A sensitive analytical liquid chromatography-tandem mass spectrometry method for the estimation of Topiramate in bulk and pharmaceutical formulation

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ABSTRACT

Topiramate is an anticonvulsant used to treat seizures and prevent migraines. The aim of this study was to develop and validate a simple and sensitive liquid chromatography-tandem mass spectrometry (LC-MS/MS) method to quantify Topiramate in its formulation. Acetonitrile and ammonium acetate were used as a mobile phase (85:15 v/v ratio), and isocratic elution mode was used for separation using Zorbax RP-C18 Column (50 mm × 4.6 mm i.d., 5 µ) as a stationary phase. The standard calibration curve ranges from 1 to 1,000 ng/ml with a correlation coefficient of 0.9990 ($R^2$). The detection and quantification limits were obtained at 0.5 and 1.0 ng/ml, respectively. The total runtime of chromatographic separation was found to be 2.0 minutes with a retention time of 1.23 minutes. The percentage recovery studies were found to be 90.3%–99.3%. The developed method was found to be simple and sensitive and can be used for the estimation of Topiramate in bulk and its pharmaceutical formulations.

INTRODUCTION

Topiramate is a hexose derivative that is 2,(3:4),5-di-O-isopropylidene-beta-D-fructopyranose, in which hydroxy group is converted to the corresponding sulfamate ester. Topiramate increases receptor activation for gamma-aminobutyric acid (GABA)-A at the sites of non-benzodiazepines and decreases the activity of glutamate in kainite and α-amino-3-hydroxy-5-methyl-4-isoxazolepropionic acid (AMPA) receptors. Moreover, it is proposed that mesolimbic activity should also be reduced. Topiramate also blocks sodium-based voltage channels to inhibit seizure spread. Structurally, Topiramate presents a very high concentration of O₂, and it does not resemble a normal therapeutic agents. It reduces the action of excitatory neurotransmitter through the AMPA receptor and kainite receptor (Drug Information, 2019). It is available commercially as tablet (25, 50, 100, and 200 mg). Topiramate is an anticonvulsant drug and is used to treat antiepileptic and prevent migraine headache. Topiramate contains not less than 98.0% and not more than 102% of C₁₂H₂₁NO₈S. Melting range is 120 - 130 °C. As per the literature survey, a few analytical methods were reported by high-performance liquid chromatography (Kumari et al., 2015; Mahadev et al., 2017; Reddy et al., 2015) for the estimation of Topiramate in bulk and pharmaceutical dosage forms and liquid chromatography-mass tandem spectrometry (LC-MS-MS) (Das 2013; Goswami et al., 2009; Park et al., 2008) methods are reported for the determination in biological samples. However, the reported method had low sensitivity and selectivity with long run time. Hence, the objective is to develop a simple, rapid, highly sensitive, and economical method for the determination of Topiramate in its formulations by LC-MS-MS.

METHODS AND MATERIALS

Chemicals

The working standard Topiramate was obtained from the Indian Pharmacopoeia Commission, New Delhi. Chemicals (ammonium acetate) and solvents (acetonitrile and formic
acid) were of LC-MS grade procured from SD Fine Chemicals. Ultrapure water was obtained from Milli-Q RO system.

**Instrument and chromatographic conditions**

Shimadzu LC-MS/MS 8,030 system was equipped with electrospay ionization interface, SIL-20AC autosampler, CBM-20 alite controller, CTO-20AC column oven, LC-20AD pump, and SPD-M20 PDA detector and operated using Lab Solutions data station.

A stationary phase consisting of Zorbax RP-C column (50 mm × 4.6 mm i.d., 5 µ) was selected, and ammonium acetate and acetonitrile were used as a mobile phase at the ratio of 15:85 v/v and pumped at a flow rate of 0.5 ml/min. 10 μl of injection volume was employed at an ambient column temperature.

**Preparation of stock and working solution**

About 10 mg of Topiramate was weighed and dissolved into 10 ml of ethanol (1 mg/ml). From the above stock solution, 1 μg/ml of working concentration was prepared. Further, from the working standard, calibration standard ranging from 1 to 1,000 ng/ml of Topiramate was prepared. Three different quality control (QC) levels were prepared, i.e., low (LQC; 3 ng/ml), medium (MQC; 100 ng/ml), and high (HQC; 900 ng/ml) in the mobile phase.

