Analytical Method Development and Validation for the Simultaneous Estimation of Abacavir and Lamivudine by Reversed-phase High-performance Liquid Chromatography in Bulk and Tablet Dosage Forms

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INTRODUCTION

Abacavir (ABAC) and lamivudine (LAMI) are synthetic nucleoside analogs that show a potent and synergistic effect on the inhibition of human immunodeficiency virus-1 (HIV-1), the causative agent of acquired immunodeficiency syndrome (AIDS). HIV encodes at least three enzymes: protease, reverse transcriptase, and endonuclease. ABAC and LAMI belong to the class of nucleoside reverse transcriptase inhibitors (NRTIs). New therapeutic strategy of AIDS treatment requires the combination of these antiretroviral (ARV) drugs. The introduction of highly effective combination regimens of ARV drugs has led to substantial improvements in morbidity and mortality. ABAC tablets in combination with other ARV agents in tablet form are indicated for the treatment of HIV-1 infection. ABAC should not be added as a single agent when ARV regimens are changed due to loss of virologic response.

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Intracellularly, ABAC is converted by cellular enzymes to the active metabolite, carbovir triphosphate, an analog of deoxyguanosine-5'-triphosphate. Intracellularly, LAMI is phosphorylated to its active 5'-triphosphate metabolite, lamivudine triphosphate. Chemically, ABAC sulfate is (1S, cis)-4-[2-amino-6-(cyclopropyl amino)-9H-purin-9-yl]-2-cyclopentene-1-methanol sulfate, and LAMI is (2R, cis)-4-amino-1-(2-hydroxymethyl-1,3-oxathiolan-5-yl)-(1H)-pyrimidin-2-one. Figures 1 and 2 show the structures of ABAC and LAMI, respectively. Numerous analytical methods have been employed for the quantitative determination of single- or multi-component NRTIs in pharmaceutical dosage forms. These methods include ultraviolet (UV)-visible spectrophotometric high-performance thin-layer chromatography and high-performance liquid chromatography.

**Table 1:** Details of chromatogram of standard mixture abacavir and lamivudine

| Name of drug | RT (min) | Area  | Plates | Tailing factor |
|--------------|----------|-------|--------|----------------|
| Abacavir     | 3.48     | 66.22 | 4943.3 | 1.4286         |
| Lamivudine   | 7.21     | 33.76 | 3663.5 | 1.3182         |

RT: Retention time
HPLC was considered the best method of assay since this method is the most accurate of all chromatographic and other separation methods. The reported method differs with respect to extraction procedure, eluent used for reverse-phase HPLC (RP-HPLC), and UV detection wavelength. The development and validation of a simple, rapid, accurate, and precise method of assay for ABAC and LAMI in tablet formulations are now reported in this work using RP-HPLC with UV detection at 245 nm.

**MATERIALS AND METHODS**

**Materials and reagents**
The analysis of the drug was carried out on Youngline (S.K.) Gradient System UV Detector. This study was equipped with reverse phase (Grace) C18 column (4.6 mm × 250 mm; 5 µm), a SP930D pump, a 20 µl injection loop, UV730D Absorbance detector, and running autochro-3000 software. ABAC and LAMI were procured from CIPLA. Orthophosphoric acid (OPA), methanol, acetonitrile (HPLC Grade Merck Specialties Pvt. Ltd. Shiv Sager Estate “A” Worli, Mumbai.), water, 0.45 µm filter (Millipore, Bangalore) were also used. A combination of ABAC (600 mg) and LAMI (300 mg) in tablet formulation was procured from local pharmacy (ABAMUNE-L, Cipla).

**Chromatographic conditions**
Column C18 (250 mm × 4.6 mm); particle size packing 5 µm; detection wavelength of 245 nm; flow rate 1.00 ml/min; temperature ambient; sample size 20 µl; mobile phase methanol: water (OPA 0.05%) (83:17); run time of 10 min.

**Table 2: Analysis of marketed formulation**

| Serial number | Amount present in mg | Amount found in mg | Percentage label claim |
|---------------|----------------------|--------------------|------------------------|
|               | Abacavir | Lamivudine       | Abacavir | Lamivudine       | Abacavir | Lamivudine |
| 1             | 60       | 30                | 60.96    | 30.43            | 101.60   | 101.45     |
| 2             | 60       | 30                | 60.83    | 30.80            | 101.38   | 102.67     |
| Mean±SD       | -        | -                 | -        | -                | 101.49±0.27 | 103.67±0.27 |
| %RSD          | -        | -                 | -        | -                | 0.27     | 0.26       |

SD: Standard deviation; RSD: Relative standard deviation

**Table 3: Details of chromatogram of abacavir and lamivudine in tablet formulation**

| Name of drug | RT (min) | Area (%) | Theoretical plates | Tailing factor |
|--------------|----------|----------|--------------------|---------------|
| Abacavir     | 3.5      | 66.82    | 4990.7             | 1.5833        |
| Lamivudine   | 7.3      | 30.72    | 2047.9             | 1.1364        |

RT: Retention time
Preparation of standard stock solution
20 mg of ABAC and 10 mg of LAMI were weighed accurately and transferred to a 10-ml volumetric flask dissolved in methanol and diluted to 10 ml with the mobile phase (methanol: water, 83:17 v/v) to give a stock solution of 2000 μg/ml ABAC and 1000 μg/ml LAMI. Table 1 shows the details of the chromatogram of standard mixture ABAC and LAMI. Figures 3 and 4 show the chromatogram of standard ABAC and LAMI. Figure 5 shows the chromatogram of standard mixture of ABAC and LAMI.

