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Original Article

A novel UV-photolysis approach with acetone and isopropyl alcohol for the rapid determination of fluoride in organofluorine-containing drugs by spectrophotometry

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ABSTRACT

A UV photolysis decomposition (UVPD) method for the determination of fluoride in fluorine containing pharmaceuticals by spectrophotometry is reported. It is based on the use of high intensity UV-irradiation in the presence of a digesting solution comprising a mixture of acetone and isopropanol. For the optimization of the UVPD procedure, three bulk drugs (levofloxacin, nebivolol and efavirenz) were chosen as representatives of three diverse compounds containing a single fluorine atom, two fluorine atoms, and trifluoromethyl groups respectively. Operational conditions of the UVPD method, such as concentration and volume of reagents (acetone and isopropyl alcohol), and UV irradiation time (1–6 minutes) were optimized. The efficiency of digestion was evaluated by the determination of fluoride in sample digests. Using the developed method, it was possible for complete conversion of the organofluoride to free fluoride ion for its subsequent determination by spectrophotometry based on bleaching of Zr–xylenol orange-color complex. Quantitative recovery (>98%) of the fluorine in the drug samples could be achieved using a mixture of 2% acetone + 2% isopropyl alcohol + 0.003% Na_2CO_3 in just 5 minutes of UV irradiation, which can be considered an important aspect considering the difficulties involved in the cleavage of the C–F bond. Accuracy was evaluated by comparison of results obtained by the UVPD method with the values estimated using formula weight of the compound and no statistical difference was observed between the results. Therefore, the proposed method is suitable for application in routine analysis of fluoride in organofluorine-containing drugs.

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1. Introduction

Fluorine has become an essential element in pharmaceutical industry. The inclusion of one or more fluorine atoms by replacing hydrogen atoms or hydroxyl groups in potential medicines can enhance their metabolic stability or modulate their physicochemical properties, binding interactions, and selective reactivities, making them more selective and increasing their efficacy [1–6]. One of the most important factors in drug design takes into account the fact that fluorine is much more lipophilic than hydrogen, thus incorporation of fluorine atom/atoms in a molecule makes it more fat soluble and hence more bioavailable. Many fluorinated compounds are currently widely used (in the treatment of various diseases) as antidepressants, anti-inflammatory, antimalarial, antipsychotics, antiviral agents, steroids, general anesthetics, antihyperintensive, antifertility, and central nervous system drugs [6].

However, one of the major limitations of introducing fluorine as substituent in to drug products is that it poses increased challenges in the manufacturing process. Hence, the accurate determination of fluoride in fluorine-containing pharmaceuticals allows to ensure the formation of target compound with proper fluoridation after synthesis. It is also for the consumer to know the truth in labeling as per the drug manufacturer, in relation to safety and efficacy of the drug. Hence, the number of samples submitted for fluoride analysis, is continuously growing.

Ionic fluoride can be easily determined by analytical techniques such as fluoride ion-selective electrode [7] and/or spectrophotometry [8–10]. However, the fluorine in organic compounds (in this case drug materials) is mainly bound to carbon. Hence, it is necessary to destroy the organic matrix (i.e., conversion of organofluorine to free fluoride ion) prior to the determination of fluoride content. Quantitative decomposition of organic fluorine compounds is often extremely difficult. Due to this, very few studies have reported the determination of fluoride in pharmaceutical samples [1,11–19]. However, these methods are generally not robust enough to be applied to routine analysis. This fact probably is due to the complexity of the drug matrix, especially for the samples containing one or more trifluoromethyl groups as one of the moiety, making the application of conventional techniques for fluoride determination much more difficult where fluorine is bound more firmly making stringent treatment conditions necessary for its liberation. We have previously reported a simple, effective and reliable UV photolysis digestion (UVPD) method for the determination of fluoride in pharmaceuticals containing fluorine as one of the constituents [20]. Although this was a simple and convenient method for the determination of fluoride, it suffers from limitations including two-step digestion process using 10% HNO_3 and relatively long digestion time (~25 min). Hence, we sought improvements in the procedure within the context of *green chemistry* principles [21,22], which aimed to reduce the amount of toxic chemical reagents at the same time simplifying and accelerating experimental procedures.

