Development and validation of a dissolution method using HPLC for diclofenac potassium in oral suspension

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The present study describes the development and validation of an in vitro dissolution method for evaluation to release diclofenac potassium in oral suspension. The dissolution test was developed and validated according to international guidelines. Parameters like linearity, specificity, precision and accuracy were evaluated, as well as the influence of rotation speed and surfactant concentration on the medium. After selecting the best conditions, the method was validated using apparatus 2 (paddle), 50-rpm rotation speed, 900 mL of water with 0.3% sodium lauryl sulfate (SLS) as dissolution medium at 37.0 ± 0.5°C. Samples were analyzed using the HPLC-UV (PDA) method. The results obtained were satisfactory for the parameters evaluated. The method developed may be useful in routine quality control for pharmaceutical industries that produce oral suspensions containing diclofenac potassium.


INTRODUCTION

Aqueous solubility of any drug is a key property that determines dissolution and absorption, and thus bioavailability in vivo. The most widely used test to establish the rate of drug release is the dissolution test, which is a very important tool to demonstrate bioequivalence from batch-to-batch as well as ensuring the quality of products and performance after certain changes, for instance in the formulation and manufacturing process (Azarmi et al., 2007; Frost, 2004; Modi, Tayade, 2007).

For drugs belonging to Biopharmaceutical Classification System Class 2, dissolution is the limiting step for drug absorption and the dissolution profile must be clearly defined and highly reproducible (Oliveira et al., 2009). From a biopharmaceutics point of view, a more
Discriminating dissolution method is preferred because the test will indicate possible changes in product quality (Vaucher, 2009).

In order to demonstrate that the method is appropriate for dissolution test purposes, the parameters of linearity, specificity, precision, accuracy, stability and influence of the filter type should be evaluated (FDA, 1997; The United States Pharmacopeia, 2012).

Diclofenac potassium (DP), benzeneacetic acid 2-[(2,6-dichlorophenyl)amino], is a non-steroidal drug with anti-inflammatory, analgesic and antipyretic properties. It is used for rheumatoid arthritis, degenerative disease, chronic pain associated with cancer and kidney stones and endodontic procedures (Janbroers, 1987; The United States Pharmacopeia, 2012).

DP is readily absorbed orally, but the presence of food reduces its plasma concentration (Cmax) from about 40% to 60%. Unlike sodium salt which has a delayed release, DP is formulated to achieve dissolution under acidic conditions in the stomach. When compared to other salts, it has higher solubility (Jijun et al., 2011; Olson et al., 1997). In the past few years several studies have been published concerning the determination of DP in pharmaceutical formulations (Elkady, 2010; Souza, Tubino, 2005; Naidoo et al., 2009; Scallion, Moore, 2009; Sparidans et al., 2008). The USP 2012, presents the official dissolution test method in vitro for DP in tablets, where the dissolution medium utilized is simulated intestinal fluid without enzyme, however the dissolution test in vitro for DP in oral suspension is not listed in any pharmacopoeia and no dissolution test for oral suspension has been reported in the literature.

The present study aims to develop and validate a dissolution test for DP in oral suspension using a high performance liquid chromatographic method (HPLC) to determine the release rate of this drug.

**MATERIAL AND METHODS**

**Chemicals and Reagents**

Diclofenac potassium reference standard with 99.8% purity, was supplied by Farmacopeia Brasileira (2012). Two batches, Z0047 and Z0049A, of oral suspension (Cataflam®) containing 2 mg/mL of diclofenac potassium were obtained from the commercial market. The excipients of the pharmaceutical formulation were citric acid, sorbic acid, deionized water, strawberry flavor, microcrystalline cellulose, sodium cyclamate, hydroxyethyl cellulose, propylparaben, methylparaben, propylene glycol, glycercyl polyoxyethylene glycol stearate, saccharin sodium. All of them were obtained from different local distributors.

Water was purified using the Millipore® system. All other reagents were of analytical grade.