Method development and validation
Serial dilutions were done to prepare various concentration stock working standard of various concentrations was prepared by taking aliquots of standard solution and diluted to get required concentration for calibration plot and which was injected.

Assay preparation for commercial formulation
For analysis of the tablet dosage form, 20 tablets were weighed individually and their average weight was determined. After that, they were crushed to fine powders and powder equivalent to 1 mg was taken and transferred to 10 ml volumetric flask and diluted with 10 ml methanol; from the above solution, 0.2 ml was taken and diluted to 10 ml.

Table 4: Linearity study

| Concentration (μg/ml) | Abacavir | Lamivudine | Area       |
|----------------------|----------|------------|------------|
|                      | Abacavir | lamivudine |
| 20                   | 10       | 214.62     | 146.535    |
| 40                   | 20       | 465.89     | 255.03     |
| 60                   | 30       | 731.9146   | 380.505    |
| 80                   | 40       | 970.18     | 483.445    |
| 100                  | 50       | 1216.433   | 592.5555   |

Table 5: Linearity of abacavir

| Concentration | Average peak area |
|---------------|-------------------|
| 20            | 216.689           |
| 40            | 469.3872          |
| 60            | 736.5661          |
| 80            | 963.5581          |
| 100           | 1210.895          |

Table 6: Linearity of lamivudine

| Concentration | Average peak area |
|---------------|-------------------|
| 10            | 146.535           |
| 20            | 255.03            |
| 30            | 380.505           |
| 40            | 483.445           |
| 50            | 592.5555          |

Table 7: Recovery studies of abacavir and lamivudine

| Level of recovery (%) | Abacavir | Lamivudine | Abacavir | Lamivudine | Abacavir | Lamivudine |
|-----------------------|----------|------------|----------|------------|----------|------------|
| Amount present (mg)   | 20       | 10         | 20       | 10         | 10       | 20         |
| Amount of standard added (mg) | 16       | 8          | 20       | 10         | 12       | 24         |
| Percentage recovery   | 97.25    | 98.41      | 99.45    | 101.64     | 99.26    | 99.62      |
|                       | 100.00   | 101.06     | 100.40   | 99.58      | 100.94   | 100.63     |
the mark with methanol: water (83:17); the amounts of ABAC and LAMI per tablet were calculated from the calibration curve. Analysis procedure was repeated five times with tablet formulation. Results are shown in Tables 2 and 3 that show the analysis of marketed formulation and details of chromatogram of ABAC and LAMI in tablet formulation. Figure 6 shows the chromatogram of ABAC and LAMI in tablet formulation.

RESULTS

Linearity and range

From ABAC and LAMI standard stock solution, different working standard solutions (20–100 μg/ml) were prepared in the mobile phase. Likewise from ABAC and LAMI standard stock solution, different working standard solutions (10–50 μg/ml) were prepared in the mobile phase. 20 μl of sample solution was injected onto the column using fixed volume loop injector. Chromatograms were recorded. The area for each concentration was recorded in Tables 4-6 that show linearity study. Figures 7 and 8 show the calibration curve of ABAC and LAMI, respectively.

Accuracy

Recovery studies were performed to validate the accuracy of developed method. To a preanalyzed tablet solution, a definite concentration of standard drug (80%, 100%, and 120%) was added and then its recovery was analyzed [Table 7]. Statistical validation of recovery studies is shown in Table 8 and Figures 9-11.

Table 8: Statistical validation of recovery studies

| Level of recovery (%) | Drug    | Mean percentage recovery±SD* | %RSD |
|-----------------------|---------|------------------------------|------|
| 80                    | Abacavir| 35.78±0.31                   | 0.87 |
| 100                   | Lamivudine | 17.98±0.15                  | 0.80 |
| 120                   | Abacavir | 39.99±0.13                   | 0.34 |
|                       | Lamivudine | 20±0.15                     | 0.74 |

Denotes average of three determinations. SD: Standard deviation; RSD: Relative standard deviation

System suitability parameters

To ascertain the resolution and reproducibility of the proposed chromatographic system for estimation of ABAC (600 mg) and LAMI (300 mg), system suitability parameters were studied. The results are shown in Figure 12 and Table 9.

