Introduction

Imatinib is chemically a N-(4-methyl-3-[(4-pyridin-3-yl) pyrimidin-2-yl] amino) phenyl)-4-[(4-methylpiperazin-1-yl) methyl] benzamid. It is an anti neoplastic agent used to treat chronic myelogenous leukemia. Imatinib is used to treat Chronic Myelogenous Leukemia (CML), Gastrointestinal Stromal Tumors (GISTs) and a number of other malignancies. Imatinib mesylate was effective in patients with systemic mastocytosis, including those who had the D816V mutation in c-Kit. However, since imatinib binds to tyrosine kinases when they are in the inactive configuration and the D816V mutant of c-Kit is constitutively active, imatinib does not inhibit the kinase activity of the D816V mutant of c-Kit.

Imatinib is a 2-phenylaminopyrimidine derivative that functions as a specific inhibitor of a number of tyrosine kinase enzymes. In chronic myelogenous leukemia, the Philadelphia chromosome leads to a fusion protein of Abl with Bcr (breakpoint cluster region), termed Bcr-Abl. As this is now a continuously active tyrosine kinase, Imatinib is used to decrease Bcr-Abl activity.

Imatinib mesylate is a protein-tyrosine kinase inhibitor that inhibits the Bcr-Abl tyrosine kinase, the constitutive abnormal tyrosine kinase created by the Philadelphia chromosome abnormality in Chronic Myeloid Leukemia (CML). It inhibits proliferation and induces apoptosis in Bcr-Abl positive cell lines as well as fresh leukemic cells from Philadelphia chromosome positive chronic myeloid leukemia. Imatinib also inhibits the receptor tyrosine kinases for Platelet Derived Growth Factor (PDGF) and Stem Cell Factor (SCF) - called c-kit. Imatinib was identified in the late 1990s by Dr Brian J. Druker. Its development is an excellent example of rational drug design. Soon after identification of the bcr-abl target, the search for an inhibitor began. Chemists used a high-throughput screen of chemical libraries to identify the molecule 2-phenylaminopyrimidin. This lead compound was then tested and modified by the introduction of methyl and benzamide groups to give it enhanced binding properties, resulting in imatinib [1].

Several analytical methods for the determination of imatinib by spectrophotometry [2,3], HPLC [4-12] and LC/MS [13] have been reported. The aim of the present work was to develop and validate a better sensitive RP-HPLC method that can be implemented for the quantification of imatinib in bulk as well as in its tablet dosage forms when compared to the data of previous established method [4-12].
Experimental

Materials

Imatinib Mesylate working standard was purchased from celon labs, Hyderabad, India. Imatinib Mesylate capsules containing 20 mg of Imatinib (Ome) were obtained from Apollo Pharmaceuticals Pvt. Ltd, Visakhapatnam. Acetonitrile (HPLC grade) were purchased from Qualigens, Potassium dihydrogen orthophosphate, Orthophosphoric acid are purchased from Sd fine-Chem Ltd; Mumbai.

Instrumentation

Analytical technologies Alliance High Pressure Liquid Chromatograph installed with Empower software Model: e2487 dual absorbance, phenomenex, C-18, (250mm x 4.6mm) column with UV – Vis spectrophotometer model UV-2450 were used.

Chromatographic conditions

The High Performance Liquid Chromatographic (HPLC) system used was operated with the column temperature maintained at 30°C, using a mobile phase composition of acetonitrile and O-Phosphoric acid (in the ratio of 30:70 v/v) at a flow rate of 0.8 mL/min within a run time of 10 min. Prior to use, the mobile phase was degassed by an ultrasonic bath and filtered by a Millipore vacuum filter system equipped with a 0.45 μm high vacuum filter. The drug was detected and quantified at 268 nm.

Preparation of standard solutions

25 mg of Imatinib Mesylate Working standard was accurately weighed and transferred into a 25 mL volumetric flask and about 20 mL of diluent was added to it and sonicated to dissolve drug completely and volume was made up to the mark with the same solvent which gave Stock solution of 1000 ppm. 1 ml of the above stock solution was pipetted into a 10 mL volumetric flask and was diluted up to the mark with diluents to prepare 100 ppm solution. Further 1 ml of prepared solution was added and solution was sonicated for 15 minutes, thereafter 10 ml of diluent was added and solution was sonicated to degas. From this stock solution (3.5 ml) was transferred to five different 10 mL volumetric flasks and volume was made up to 10 mL with same solvent system. The solution prepared was injected into the HPLC system and the peak areas were recorded. A duplicate injection of the standard solution was also recorded. In five replicates into the HPLC system and the observations were recorded to five different 10 mL volumetric flasks and volume was made up to 10 mL with same solvent system. The solution prepared was injected into the HPLC system and the peak areas were recorded.