**Instrumentation and chromatography conditions**

The dissolution test was performed in a PHARMA TEST®, PTWS-3E (Hainburg/Germany), digitally controlled heater/circulator and multibath (n=8), in accordance with general methods (United States Pharmacopeia, 2012). The LC system consisted of a Shimadzu® (Kyoto, Japan), provide with an LC-20AT pump, SIL-20A ht auto sampler, CTO-20AC column oven, SPD-M20A PDA detector, CBM-20A system controller, and LC solution software was used to quantify the samples. The Ultra Basic Denver potentiometer was used to determine the pH of all solutions.

Chromatographic separations were achieved using a Phenomenex® Luna C8 (150 x 4.6 mm, 5 µm) column at 30.0 ± 0.5°C. The mobile phase contained a mixture of methanol: buffer phosphate pH 2.5 (70:30 v/v), flow rate of 1.0 mL/min, PDA detection at 275 nm. The injection volume was 20 µL.

**Determinations of sink conditions**

The selection of a dissolution medium may be based on the solubility data and dosage range of the drug product. The sink conditions were determined in different solvents, such as: phosphate buffer (pH 6.8 and 7.4) and water with sodium lauryl sulphate (0.3%, 0.5%, 1.0% and 1.5%). An amount of drug equivalent to the highest dose that can be administered was added in 250 mL of each medium. After stirring for 24 hours, an aliquot was transferred to a volumetric flask and diluted with dissolution medium. The drug solubility in each medium was determined in duplicate.

**In vitro drug release studies**

The dissolution test study with USP apparatus 2 (50/75 rpm, paddles) was tested to evaluate the best conditions. The following procedure was performed for all tests to develop this method: an equivalent amount of 10.0 mg of DP was added to each vessel containing medium that was selected based on the solubility data. Syringes were utilized to add the product to each vessel. The syringes were weighed before and after adding the product, and the weight difference was related to product density.

Sample aliquots were withdrawn at 5, 10, 15, 30 and 60 minutes and replaced with an equal volume of fresh medium to maintain a constant total volume. The percentage of drug dissolved was determined using the HPLC method.
Dissolution method validation

Specificity
It was evaluated by preparing a placebo sample of oral suspension at the usual concentration. This sample was transferred to a vessel \( (n = 3) \) with dissolution medium and stirred for 2 hours at 150 rpm using paddle and a temperature of 37.0 ± 0.5°C. Aliquots of this solution were filtered and analyzed using the HPLC method.

Linearity
Aliquots of a 100 µg/mL solution of DP reference standard prepared in a dissolution medium were transferred to 25 mL volumetric flasks to obtain the final concentrations of 2.0, 6.0, 10.0, 14.0 and 18.0 µg/mL. Each solution was prepared in triplicate. The linearity was evaluated by linear regression analysis, using analysis of variance (ANOVA).

Accuracy and precision
Accuracy was evaluated by recovering the amount of DP reference substance added to the placebo. Aliquots of 0.36, 1.8 and 3.24 mL of the standard solution (5 mg/mL) were added to the vessel containing placebo equivalent to a usual concentration and dissolution medium at 37.0 ± 0.5°C, and agitated for 60 minutes with a paddle at 50 rpm. The final concentrations were 2.0, 10.0 and 18.0 µg/mL. The analysis was done in duplicate on three days. Repeatability and intermediate precision were evaluated based on RSD from the recovery data.

Stability and influence of filter
Dissolution of the sample \( (n=3) \) was carried out for analysis of stability, under previously selected conditions. Samples were collected after 2 hours and injected into the HPLC system at 0, 12 and 24 hours. For determination of filter interference, samples \( (n=3) \) of DP were submitted to a dissolution test. After a predetermined time the samples were collected and filtered using F. Maia filter (Sample A) and centrifuged (sample B). Sample B was used as a standard value. This study aims to evaluate whether the drug will adsorb on polymeric membrane filter. The acceptance criterion for loss by adsorption is a maximum of 5.0% (Linderberg et al., 2005).

Evaluation of dissolution profiles
The dissolution profiles were compared using the model independent method. The model independent approach includes the difference factor \( (f_i) \) and the similarity factor \( (f_2) \) using equations 1 and 2 respectively:

\[
f_i = \left\{ \frac{\sum_{i=1}^{n} |R_f - T_f|}{\sum_{i=1}^{n} R_f} \right\} \times 100\% \quad \text{(Equation 1)}
\]

\[
f_2 = 50 \times \log \left\{ \frac{1}{n} \sum_{t=1}^{n} (R_t - T_t)^2 \right\}^{0.5} \times 100\%
\]

where \( n \) is the number of time points, \( R \), and \( T \), are the percent dissolved of the reference and test product, respectively.