The decomposition of organic matter under the influence of UV radiation was initially described by Armstrong et al [23] as an efficient sample preparation method. UV photolysis decomposition/digestion is based on radical mechanism, involving many intermediate reactive species such as the excited states of hydrogen peroxide, hydroxyl radicals, singlet oxygen, super oxide ions, and other radicals generated during photolysis and reacting with organic molecules, degrading them [24]. Because of these excellent properties, UV irradiation process has already been well exploited for a number of analytical applications such as speeding up solid–liquid extraction of elements/species of interest for the determination of total-element contents and speciation analysis and a number of other analytical and industrial applications [25–32]. Various studies on the analytical applications of UV-irradiation for the determination of various elements including fluoride in a wide variety of matrices have earlier been reported from our laboratory [33–37].

The main objective of this study is to develop a simple, rapid, and environment-friendly sample preparation method with the aid of UV photolysis for the conversion of bound fluorine to free fluoride ion in a wide variety of drug samples containing single to multiple fluorine constituents and its subsequent determination by spectrophotometry based on the destruction of the colored complex of zirconium–xylenol orange by the generated fluorides. In this work, the efficacy of the UV photolysis digestion method using a mixture of acetone and isopropyl alcohol (IPA) for the quantitative determination of fluoride was evaluated. A previously reported two-step method based on the use of 10%HNO_3 (v/v) [20] was also utilized for comparison purposes.

2. Experimental

2.1. Instrumentation

All the photolysis experiments were carried out using a UV digester (Model No. 705, Metrohm, Herisau, Switzerland) assembly, incorporating a high-intensity mercury lamp (500 W, 10 MPa). The 705 UV digester is equipped with a sample holder with a provision for holding 12 quartz tubes of 15-mL capacity. In each set of samples, one quartz tube was reserved for monitoring the digestion temperature using a thermometer. The temperature of the UV photolysis unit was maintained at 85 ± 5°C with the help of a water-recirculating system integral to the digester.

2.2. Reagents and materials

Deionized water further purified to get ultrapure water of > 18 MΩ resistivity by passage through a Milli-Q system (Millipore Corp., Billerica, MA, USA) located in a class 200 area, was used for dilution of the standards, reagents, preparing the samples and the final rinsing of the acid-cleaned vessels.

Acetone and IPA were used as received. All other chemicals were of analytical-reagent grade unless otherwise stated. Prior to use, all containers were cleaned in 20% HNO_3 followed by rinsing with water. A certified fluoride standard solution (100 μg/mL, Thermo Orion 940907) traceable to National Institute of Standards and Technology (NIST) reference materials, was used in the preparation of the working standards by sequential dilutions. Graduated polypropylene centrifuge tubes of 15 mL and 50 mL volume (Tarson Products Pvt. Ltd., Kolkata, India) were used for preparing sample solutions throughout this work.

2.3. General UVPD procedure

For the optimization of the UVPD procedure, three pure bulk drug samples (levofloxacin, nebivolol, and efavirenz; Hetero Drugs Pvt. Ltd, Hyderabad, India), were chosen as representatives of the three diverse matrices: containing a single fluorine atom per molecule, two fluorine units, and trifluoromethyl group respectively.

Accurately weighed amounts (~30 mg) of the three representative bulk drug samples was placed in three precleaned polypropylene tubes and then 5 mL of a mixture of acetone and IPA was added in each tube to dissolve the samples. From this stock solution, a known volume (100–500 μL) is taken into quartz tubes containing 10 mL of a mixture of 2% acetone and 2% IPA (v/v). These tubes were kept in the sample holder and loaded in the UV-digester for irradiation. Then the sample solutions were subjected to UV photolysis for 5 minutes, while maintaining the sample temperature at 80–85°C using the water-cooling system. At the end of the irradiation, the sample digests were cooled and transferred to 50 mL capped polypropylene tubes and made up to the required volume with high-purity water for subsequent analysis by Zr–xylenol orange-based spectrophotometry method.