Method validation

The method was validated in accordance with ICH guidelines [14]. The parameters assessed were linearity, accuracy, and Limit of Detection (LOD), limit of quantification (LOQ), precision, reproducibility, robustness and system suitability.

Accuracy

Accuracy was best determined by the standard addition method. Previously analyzed samples of Imatinib API were added with standard drug solutions and are analyzed by the proposed method. Recovery (%), RSD (%) and bias (%) were calculated for each concentration.

Precision

Precision was determined as both repeatability and intermediate precision, in accordance with ICH guidelines. Repeatability of sample injection was determined as intraday variation and intermediate variation. For these determinations, single concentration (10 µg/ml) at different time intervals and different days, of the solution of Imatinib API was used. The precision of each method was ascertained separately from the peak areas & retention times obtained by actual determination of five replicates of a fixed amount of drug. Imatinib (API) The percent relative standard deviation was calculated for Imatinib.

Robustness

The concept of robustness of an analytical procedure has been defined by the ICH as “a measure of its capacity to remain unaffected by small but deliberate variations in method parameters”. To determine the robustness of the method experimental conditions are purposely altered and chromatographic characters are evaluated. Influence of small changes in chromatographic conditions such as change in flow rate, wavelength of detection and acetonitrile content in mobile phase were studied to determine the robustness of the method.

Limit of Detection (LOD)

The Limit of Detection (LOD) of an analytical method may be defined as the concentration, which gives rise to an instrument signal that is significantly different from the blank. For spectroscopic techniques or other methods that rely upon a calibration curve for quantitative measurements, the IUPAC approach employs the standard deviation of the intercept (Sa), which may be related to LOD and the slope of the calibration curve, b, by

\[ \text{LOD} = 3 \frac{S_a}{b} \]

Limit of Quantitation (LOQ)

The LOQ is the concentration that can be quantitated reliably with a specified level of accuracy and precision. The LOQ represent the concentration of analyte that would yield a signal-to-noise ratio of 10.

\[ \text{LOQ} = 10 \frac{S_a}{b} \]

Where, Sa is the standard deviation of the peak area ratio of analyte to IS (6 injections) of the drugs and b is slope of the corresponding calibration curve.
Table 1: Optimization of chromatographic conditions of Imatinib.

<table>
<thead>
<tr>
<th>Trials</th>
<th>Column Used</th>
<th>Mobile Phase</th>
<th>Flow Rate</th>
<th>Wave Length</th>
<th>Observation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hiq Sil, C-18, V size (250mm*4.6mm)</td>
<td>Potassium dihydrogen phosphate Buffer: ACN(50:50)</td>
<td>1 ml/min</td>
<td>268nm</td>
<td>Peak tailing and negative peak was found</td>
<td>Method Rejected</td>
</tr>
<tr>
<td>2</td>
<td>Hiq Sil, C-18, V size (250mm*4.6mm)</td>
<td>Potassium dihydrogen phosphate Buffer: Methanol: ACN(50:30:20)</td>
<td>1 ml/min</td>
<td>268nm</td>
<td>Poor resolution. Peak fronting and a broad Peak were found</td>
<td>Method Rejected</td>
</tr>
<tr>
<td>3</td>
<td>waters, C-18, (250mm*4.6mm)</td>
<td>Potassium dihydrogen phosphate Buffer: ACN (60:40)</td>
<td>1 ml/min</td>
<td>268nm</td>
<td>Peak shape was not good and also a tailing was found</td>
<td>Method Rejected</td>
</tr>
<tr>
<td>4</td>
<td>waters,C-18, (250mm*4.6mm)</td>
<td>Potassium dihydrogen phosphate buffer: ACN (65:35)</td>
<td>1 ml/min</td>
<td>268nm</td>
<td>Poor resolution and peak tailing was also found</td>
<td>Method Rejected</td>
</tr>
<tr>
<td>5</td>
<td>waters, C-18, (250mm*4.6mm)</td>
<td>Potassium dihydrogen phosphate buffer: acetonitrile (70:30)</td>
<td>0.8 ml/min</td>
<td>268nm</td>
<td>Good resolution, theoretical plate count and less tailing factor</td>
<td>Method Accepted</td>
</tr>
</tbody>
</table>

