***Research Article***

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**DESIGN, SYNTHESIS, ANTI-VIRAL ACTIVITY AND CYTOTOXICITY STUDIES OF SOME NOVEL N-SUBSTITUTED PIPERAZINYL FLUOROQUINOLONE DERIVATIVES**

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## Abstract

A series of novel N-substituted piperazinyl fluoroquinolones were synthesized and screened for their antiviral activity and cytotoxicity. Twenty two derivatives of known fluoroquinolones (Ciprofloxacin, Norfloxacin, Sparfloxacin and Gatifloxacin) were synthesized by modifying the N4-hydrogen of piperazine in fluoroquinolone with Mannich reaction. The purity of the compounds was ascertained by consistency in the Rf value as well as melting point determination and were characterized by means of their spectral analysis (IR and 1H NMR). The anti-HIV activities of the derivatives were screened against replication of HIV-1(III B) and HIV-2(ROD) in MT-4 cells. The synthesized compounds were tested for antiviral activity against HeLa cells (VSV and RSV) HEL cells (HSV-1 and HSV-2) CRFK cells (Feline Corona and Feline Herpes Virus) and Vero cells (Para influenza-3, Reovirus-1, Sindbis virus, Coxsackie virus B4 and Punta Toro virus). Among the compounds, compound SF-2A4PT and GF-2A4PT exhibited anti-viral activity against Vesicular Stomatitis virus in HeLa cells at the concentration of 7µg/ml and 12µg/ml respectively, where as their cytotoxicity was found to be more than 100µg/ml. Compound SF-2A4PT also inhibit the replication of Respiratory Syncytial Virus (RSV) at the concentration of 45µg/ml and its cytotoxicity was found to be more than 100µg/ml. *In–vitro* cytotoxicity studies of the synthesized compounds were determined by using MTT assay in Human liver cancer cells (Hep G2 cells). All the tested compounds exhibited significant cytotoxicity. Hence these merits further investigation to screen its anti cancer activity using *in-vitro* and *in-vivo* models.

**Keywords:** Mannich reaction, Fluoroquinolones, MT-4 Cells, HeLa cells, HEL Cells, Vero cells, MTT assay.

## Introduction

Quinolones are considered as a big family of multi- faceted drugs; their chemical synthesis is flexible and can be easily adapted to prepare new congeners with rationally devised structures. Quinolone derivatives have been shown to inhibit HIV-1

replication in do novo- and chronically infected cells1. A few works are available in the literature for Fluoroquinolone derivatives with different substitutions. SAR studies revealed that very fine changes in the main skeleton, as well as the fusion of rings will substantially affect the

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pharmacological activity profiles of these compounds. Among the various fluoroquinolones reported, N-1 substituted fluoroquinolones and N- substituted piperazinyl fluoroquinolones exhibit interesting pharmacological activities. N- substituted piperazinyl fluoroquinolones are considered a central scaffold to build chemical libraries with promising bioactivity potential and have been reported to display biological activities like antibacterial2,3, antifungal4, anticonvulsant, anti-HIV5,6, antitubercular7, antiplatelet, anti-viral8, and anticancer9,10 activities.

In spite of a large number of fluoroquinolones that have been synthesised and studied for various pharmacological activities, the anti viral and anti cancer activities of fluoroquinolones are selectively less explored. Studies revealed that antibacterial fluoroquinolones can exhibit antiviral activity as well. In the SAR study, the aryl substituents on the piperazine nitrogen were found to play an important role for the anti-HIV-I activity. Recently, newer arylpiperazinyl fluoroquinolones were synthesized and studied for their anti- HIV activity11-17. The present work deals with the synthesis of Mannich bases of fluoroquinolones with different heterocyclic primary amines, formaldehyde and to study their important pharmacological properties (antiviral activities and cytotoxicity) that are selectively less explored.

### Methods

The purity of the newly synthesized compounds were checked by Thin Layer Chromatography (TLC) using silica gel-G as stationary phase and the spot was visualized by Iodine vapour. The melting point of synthesized compounds was determined by open ended capillary tube method on a Thomas Hoover melting point apparatus and the values are found and uncorrected. The structures of the synthesized compounds were elucidated by Fourier Transformed-Infra Red (FT- IR) spectrophotometer by using KBr pellet. IR values are measured in cm-1 in the range of 4000 to 400 cm-1. The measurements were conducted on Bruker ATR, ZnSe - FTIR (Al-Shifa College of Pharmacy); JASCO 4100 (Calicut university) ; Perkin Elmer Spectrum AXI (CSIR, Chennai). Proton NMR of the synthesised compounds was recorded on solutions in dimethyl sulfoxide DMSO-*d6* on Bruker Ultra Shield DPX 400 at IISe Bengaluru. Tetra Methyl Silane (TMS) was used as

internal standard. Chemical shifts were reported in δ (ppm).