Corresponding process blanks, without addition of sample, were also prepared in the same way and were carried throughout the whole UVPD procedure. Three aliquots of each sample were subjected to the UVPD procedure. With each series of digestions, a blank was also determined. All of the analytical measurements were run in triplicate for the sample solutions. Quantification of the fluoride content in the samples is based on calibration plots obtained with aqueous standards as well as standard addition method.

Xylenol orange, the sodium salt of 3,3′-bis[N,N-di(carboxymethyl)-aminomethyl]-o-cresol-sulphonphthalein, forms a colored complex with zirconium that is decolorized by the presence of fluoride ions. This reaction is used for the spectrophotometric determination of fluoride. The reagent solution, Zr–xylenol orange was prepared by mixing the dye [0.01% (w/v) with depolymerized zirconium solution (0.04% (w/v)] in 20% (v/v) HCl medium [9]. At the time of analysis, 1 mL of reagent solution was added to 4 mL of sample solution (1:4). The resultant color of the mixture was monitored by measuring the absorbance at 550 nm.

A 5-point aqueous calibration curve [0 (analytical blank)–1 μg/mL] was used in the quantification studies of fluoride and standard addition method was also applied, in order to see possible matrix interferences, if any. To determine the loss of fluoride, if any, during the photolysis process, a series of standards containing known concentrations of fluoride (0.05–1 μg/mL) prepared using the optimized digesting mixture and were subjected to the proposed UV-photolysis procedure as in the case of samples. Calibration plots were also obtained with the processed standard solutions and compared the plots obtained with the pure aqueous standards of fluoride.

The percentage recoveries of fluoride in the test samples after UV-photolysis were calculated using the following equation

$$\%\ \text{Recovery} = \frac{\textit{Fluoride obtained}}{\textit{Fluoride as per formula weight}} \times 100$$

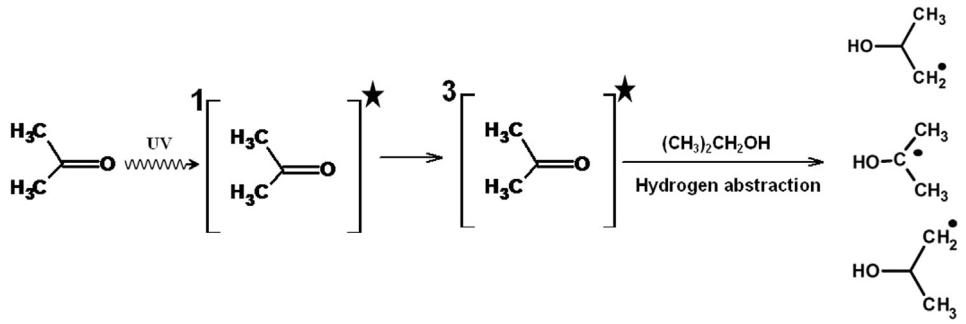
3. Results and discussion

The operating principle of the present UV-photolysis process is based on the release of fluoride from the drug samples, which is subsequently analyzed by spectrophotometry. The decomposition behavior of various drug compounds under the influence of UV may not be equally efficient under identical conditions, so maximizing the fluoride recoveries requires process variables to be optimized to enable application of the method for all matrices. Hence detailed studies were carried out using the three representative materials (levofloxacin, nebivolol, and efavirenz) to optimize the process parameters such as composition of digesting solution and irradiation time. The efficiency of the proposed approach was established by calculating the percentage recovery of fluoride using the equation as shown in the experimental section. The volume of digesting solution was maintained at 10 mL throughout the studies.

3.1. Development of UVPD procedure

Direct determination of fluoride in the test pharmaceutical samples (after dissolving them in the mixture of acetone and IPA) was not feasible, possibly due to the undissociated C–F bond. Therefore, the application of UV-photolysis approach was considered in the present study for the decomposition of drug samples, i.e., conversion of organic bound fluorine (–C–F) to free fluoride ion. However, it is necessary to identify suitable digesting solutions that facilitate the UV-irradiation process for the decomposition of organic matter.

Ketone photochemistry has been widely used to facilitate the solar-promoted dehalogentation of halo-organics. During photolysis, ketones undergo various types of photochemical reactions including intermolecular and intramolecular hydrogen abstraction, thereby generating a number of highly reactive free radicals as shown below. The generated free radicals are mainly responsible for the digestion/decomposition of organic compounds as shown in the following equation.