Results and Discussion

Optimization of chromatographic conditions

The chromatographic conditions were optimized by different means i.e. using different column, different mobile phase, different flow rate, different detection wavelength and different diluents for standard drug are summarized in Table 1 & 2 and the optimised chromatogram (Figure 1) is shown. Appreciable results were obtained by using mobile phase consisting of Potassium dihydrogen phosphate buffer: acetonitrile (70:30) on phenomenex C-18, (250mm*4.6mm) column with wavelength of detection of 268 nm. Flow rate was fixed at 0.8 ml/ min with a run time of 10 min.

A chromatogram of Imatinib standard was made to run by injecting the solution prepared in section 2.4 in to HPLC.

Specificity

Chromatogram obtained for the injection is shown figure 2 with Rt of 2.67 mins without the use of any internal standard.

Linearity & Range

The calibration curve showed in figure 3 has good linearity in the range of 5 – 35 µg/ml (Table 3), for Imatinib (API) with correlation coefficient ($r^2$) of 0.9963. The slope and intercept of the calibration graph was calculated by using linear regression analysis.
The regression equation of the calibration curve was: 
\[ y = 76594x - 24947 \] 
\[ r^2 = 0.996 \]
A correlation coefficient of 0.996 suggests that the developed HPLC method had an excellent linearity over the investigated range.

**Precision**

**Repeatability:** The precision of each method was ascertained separately from the peak areas & retention times obtained by actual determination of five replicates of a fixed amount of drug, Imatinib (API). The percent relative standard deviation was calculated for Imatinib are presented in the table 3 and Overall repeatability for Imatinib is shown in figure 4.

**Accuracy:** Recovery study

The recovery of the method, determined by adding a previously analyzed test solution with additional drug standard solution at three levels of concentration, was 99.99–100.46 %. The values of recovery (%) and RSD (%) listed in Table 5 indicate the method is accurate. The mean recovery was found to be 99.882% for Imatinib and shown in table 5. The limit for mean % recovery is 98-102% and as both the values are within the limit, hence it can be said that the proposed method was accurate.

**Limit of detection and limit of quantification**

The LOD was found to be 0.341µg/ml and LOQ was found to be 1.023 µg/ml for Imatinib which represents that sensitivity of the method is high.
System suitability

The system suitability parameters are shown in table 6.

Table 6: Data for system suitability parameters.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Parameter</th>
<th>Limit</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Resolution</td>
<td>Rs &gt; 2</td>
<td>9.15</td>
</tr>
<tr>
<td>2</td>
<td>Asymmetry</td>
<td>T ≤ 2</td>
<td>Imatinib=0.12</td>
</tr>
<tr>
<td>3</td>
<td>Theoretical plate</td>
<td>N &gt; 2000</td>
<td>Imatinib=3246</td>
</tr>
</tbody>
</table>

Estimation of Imatinib in Capsule Dosage Form

Assay was performed by using the regression equation (y = 76594x - 24947; r^2 = 0.996) obtained from the standard curve of Imatinib API. Results obtained are given in table 8 and represented as chromatogram in figure 5.

The amount of drugs in omef capsule was found to be 99.10 (±0.498) mg/tab for Imatinib.

Conclusion

A New RP-HPLC method indicating assay of Imatinib in bulk and in pharmaceutical dosage form is established. This method is simple, reliable, linear, accurate, sensitive and reproducible as well as cost effective for the effective quantitative analysis of imatinib in bulk and capsule formulations. The method was completely validated showing satisfactory data for all the method validation parameters tested and method is free from interference of the other active ingredients and additives used in the formulations. Therefore the method is suitable for use of the routine quality control analysis of imatinib in API or in pharmaceutical dosage forms.

References


14. ICH. Validation of analytical procedures: Methodology harmonized tripartite guideline prepared within the international conference on harmonization of technical requirements for the registration of pharmaceuticals for human use. ICH-Q2B: Geneva; 1996.