The percent of error is zero when the test and drug reference profiles are identical and increase proportionally with the dissimilarity between the two dissolution profiles (Polli et al., 1996). According to the FDA, 1997, two dissolution profiles are declared similar if \( f_i \) is between 0 and 15 and \( f_2 \) is between 50 and 100.

RESULTS AND DISCUSSION

Solubility determination

DP BCS (Biopharmaceutical Classification System) is class II, and showed low solubility and high permeability. Therefore, drugs of this class may show dissolution rate as the limiting factor in the absorption process (Fortunato, 2005; Qureshi, 2006). The solubility test showed that DP was soluble in phosphate buffer (pH 6.8 and 7.4) and water with sodium lauryl sulphate (0.3%, 0.5%, 1.0% and 1.5%), Table I, suggesting that the sink condition was satisfied. The term sink condition is defined as the volume of medium at least greater than three times that required, forming a saturated solution of a drug (The United States Pharmacopeia, 2012).

TABLE I - Solubility test of diclofenac potassium in different fluids

<table>
<thead>
<tr>
<th>Dissolution medium</th>
<th>% Drug Dissolved after 24 hours(^a)</th>
<th>RSD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer solution phosphate (pH 6.8)</td>
<td>98.07</td>
<td>0.34</td>
</tr>
<tr>
<td>Buffer solution phosphate (pH 7.4)</td>
<td>99.93</td>
<td>0.72</td>
</tr>
<tr>
<td>Water + 0.3% SLS</td>
<td>98.41</td>
<td>0.41</td>
</tr>
<tr>
<td>Water + 0.5% SLS</td>
<td>98.05</td>
<td>0.91</td>
</tr>
<tr>
<td>Water + 1.0% SLS</td>
<td>98.49</td>
<td>0.37</td>
</tr>
<tr>
<td>Water + 1.5% SLS</td>
<td>98.96</td>
<td>0.68</td>
</tr>
</tbody>
</table>

\(^a\)Mean of two analysis; RSD = Relative Standard Deviation

Dissolution profiles of DP in oral suspension

Dissolution tests using a paddle at 75 rpm and phosphate buffer (pH 6.8 and 7.4) and water with sodium lauryl sulphate (0.3%, 0.5%, 1.0% and 1.5%) were evaluated (Figure 1 and 2, respectively).
For assays utilizing buffer pH 6.8 and 7.4, a very rapid drug release was found in the first 5 minutes, 83.98% and 96.96% respectively, however for the dissolution media using water with SLS at concentrations of 0.3%, 0.5%, 1.0% and 1.5%, we found that the release rate of the drug increases as the surfactant concentration increases in the dissolution media. A rotation speed of 50 rpm (Figure 3) was used to retard drug release in dissolution medium containing water with SLS 0.3% and 0.5%.

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For both dissolution mediums tested the agitation speed of the apparatus significantly influenced the rate of drug release at each sampling time.

Using water with sodium lauryl sulphate 0.3% and apparatus rotating at 50 rpm, a slower, reproducible and discriminating release profile was obtained between batches when compared with the dissolution medium containing water with SLS 0.5%. FDA (1997) recommends using the smallest possible amount of surfactant in the dissolution medium, because the higher the concentration of the surfactant, the greater the difficulty of obtaining a correlation. Therefore, the dissolution medium containing water with 0.3% SLS was selected to develop the method.

**Method validation**

**Specificity**

Specificity was observed by analyzing a placebo solution. The chromatograms showed that no interference of excipients was observed for the drug retention time (about 7.2 min) Figure 4.