### General Procedure For Synthesis

0.01 mole of active hydrogen compound (2-amino - 4-phenyl thiazole, Sulphaguanidine, Sulphanilic acid, 2-amino benzthiazole, 2-amino pyridine, Trimethoprim, Lamotrigine, p-amino acetophenone, p-nitro aniline) was dissolved in 5ml of methanol in a 100ml beaker. The PH of reaction mixture was adjusted to 3.5-4.0 with concentrated hydrochloric acid. The beaker was kept in perfect ice cold condition on a magnetic stirrer. 1.0 ml of formaldehyde solution 37% w/v was added slowly with constant stirring. This was followed by addition of equimolar concentration of fluoroquinolone (0.01mol) (Ciprofloxacin, Norfloxacin, Sparfloxacin, Gatifloxacin) in small installments with constant stirring at efficient ice cooling. The reaction mixture was cooled well and stirred for 3 hours on a magnetic stirrer.

After 3 hours the reaction mixture was transferred into a 250 ml round bottom flask and placed on a water bath for refluxing. The reflux time varied with different active hydrogen compound used. The reaction mixture was kept at 00C over night in refrigerator. The Mannich product thus obtained was filtered and purified by washing twice with diethyl ether and then with acetone and then recrystallized from ethanol. (Scheme1, Table 01 & 02). The physical constants of the synthesised compounds are presented in table 03.

### Spectral Data

**CF-2A4PT:** IR (KBr) NH-3520, OH-3357, C=O- 1714, C=N-1624, C=C-1495, Ar-H-696, CF-557. PMR (DMSO-d6) 9.34-( s, 1H, NH ), 8.66-( s, 1H

,COOH ), 7.95-( d, 1H, quinine CH ), 7.45-7.65-(

m, 6H, Ar-H ), 4.49-( s, 2H, N-CH2- N ), 3.82-3.86-

(m, 8H, Piperazinyl ), 3.55-( m, 4H, Piperazinyl ), 1.12-1.19-( m, 3H, Cyclopropyl ). **CF-SG:** IR (KBr) NH-3410, C=N-1589, C=C-1540, SO2-1I22, Ar-H-750, CF-553. PMR (DMSO-d6) 8.8-( s, 1H,

NH ), 8.6-( s, 1H, COOH ), 7.5-8.0-( m, Cyclopropyl ). **CF-SA:** IR (KBr) NH-3535, C=O- 1714, C=C-1642, SO2-1178, Ar-H-696, CF-589. **CF-2ABT:** IR (KBr) NH-3520, C=O-1720, C=N- 1624, C-Nstr.-1482, Ar-H-696, CF-574. **CF-TRM:** IR (KBr) NH-3534, C=0-1720, C=N-1625, C=C- 1589, C-O-C-1124, Ar-H-690, CF-535. PMR (DMSO-d6) 9.53-( s, b, 2H, NH2 ), 8.673-( s, 1H,

COOH ), 7.96-( d, 1H, Quinone -CH ), 7.57-7.75-

( m, 2H, Ar-H ), 7.45-( s, 1H, Pyrimidinyl ), 6.613-

( s, 2H, Benzyl ), 3.87-( s, 2H, N-CH2-N ), 3.62-( s,

2H, Piperazinyl ), 3.58-( m, 4H, Piperazinyl ), 3.42- ( s, 9H, 3×OCH3 ), 1.16-1.2-( m, 3H, Cyclopropyl

). **CF-LTG:** IR (KBr) NH-3520, C=O-1724, C=N- 1624, CNstr.-1464, Ar-H-624, CF-571. PMR (DMSO-d6) 9.6-( b, 2H, NH2-Pyrimidinyl ), 9.182-(

s, IH, CH-NH ), 8.66-( s, 1H, COOH ), 7.95-( d,

1H, Quinone-CH ), 7.83-( s, IH, Pyrimidinyl ), 7.15-7.5-( m, 5H, Ar-H ), 3.87-( s, 2H, N-CH2-N ),