Betterton [37] described mechanism of photosensitized dehalogenation of CCl_4 to $CHCl_3$ by 2-propanol in the presence of acetone in aqueous solution. It was observed that the rate of reaction is extremely rapid (< 2 min) by exposure to sunlight. This fundamental knowledge has been utilized in the present work for the cleavage of the –C–F bond in the organofluorine-containing drug samples using dilute solutions of IPA and acetone as digesting mixture. During the development of the UVPD procedure, the two experimental parameters—composition of digesting solution (acetone and IPA) and UV-photolysis time—were optimized for the three representative pharmaceutical compounds.

3.2. *Effect of composition of digesting solution (IPA and acetone)*

One of the main requirements of the UVPD procedure is that the samples should be completely in solution form. Therefore, a correct composition of the digesting mixture is fundamental to UV-photolysis process of drug compounds (i.e., conversion of bound fluorine to free fluoride) for quantitative determination of fluoride. Preferably, the solvent mixture should also have compatibility with the spectrophotometric method, which is used for quantification of fluoride in the present work. Additionally, demands for green and safe analytical methods must be fulfilled. Hence a mixture of acetone and IPA was selected and its composition was optimized to obtain quantitative recovery of fluoride.

In order to optimize the best composition of acetone and IPA, a factorial (2 factors, 3 levels) experimental design approach was applied and recovery of fluoride at each level of treatment was calculated. Based on the results obtained from initial set of experiments, a composition of 3% acetone and 3% IPA was chosen as base level for the three representative materials and the upper and lower levels were obtained using a difference of ±1% for both the solvents from the base level. Corresponding digesting mixtures were employed as blanks.

Figure 1 shows the effect of the recoveries obtained for fluoride at each level of treatment when the representative drug materials were taken through the general UV-assisted photolysis procedure at different concentration levels of acetone and IPA. These results indicate that the proposed UV-assisted photolysis procedure was only moderately effective (F recovery was < 75%) for efavirenz, which has a trifluoromethyl group as one of the constituents while quantitative recovery (> 98%) was obtained with a mixture of 2% acetone+2% IPA for both levofloxacin and nebivolol representative samples. The low recoveries (< 75%) of fluoride for efavirenz sample that contain a CF_3 group were obtained even after irradiating the sample mixture longer time (up to 20 minutes). With the aim of improving recovery of fluoride in efavirenz, the following compositions were also tried with 10 mL of: 10% acetone + 5% IPA, 5% acetone + 10% IPA, 10% acetone + 10% IPA and 20% acetone + 10% IPA. However, fluoride recovery for the efavirenz was in the range of 75–80% with any of these solvent mixtures. The difference in behavior between the representative bulk drug samples may possibly be due to the number and type of fluorine atoms present. Also, the low recoveries of fluoride obtained for efavirenz may possibly be due to incomplete dissociation of fluorine from –CF_3 group. To be the most practical in implementation, it was desired to develop a procedure that can be applied to multiple matrices, i.e., drug sample containing single or multiple organofluorine constituents.

It is well known that fluoride has very high affinity to elements such as Na, Ca, and Zr. Among these, Zr cannot be used herein as the present spectrophotometric detection method involves the bleaching of Zr–xylenol colour complex. Hence Na_2CO_3 was selected as complexing agent due to its ease of preparation and availability in pure form. Based on these observations, a mixture of acetone + IPA + Na_2CO_3 was therefore chosen as the digesting mixture for further studies, in order to avoid the use of highly concentrated organic solvents. To achieve quantitative recovery of fluoride from efavirenz, Na_2CO_3 was added as the complexing agent to the optimized mixture of digesting solution, i.e., mixture of 2% acetone and 2% IPA. Based on initial set of experiments, concentration of Na_2CO_3 was varied from 0.001% to 0.005% (w/v) keeping all the other parameters such as composition (2% acetone and 2% IPA) and volume of digesting solvent (10 mL), photolysis time (5 minutes), and amount of sample (~3 mg, i.e., 500 μL of 6 mg/mL stock solution) fixed.

