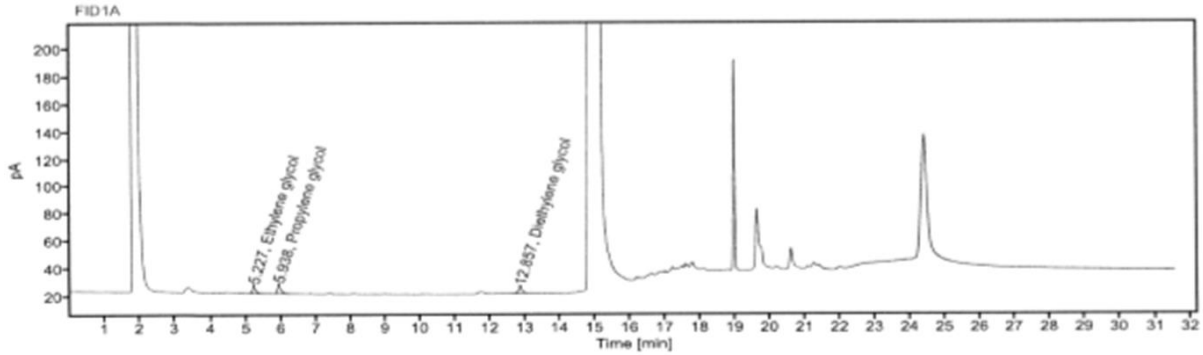

Figure 10 Spiked sample Chromatogram