3.45-( b, 4H, Piperazinyl ), 1.15-1.19-( m, 3H, Cyclopropyl ). **CF-PAA:** IR (KBr) NH-3525, C=O-1714, C=C-1614, CNstr.-1464, Ar-H-642, CF-571. **CF-PNA:** IR (KBr) NH-3510, C=O- 1732, C=C-1642, CNstr.-1492, Ar-H-714, CF-571. **NF-2A4PT:** IR (KBr) NH-3428, OH-2939, C- Acyl-2723, C=O-1722, C=N-1626, C=C-1475, Ar- H-748, CF-670. **NF-SG:** IR (KBr) NH-3419, OH- 2935, C-Acyl-2724, C=O-1722, C=N-1627, C=C-

1477, SO2-1133, Ar-H-748, CF-567. **NF-SA:** IR (KBr) NH-3404, OH-2931, C-Acyl-2723, C=O- 1719, C=N-1627, C=C-1480, SO2-1165, Ar-H-685, CF-567. PMR (DMSO-d6) 9.16-( b, 1H, NH-CH2 ), 8.96-( s, 1H, COOH ), 7.96-( d, 1H, CH ), 7.1-7.8-(

m, 6H, Ar-H ), 5.3-( s, 2H, N-CH2-N ), 4.6-( q, 2H,

CH2 ), 3.54-( s, 4H, Piperazinyl ), 1.4-( t, 3H, CH3

). **NF-TRM:** IR (KBr) NH-3408, OH-2934, C- Acyl-2408, C=O-1721, C=N-1627, C=C-1475, C- O-C-1093, Ar-H-695, CF-566. **NF-LTG:** IR (KBr) NH-3308, OH-3095, C-Acyl-2934, C=O-1717, C=N-1633, C=C-1483, Ar-H-749, CF-571. **NF- PAA:** IR (KBr) NH-3423, OH-2936, C-Acyl- 2724, C=O-1721, C=N-1626, C=C-1476, Ar-H-

748, CF-567. **NF-PNA:** IR (KBr) NH-3407, OH-

2927, C-Acyl-2720, C=O-1717, C=N-1627, C=C-

1482, Ar-H-748, CF-568. **SF-2A4PT:** IR (KBr) NH-3412, OH-3271, C=O-1709, C=N-1634, C=C- 1564, Ar-H-658,708, CF-549. PMR (DMSO-d6)

9.34-(b, 1H, NH), 8.53-( s, 1H, COOH ), 7.39-

7.69-( m, 5H, Ar-H ), 4.015-( s, 2H, N-CH2-N ),

3.17-3.23-( s, 4H, Piperazinyl ), 1.26-( s, 6H, 2 X

CH3 ), 1.22-( s, 3H, CH3 ), 1.11-1.13-( m, 3H, Cyclopropyl ). **SF-SG:** IR (KBr) NH-3412, C=O- 1708, C=N-1641, C=C-1546, Ar-H-673, CF-549. PMR (DMSO-d6) 9.22-( b, 1H, NH-guanidine ), 8.71-( b, 1H, NH-CH2 ), 8.53-( s, 1H, COOH )7.1-

7.4-( m, 4H, Ar-H ), 4.016-( s, 2H, CH2-NH ),

3.39-3.53-( m, 4H, Piperazinyl ), 3.23-( m, 2H,

Piperazinyl ), 1.25-( s, 3H, CH3 ), 1.24-( s, 3H, CH3

), 1.10-( s, 3H, CH-Cyclopropyl ). **SF-SA:** IR (KBr) C=O-1708, C=N-1641, C=C-1546, SO2- 1180, Ar-H-673, CF-548. **SF-TRM:** IR (KBr)

NH2-3450, C=O-1708, C=N-1639, C=C-1560, C- O-C-1128, Ar-H-639, CF-522. **SF-2AP:** IR (KBr) NH-3565, C=O-1707, C=N-1644, C=C-1514, Ar- H-664, CF-538. PMR (DMSO-d6) 8.66-( b, 1H,

NH-CH2 ), 8.53-( s, 1H, COOH ), 7.2-7.4-( m, 4H,

Ar-H ), 4.01-( s, 2H, CH2-NH ), 3.39-3.5-( m, 4H,

Piperazinyl ), 3.18-3.21-( m, 2H, Piperazinyl ), 1.25-( d, 6H, 2×CH3 ), 1.11-( m, 3H, Cyclopropyl ). **GF-2A4PT:** IR (KBr) C=O-1707, C=N-1645, C=C-1547, C-O-C-1083, Ar-H-677, CF-537. **GF- SG:** IR (KBr) C=O-1714, C=N-1654, C=C-1540, C-O-C-1092, Ar-H-664, CF-541.