The recoveries obtained for fluoride when all the representative drug materials were taken through the general UV-assisted photolysis procedure at different concentrations of Na_2CO_3 are shown in Figure 2. As seen here, the recovery of fluoride varies significantly as a function of concentration of Na_2CO_3. The results showed that the recovery was increased from 80% to > 98% with increased concentration of Na_2CO_3 from 0.001%, while the best fluoride recoveries (> 98%) were obtained at a concentration of 0.003% and reached plateau. Similar studies were also performed with levofloxacin and nebivolol bulk drug samples, but the results were not affected by the addition of Na_2CO_3. These studies clearly indicate that

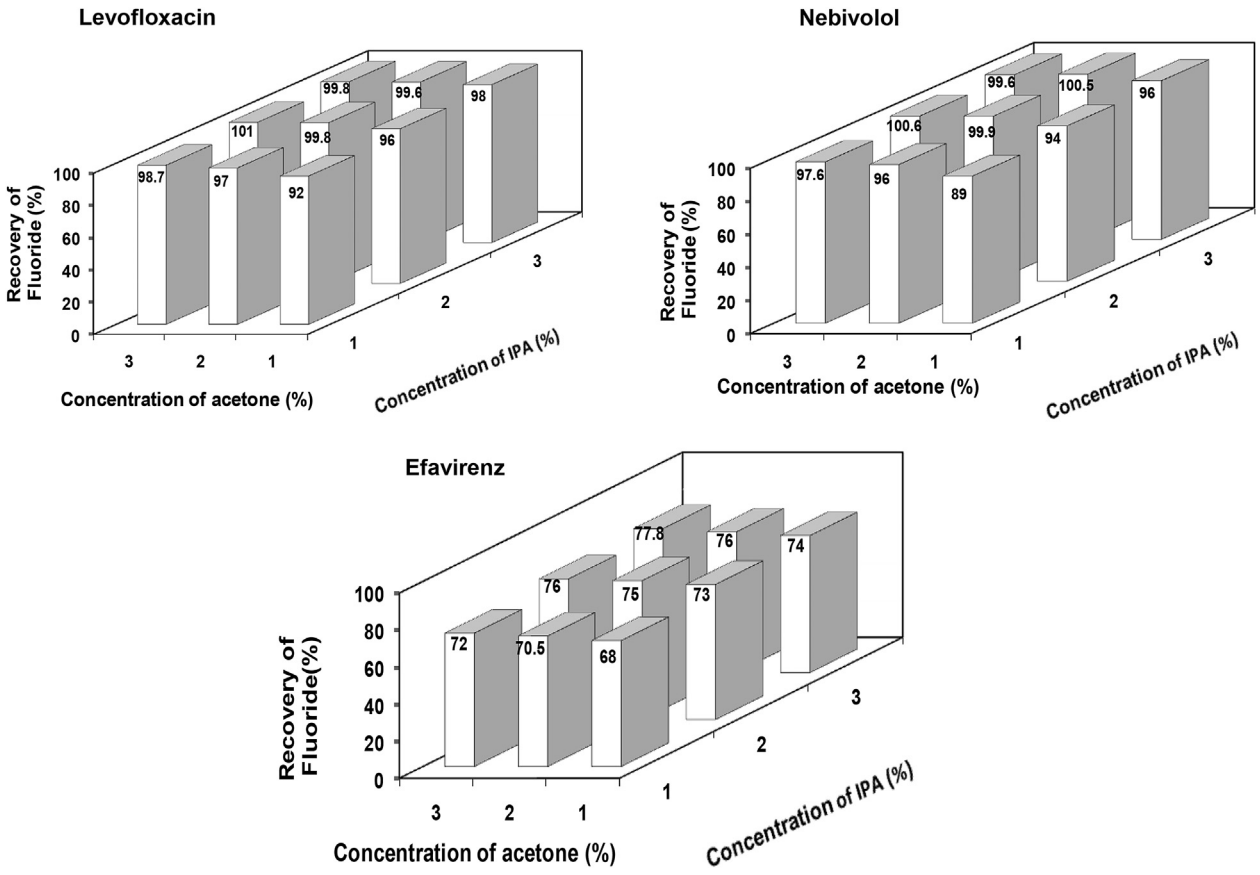


Figure 1 – Optimization of reagent composition (acetone and isopropyl alcohol) for the quantitative recovery of fluoride from the three representative samples; levofloxacin, nebivolol, and efavirenz; sample mass = 3 mg, volume of the reagent solution = 10 mL, UV irradiation time = 5 minutes.