**Linearity and Range**

The linearity was tested in the concentration range of 2.0 – 18.0 µg/mL of drug substance. The results demonstrate method linearity with a correlation coefficient of 0.9999, the slope and y-intercept obtained were 42580 and 6257, respectively. The analysis by ANOVA showed significant regression and non-significant linearity deviation ($P < 0.05$) for the relation between the area of the peaks of substance and its concentrations. The results were considered acceptable and the linearity curves were used to calculate in vitro drug release studies.
**Accuracy and Precision**

The recovery measured is typically 95.0-105.0% of the drug amount added (FROST, 2004). The accuracy of this method was considered adequate in the range of 97.85-100.08% for DP (Table II), corroborating the accuracy of the method. The intermediate precision and repeatability were evaluated at three different concentrations of 2.0, 10.0 and 18.0 µg/mL over three days, by different analysts. The RSD values are shown in (Table III).

<table>
<thead>
<tr>
<th>TABLE II - Accuracy of the dissolution method for DP in oral suspension</th>
</tr>
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<tbody>
<tr>
<td>Standard solution (µg/mL)</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>18</td>
</tr>
<tr>
<td>Mean recovery (%) ± SD (n = 18)</td>
</tr>
<tr>
<td>SD – Standard Deviation</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>TABLE III - Intermediate precision and repeatability of the dissolution method for DP in oral suspension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intraday (n = 6)</td>
</tr>
<tr>
<td>day I</td>
</tr>
<tr>
<td>day II</td>
</tr>
<tr>
<td>day III</td>
</tr>
<tr>
<td>Interday (n = 3)</td>
</tr>
<tr>
<td>SD – Standard Deviation; RSD – Relative Standard Deviation</td>
</tr>
</tbody>
</table>

**Stability of drug in solution and influence of filter type**

After testing the stability of drug in dissolution medium, the drug remained stable in solution for 24 hours when stored at room temperature. All results obtained during analysis times were very close to the initial value, according to (Table IV).

<table>
<thead>
<tr>
<th>TABLE IV - Stability of drug after dissolution test</th>
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<tbody>
<tr>
<td>Dissolution medium</td>
</tr>
<tr>
<td>Sample in solution (n = 3)</td>
</tr>
<tr>
<td>Sample in solution (n = 3)</td>
</tr>
<tr>
<td>RSD – Relative Standard Deviation</td>
</tr>
</tbody>
</table>

The filter used was unable to interfere in the quantitative analysis of the drug. The sample filtered using F. Maia filter (sample A) presented an average content of 99.42% and the centrifuged sample (sample B), an average content of 97.71%, which proves the noninterference of the filter used in the tests.

**Discrimination power of selected dissolution method**

Evaluation of dissolution profiles is an important tool when it is necessary to know the behavior of two products before submitting them to the Study on Bioavailability/Bioequivalence, for post-registration changes, waiver of in vivo studies of smaller dosages as well as optimizing the pharmacotechnical process to develop new formulations (Brasil, 2010). The profiles were evaluated accordingly (Brasil, 2010), using points 10, 15 and 30 minutes. Factors $f_1$ and $f_2$ were 2.55 and 72.65 respectively, coefficient variation was less than 20.0% for the first points and less than 10.0% for the other points, confirming that the profiles obtained between batches of pharmaceutical products are similar, according to (Figure 5). The results of dissolution profiles for both products are given in Table V.

**CONCLUSION**

A quick, simple dissolution method was successfully developed for the evaluation of the in vitro release of DP...
in oral suspension. The conditions used were USP type II apparatus at 50 rpm, containing 900 mL of water with 0.3% SLS, at 37.0 °C ± 0.5. Drug stability was maintained under the developed dissolution conditions, and therefore the method could be used in routine quality control of DP in oral suspension.

REFERENCES


**TABLE V** - Comparison of *in vitro* drug release profiles of two batches of DP oral suspension

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>% drug release</th>
<th>RSD (%)</th>
<th>Time (minutes)</th>
<th>% drug release</th>
<th>RSD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>43.48</td>
<td>2.05</td>
<td>43.26</td>
<td>3.49</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>58.91</td>
<td>2.23</td>
<td>53.76</td>
<td>1.09</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>69.74</td>
<td>1.41</td>
<td>67.44</td>
<td>2.18</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>88.16</td>
<td>1.49</td>
<td>89.73</td>
<td>2.54</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>98.89</td>
<td>1.38</td>
<td>99.06</td>
<td>1.81</td>
<td></td>
</tr>
</tbody>
</table>

*Mean of two analysis; RSD – Relative Standard Deviation*


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