Precision

The method was established by analyzing various standards of ABAC and LAMI. All the solutions were analyzed thrice to record any intraday and interday variation in the result. The results obtained for interday and intraday variation are shown in Table 10 and Figure 13.

Robustness

The robustness is a measure of its capacity to remain unaffected by small and deliberate variations in method parameters and provides an indication of its reliability during normal usage; hence, the following are performed by slight variations in parameters. The assay content of the sample was measured by change in the flow rate of 0.90–1.10 ml/min. The results indicate that less variability in retention time and tailing factor were observed [Tables 11 and 12].

DISCUSSION

The proposed methods for simultaneous estimation of ABAC and LAMI in tablet dosage forms were found to be simple, accurate, economical, and rapid. The method was validated as per the International Conference on Harmonization Q2 (R1) guidelines. Standard calibration yielded correlation coefficient (r²) 0.999 for both ABAC and LAMI at all the selected wavelengths. The values of % relative standard deviation are within the prescribed limit of 2%, showing high precision of methods, and recovery was close to 100% for both drugs. Results of the analysis of pharmaceutical formulations reveal that the proposed method is suitable for their simultaneous determination, with virtually no interference of any additive present in pharmaceutical formulations. Hence, the above methods can be applied successfully for simultaneous estimation of ABAC and LAMI in formulations.

CONCLUSION

The developed HPLC methods in that linearity, precision, range, and robustness were found to be more accurate, precise, and reproducible. The methods were found to be simple and time saving. All proposed methods could be applied for routine analysis in quality control laboratories.

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Table 8: Statistical validation of recovery studies

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| 120                   | Abacavir | 39.99±0.13                   | 0.34 |
|                       | Lamivudine | 20±0.15                     | 0.74 |

Denotes average of three determinations. SD: Standard deviation; RSD: Relative standard deviation

Table 9: System suitability parameters

| System suitability parameters | Proposed method |
|-------------------------------|-----------------|
|                               | Abacavir | Lamivudine |
| RT                            | 3.4833     | 7.5667     |
| Area                          | 502.5529   | 256.7151   |
| Theoretical plate number      | 4943.3     | 3527.6     |
| Tailing factor                | 1.5000     | 0.8387     |

RT: Retention time

Table 10: Intra- and inter-day precision studies on high-performance liquid chromatography method for abacavir and lamivudine

| Method            | Drug    | Concentration (μg/ml) | Intraday precision | Interday precision |
|-------------------|---------|-----------------------|--------------------|--------------------|
|                   |         |                       | Mean±SD            | Percentage amount found | Mean±SD | Percentage amount found |
| RP-HPLC method    | Abacavir| 20                    | 223.80             | 100.35             | 218.34 | 98.18 |
|                   |         | 60                    | 725.68             | 100.85             | 740.74 | 102.88 |
|                   |         | 100                   | 1179.89            | 97.11              | 1245.07 | 102.30 |
|                   | Lamivudine | 10                    | 142.80             | 100.20             | 150.89 | 102.04 |
|                   |         | 30                    | 380.18             | 102.57             | 377.38 | 101.73 |
|                   |         | 50                    | 589.57             | 98.94              | 592.33 | 99.46 |

Mean of each 3 reading for HPLC method. HPLC: High-performance liquid chromatography; RP-HPLC: Reverse phase-HPLC; SD: Standard deviation
Table 11: Robustness study of abacavir

| Parameters               | Concentration | Amount of detected (mean±SD) | %RSD |
|--------------------------|---------------|------------------------------|------|
| Mobile phase composition |               |                              |      |
| 84:16                    | 60            | 6.38±1.01                   | 0.88 |
| 82:18                    | 60            | 10.77±1.5                   | 1.48 |
| Wavelength change (nm)   |               |                              |      |
| 244                      | 60            | 4.70±0.89                   | 0.59 |
| 246                      | 60            | 9.17±1.4                    | 1.28 |
| Flow rate change (ml)    |               |                              |      |
| 0.90                     | 60            | 2.85±0.41                   | 0.38 |
| 1.10                     | 60            | 5.70±0.74                   | 0.80 |

SD: Standard deviation; RSD: Relative standard deviation

Table 12: Robustness study of lamivudine

| Parameters               | Concentration | Amount of detected (mean±SD) | %RSD |
|--------------------------|---------------|------------------------------|------|
| Mobile phase composition |               |                              |      |
| 84:16                    | 30            | 4.8±0.89                     | 1.29 |
| 82:18                    | 30            | 4.95±0.97                    | 1.36 |
| Wavelength change (nm)   |               |                              |      |
| 244                      | 30            | 2.87±0.38                    | 0.76 |
| 246                      | 30            | 0.18±0.09                    | 0.21 |
| Flow rate change (ml)    |               |                              |      |
| 0.90                     | 30            | 0.88±0.14                    | 0.22 |
| 1.10                     | 30            | 2.01±0.77                    | 0.52 |

SD: Standard deviation; RSD: Relative standard deviation

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Conflicts of interest
There are no conflicts of interest.

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