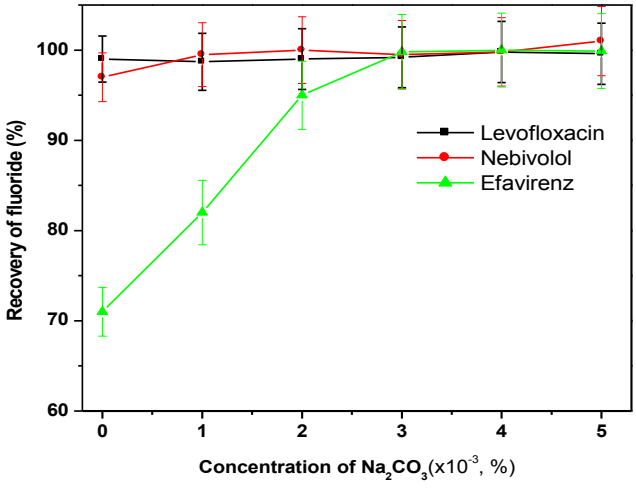


Figure 2 – Effect of concentration of Na_2CO_3 on the recovery of fluoride from the three representative samples (levofloxacin, nebivolol, and efavirenz) selected for UV-assisted decomposition studies. Sample mass = 3 mg, volume of the reagent solution = 10 mL, composition of reagent solution = 2% acetone + 2% IPA, UV irradiation time = 5 minutes.

maximum recovery of fluoride was achieved with a reagent mixture of 2% acetone + 2% IPA + 0.003% Na_2CO_3 for all three representative samples and was used in all subsequent experiments. In the presence of UV radiation, the anionic part of the Na_2CO_3 can be easily removed as CO_2; thereby, free Na is available for immediate binding with fluoride. The reason for this quantitative recovery may possibly be the combined effect of high reactivity of free radicals (which are generated by UV-photolysis process) and complex formation with Na, which led to their rapid decomposition (i.e., breaking of the C–F bond) during UV-photolysis process.

3.3. *Optimization of UV-photolysis time*

The photolysis time necessary for achieving total quantitative recovery of fluoride mainly depends on the strength and type of C–F bond as well as composition and concentration of the digesting medium. A set of experiments were carried out to see the effect of UV irradiation time on the fluoride recovery by maintaining a constant temperature of the UV system (~85°C). In the present study, optimization studies of UV photolysis time were carried out by varying the irradiation time from 1 minute to 6 minutes by keeping the digesting solvent mixture composition, volume of digesting mixture and sample weight constant at (2% acetone + 2% IPA + 0.003%

Na_2CO_3), 10 mL and (~3 mg, i.e., 500 μL of 6 mg/mL stock solution) respectively. Periodically sample aliquots were taken out and analyzed for fluoride content. In all the present optimization studies, general procedure was followed and fluoride recovery values were calculated in each case according to the equation given in the earlier section. The extent of mineralization of the representative material, i.e., conversion of organofluorine to fluoride ion, was determined on the basis of the recovery of fluoride present in the sample digests by spectrophotometric method. Therefore, the UV-irradiation process was continued until fluoride recovery values are consistent.

The influence of UV exposure time on the recovery of fluoride is shown in Figure 3. In all cases, the efficiency of the UVPD system (i.e., breaking of the C–F bond) increases with increasing UV exposure time. As can be seen in Figure 3, for levofloxacin and nebivolol representative samples, quantitative recovery of fluoride (>98%) was achieved within a UV-exposure time of 4 minutes in a single step while efavirenz requires UV-exposure time of 5 minutes. The difference in fluoride recovery among the three representative materials with varying UV-irradiation conditions is essentially due to the C–F bonding nature of these representative materials. Based on these observations, UV-photolysis time of 5 minutes was selected for further optimization studies.