### Anti-HIV activity

The synthesised compounds were screened for anti- HIV activity against HIV-1 (III B) and HIV-2 (ROD) in acutely infected MT-4 cells18,19,20 and cytotoxicity of compounds were also tested with mock-infected MT-4 cells21 (Adult-C-type T- Leukemia cells). The MT-4 cells were grown in RPM1-1640 DM (“Dutch Modification”) medium (Flow Laboratories, Irvine, Scotland), supplemented with 10% (v/v) heat-inactivated fetal calf serum (FCS) and 20µg/ml gentamycin (E. Merck, Darmstadt, F.R.G.). The cells were maintained at 37°C in a humidified atmosphere of 5% CO2 in air. Inhibitory effect of test compounds on HIV replications was determined by inhibition of virus- induced cytopathic effect in MT-4 cells and was estimated by MTT assay. The MTT assay was based on the reduction of the yellow colored 3- (4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) by mitochondrial dehydrogenase of metabolically active cells to a blue formazan which can be measured spectrophotometrically. The absorbances were read at two wavelengths (540, 690 nm). The absorbance measured at 690 nm was automatically subtracted from the absorbance at 540 nm, so as to eliminate the effects of non-specific absorption. A blank was also carried out directly on the micro titer plates with all reagents except the MT-4 cells. IC50 - the effective concentration of compound, achieving 50% protection of MT-4 cells against the cytopathic effect of HIV was calculated. The 50% cytotoxic concentration (CC50) was also calculated which was defined as the concentration of the compound that reduced the absorbance (OD540) of the Mock- infected control sample by 50%. The maximum percentage protection achieved by the compounds in HIV-infected cells was calculated by the following formula:

Cytotoxicity of test compounds against mock- infected MT-4 cells was also assessed by the MTT method. Compounds were evaluated for their inhibitory effect on the replication of HIV in human MT-4 cells. The anti-HIV and cytotoxicity data are presented in table 04.

### Antiviral activity

Anti-viral activity and cytotoxicity of the synthesised compounds were determined by an in- vitro cell culture technique22. The anti-viral assays were based on inhibition of virus-induced cytopathicity of HeLa cells (VSV and RSV), HEL cells (HSV-1 and HSV-2), CRFK cells (Feline Corona and Feline Herpes Virus), Vero cells (Parainfluenza-3, Reovirus-1, Sindbis virus, Coxsackie virus, B4 and Punta Toro Virus). Briefly, confluent cell culture in 96-well microtiter plates were inoculated with 100 CCID50 of virus, one CCID50 being the virus dose required to infect 50% of the cell cultures. After 1 hr. of virus adsorption period, residual virus was removed, and the cell cultures were incubated in the presence of varying concentrations (400, 200 and 100 µg/ml) of the test compounds. Viral cytopathicity was recorded as soon as it reached completion in the control virus-infected cell cultures that were treated with the test compounds. The anti viral activity of the compounds were expressed as the concentration required to inhibit viral cytopathogenicity by 50% (EC50). Cytotoxicity of the compounds was determined as the minimum concentration required to cause microscopically detectable alteration of

normal cell morphology. The anti viral and cytotoxicity data are presented in tables 05 to 08.

### In vitro cytotoxicity studies

*In–vitro* cytotoxicity studies of the synthesised compounds were determined by MTT assay in Human liver cancer cells23 (Hep G2 cells). This assay is based on the assumption that dead cells or their products do not reduce tetrazolium salt into a blue coloured product-formazan. The monolayer cell culture was trypsinized and the cell count was adjusted to 1.0x105 cells/ml using medium containing 10% new born calf serum. To each well of the 96 well microtitre plate, 0.1ml of the diluted cell suspension (approximately 10,000 cells) was added. After 24 hours, when a partial monolayer was formed, the supernatant was flicked off, washed the monolayer once and 100l of different drug concentrations was added to the cells in microtitre plates. The plates were then incubated at 37oC for 3 days in 5% CO2 atmosphere, and microscopic examination was carried out and observations recorded every 24 hours. After 72 hours, the drug solutions in the wells were discarded and 50l of MTT in MEM was added to each well. The plates were gently shaken and incubated for 3 hours at 37oC in 5% CO2 atmosphere. The supernatant was removed and 50l of propanol was added and the plates were gently shaken to solubilize the formed formazan. The absorbance was measured using a microplate reader at a wavelength of 540nm. The percentage growth inhibition was calculated using the formula below:

50% cytotoxic concentration (CTC50) of the compounds was then calculated from the plot of concentration v/s % growth inhibition. The cytotoxicity data are presented in table 09.