**Optimization of mass range**

The optimization of mass conditions was performed using standard Topiramate (1,000 ng/ml). The transition was obtained at m/z 338.05 (precursor ion) → 77.95 (product ion) and m/z 338.05 → 95.90 which were used to monitor Topiramate (Fig. 1).

**Method validation**

As per the ICH guidelines, analytical method was validated using various validation parameters such as specificity, linearity range, accuracy and precision, Detection limit (LOD) and quantification limit (LOQ), robustness, and system suitability (ICH, 1996).

**Linearity**

Six different concentrations of Topiramate ranging from 1 to 1,000 ng/ml were used to determine the linearity. The linearity curve was used to measure the correlation coefficient ($R^2$), slope (m), and intercept values.

**Specificity**

The method specificity was determined based on the ability of the method to determine the analyte in the presence of interferences.

**Accuracy and precision**

As per the ICH guidelines, the accuracy and precision of the method were determined at three QC levels by analyzing six replications. Recovery of the method was used to determine the accuracy of the method. Intra- and interday precision was carried out to determine the method precision, and the results were recorded in terms of percent relative standard deviation (% RSD).

**RESULTS AND DISCUSSION**

**Specificity**

At the retention time of Topiramate, there were no potential interference peaks found (Fig. 2a). Therefore, the method was found to be selective and highly sensitive.

**Accuracy and precision**

The method accuracy was determined by recovery studies for three QC samples. The recovery ranged between 93.3% and 99.7% with % RSD ranging from 0.10% to 1.85% for precision study (Table 1).

**Linearity**

The linearity curve was determined at six different concentration levels, and the regression equation was found to be $y = 1,055.x + 1,287$ (Fig. 3).
LOD and LOQ

The LOD and LOQ were obtained at 0.5 and 1.0 ng/ml for the developed method, respectively, based on the minimum level of peak area and signal-to-noise ratio.

Robustness

The conditions such as flow rate (0.2, 0.5, and 0.8 ml/min), pH (5.5, 6.0, and 6.5), and acetonitrile percentage (75%, 85%, and 90%) were studied to determine the robustness of the method. The % RSD was calculated for flow rate (1.10%, 0.82%, and 0.25%), pH (1.20%, 0.91%, and 0.33%), and acetonitrile percentage (1.30%, 0.79%, and 0.22%) which were found to be within the limit and demonstrated that the developed method was found to be robust (Table 2).

System suitability

The system suitability study was carried out to determine parameters such as tailing factor ($T$), number of theoretical plates ($N$), and retention factor ($R$), as per the ICH guidelines. The results were found to be within the limits (Table 3).

Estimation of Topiramate dosage form

Twenty tablets of Topiramate tablet were accurately weighed and crushed into powder, and the weight equivalent to 10 mg was taken. The powder was dissolved using 5 ml of organic solvent by sonication for 15–20 minutes and filtered through 0.45-μm membrane, and the volume was made up to 10 ml using organic solvent (ethanol). From the resulting solution (1 mg/ml), the QC samples (3, 100, and 900 ng/ml) were prepared by appropriate dilution and analyzed (Table 4 and Fig. 2b).
CONCLUSION

An accurate, simple, precise, rapid, selective, and cost-effective method was successfully developed and applied for the quantitative determination of Topiramate in bulk and commercial formulation. The newly developed and validated method will be useful for the clinical pharmacokinetic, biopharmaceutical, and bioequivalence studies due to their high sensitivity.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

Table 3. System suitability.

| Parameters                  | Topiramate |
|-----------------------------|------------|
| Limit of detection          | 0.5 ng/ml  |
| Limit of quantitation       | 1.0 ng/ml  |
| Theoretical plates          | 5,760      |
| Tailing factor              | 1.1        |
| Linearity range             | 1−1,000 ng/ml |
| Correlation coefficient ($r^2$) | 0.999    |

Table 4. Recovery studies for the Topiramate formulation.

| Formulation | Label claim | Quality control for assay (ng/ml) | Amount found ± SD | Recovery % |
|-------------|-------------|-----------------------------------|-------------------|------------|
| Topiramate  | 25 mg       | 3.0                               | 2.23 ± 0.05       | 90.3       |
|             |             | 100                               | 96.50 ± 0.15      | 96.5       |
|             |             | 900                               | 894.41 ± 0.20     | 99.3       |

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