3.4. *Analytical performance*

The analytical performance of the proposed UVPD method was studied by examining the three parameters namely recovery of fluoride, limit of detection and precision (relative standard deviation). Calibration plots of fluoride were obtained across a concentration range from 0 (i.e., analytical blank) to 1 μg/mL with the first set (aqueous), second set (fluoride spiked in reagents mixture, i.e., 2% acetone + 2% IPA + 0.003% Na_2CO_3) and third set (fluoride spiked in reagents mixture after applying UVPD procedure) of solutions. In all the cases, fluoride concentration was determined by taking absorbance measurements by spectrophotometry. The main intention of this study was to see the effect of matrix, loss of fluoride if any and apply a simple method of external aqueous calibration for quantification of fluoride in order to improve the sample throughput. In all the cases, good linearity and satisfactory correlation coefficients ($R^2 > 0.995$) were obtained. The calibration plots obtained with spiked fluoride standards show that the recovery of fluoride was very quantitative (>98%). This study also clearly indicated that there was no significant loss of fluoride during the UV photolysis process. As shown in Table 1, the analytical curves obtained for all the three sets of solutions exhibited almost the same slope and good reproducibility. This allows the use of aqueous calibration for quantification purposes, which is very important for obtaining high sample throughput. Under optimal conditions, fluoride recoveries obtained for the three representative samples are presented in Table 2. As seen here, good recoveries obtained in all the three cases demonstrating the efficacy of the proposed UVPD procedure.

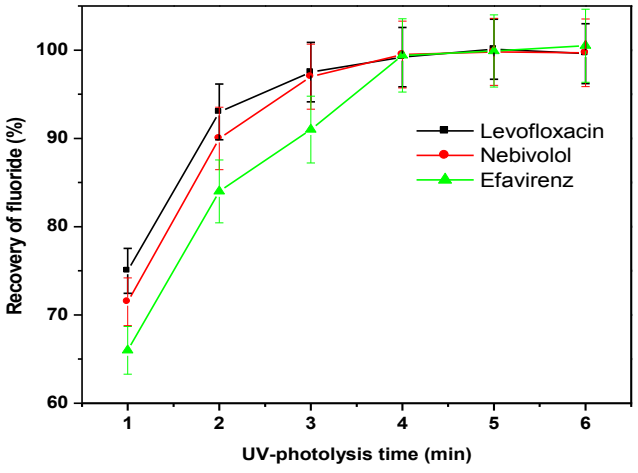


Figure 3 – Influence of UV irradiation time on the recovery of fluoride from the three representative samples (levofloxacin, nebivolol, and efavirenz). Sample mass = 3 mg, volume of the reagent solution = 10 mL, composition of reagent solution = 2% acetone + 2% IPA + 0.003% Na_2CO_3.

Under optimal conditions, the limits of detection (defined as concentration equivalent to three times standard deviation of five measurements of a blank) obtained for spectrophotometry in conjunction with the UV photolysis decomposition method was found to be 0.20 μg/g. The relative standard deviation values obtained from the three replicate determinations of the three bulk drug samples after taken through the general UVPD procedure were in the range of 1–6% in all cases. Good agreement is also seen between the results obtained with both the external and standard addition procedures (data not shown here), which clearly demonstrates the efficacy of the UVPD method for quantitative conversion of all bound fluoride to fluoride ion of the tested drug materials. Using the UV photodigester equipped with a sample holder of 12 quartz tubes, a set of six samples (in duplicate) can be processed simultaneously. In the case of developed UVPD procedure, the time needed for decomposition of a set of drug samples was 5 minutes followed by analysis (~1 minute per sample) making it possible to analyze 250 samples (approximately) in an 8-hour working day.

To assess the efficacy of the present method, the same representative materials were also processed using the previously reported two-step method based on the use of 10% HNO_3 (v/v) for comparison purposes. The results obtained in

Table 1 – Analytical response characteristics of fluoride with spectrophotometry.

Medium	Response function	R^2
Aqueous	$y = 0.578x + 0.029$	0.996
2% acetone + 2% IPA + 0.003% Na_2CO_3 (spiked with fluoride before UV photolysis)	$y = 0.586x + 0.032$	0.996
2% acetone + 2% IPA + 0.003% Na_2CO_3 (spiked with fluoride after UV photolysis)	$y = 0.580x + 0.022$	0.998

Calibration range = 0.05–1 μg/mL.

Table 2 – Fluoride values obtained for the three representative bulk drug samples after UV-photolysis by spectrophotometry ($n = 3$).

Drug name	Fluoride content as per formula weight (%)	Obtained value (%)	Recovery (%)
Levofloxacin Formula: $C_{18}H_{20}FN_3O_4$ Molecular mass: 361.368 g/mol	5.26	5.23 ± 0.16	99.4
Nebivolol Formula: $C_{22}H_{25}F_2NO_4$ Molecular mass: 405.435 g/mol	9.37	9.41 ± 0.17	100.4
Efavirenz Formula: $C_{14}H_9ClF_3NO_2$ Molecular mass: 315.675 g/mol	18.06	18.18 ± 0.26	100.7

Table 3 – Application of UV-photolysis decomposition method to various commercially available drug samples for fluoride determination by spectrophotometry ($n = 3$).

Drug name	Molecular formula (mass, g/mol)	Fluoride content as per formula weight (%)	Obtained value (%)	Recovery (%)
Atarovastatin	$C_{33}H_{35}FN_2O_5$ (558.64)	3.40	3.36 ± 0.14	98.8
Resperidal	$C_{23}H_{27}FN_4O_2$ (410.48)	4.63	4.59 ± 0.15	99.1
Ciprofloxacin	$C_{17}H_{18}FN_3O_3$ (331.35)	5.73	5.77 ± 0.12	100.7
Citalopram	$C_{20}H_{21}FN_2O$ (324.39)	5.86	5.91 ± 0.19	100.9
Pantoprazole	$C_{16}H_{15}F_2N_3O_4S$ (383.37)	9.91	9.84 ± 0.23	99.3
Fluxetine (Prozac)	$C_{17}H_{18}F_3NO$ (309.33)	18.43	18.35 ± 0.28	99.6
Celecoxib	$C_{17}H_{14}F_3N_3O_2S$ (381.37)	14.95	14.72 ± 0.23	98.5
Mefloquine	$C_{17}H_{16}F_6N_2O$ (378.31)	30.13	30.29 ± 0.32	100.5

these two methods were in good agreement. However, the reported method [20] necessitates a two-step digestion process with an irradiation time of ~25 minutes. As in the case of alkali fusion method, sample preparation takes up to 24 hours at a temperature of 300°C which restricts sample throughput [14]. This clearly shows that the present single-step UV-photolysis approach is very fast with added advantage that it is a powerful tool for the sensitive determination of fluoride in organofluorine-containing drugs.

3.5. *Application to commercial drug samples*

The ultimate goal of this study was to demonstrate applicability of the developed UVPD approach to commercial drug samples. The proposed methodology was therefore finally applied to a variety of drug samples purchased from a local pharmacy for the determination of fluoride. The efficacy and reliability of the proposed UVPD method was checked by fluoride recovery experiments and compared with fluoride values of the drug samples as per their formula weight. The obtained and calculated (according to the formula weight) fluoride values were in good agreement demonstrating the capability of the developed UVPD method. In all cases, recoveries were found to be > 98% (Table 3).

4. Conclusion

A single-step and acid-less UV photolysis decomposition method in conjunction with spectrophotometry has been successfully demonstrated. The use of dilute mixture of acetone and IPA with the aid of UV photolysis followed by spectrophotometry detection allowed the determination of fluoride in pharmaceuticals making the procedure suitable for routine analysis. Quantitative recovery of fluoride (> 98%) was achieved with single step UVPD process using a reagent mixture of 2% acetone + 2% IPA + 0.003% Na_2CO_3 and an irradiation time of 5 minutes demonstrating that the whole process is much simpler and more rapid as compared to our earlier reported method [20]. An overall precision of better than 6% was achieved in all the cases. This method posses many features including simple, rapid, low reagent consumption and environment friendly as acids are completely avoided, which make it an attractive approach for the determination of fluoride in a variety of drug samples containing single to multiple fluorine atoms on routine basis.

Conflicts of interest

All authors have no conflicts of interest to declare.

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