## Results and Discussion

This research work described the synthesis of N- Mannich bases of fluoroquinolones and *in-vitro* evaluation of their cytotoxicity and anti viral activities. Four series of N-Mannich bases of fluoroquinolones have been prepared through Mannich reaction. The formation of mannich base can be confirmed from the appearance of new 1H

NMR signal in the range of δ 3.8-5.5 due to 2H; CH2 of methylene linkage formed during mannich base formation. The anti-HIV activities of the derivatives were screened against replication of HIV-1(III B) and HIV-2(ROD) in MT-4 cells

through MTT- assay. Cytotoxicity of test compounds against mock-infected MT-4 cells was also assessed by the MTT method. All the compounds displayed cytostatic properties in T- lymphocyte MT-4 cells. Among the derivatives tested, compounds CF-APH (CC50:2.39±0.43 μg/ml) and CF-PME-APH (CC50:3.47±2.01 μg/ml) was found to be more toxic in this series. The

synthesised compounds were tested for anti-viral activity against HeLa cells (VSV and RSV) HEL cells (HSV-1 and HSV-2), CRFK cells (Feline Corona and Feline Herpes Virus) and Vero cells (Para influenza-3, Reovirus-1, Sindbis virus, Coxsackie virus B4 and Punta Toro virus). Among the derivatives tested, compound SF-2A4PT and GF-2A4PT exhibited anti-viral activity against Vesicular Stomatitis virus in HeLa cells at the concentration of 7µg/ml and 12µg/ml, respectively, and their cytotoxicity was found to be more than 100µg/ml. Compound SF-2A4PT also inhibit the replication of Respiratory Syncytial Virus (RSV) at the concentration of 45µg/ml. Hence these broad- spectrum antiviral properties should be further explored in order to assess the potential of fluoroquinolone derivatives in the treatment of viral infection. *In–vitro* cytotoxicity studies of the synthesised compounds were determined by using

MTT assay in Human liver cancer cells (Hep G2 cells). All the tested compounds exhibited significant cytotoxicity. Among the compounds, SF-SG (CTC 50 = 164.93±4.11µg/ml) was found to be more toxic, where as the CTC 50 of standard cisplatin was found to be 11.09 ± 0.59 µg/ml. Hence SF-SG merits further investigation to screen its anti cancer activity using *in-vitro* and *in-vivo* models. From the results it has been found that introduction of heterocyclic primary amine at N-4 hydrogen of piperazine in fluoroquinolone through mannich reaction will substantially affect the antiviral activity and cytotoxicity of fluoroquinolones and many future drugs may be produced by the structural diversity of Mannich bases of fluoroquinolones.

O H O R 2

N

R 1 R 3

F

O

HCHO

+

4

+ H 2 N R\*

R

N

N H

Fluoroquinolone R 5

Formaldehyde 1 0 Amine

CH 3 OH

Conc.HCl

O H O R 2

O

F

N

R 1

N

R 3

N

R 5

R 4

C H 2

N H R\*

Fluoroquinolone derivative

### Scheme 1: Synthetic Protocol of studied Compounds

**Table No. 01: List of synthesized fluoroquinolone derivatives**

**Compound R1 R2 R3 R4 R5**

Norfloxacin C2H5 H H H H

Ciprofloxacin

H

H

H H

Sparfloxacin

NH2 F CH3 CH3

Gatifloxacin

H OCH3 CH3 H

**Compound Code**

### Table No. 02: List of studied compounds

**H 2N - R\* IUPAC Name**

CF-2A4PT

H2N

H2N

 O

S NH

1-Cyclopropyl-6-fluoro-4-oxo-7-{4-[(4-phenyl-thiazol-2- ylamino)-methyl]-piperazin-1-yl}-1,4-dihydro-quinoline-3- carboxylic acid.

NH 1-Cyclopropyl-7-(4-{[4-(diaminomethylene-sulfamoyl)-

S

N

phenylamino]-methyl}-piperazin-1-yl)-6-fluoro-4-oxo-1,4-

CF-SG

S

O NH2

O

dihydro-quinoline-3-carboxylic acid.

1-Cyclopropyl-6-fluoro-4-oxo-7-{4-[(4-sulfo-phenylamino)-

CF-SA

CF-2ABT

CF-TRM

CF-LTG

H2N

H 2N

H 2 N

NH2

N

N

H2N

N N

N

CH2

O H

O

S

N

OCH3

OCH3 OCH3

methyl]-piperazin-1-yl}-1,4-dihydro-quinoline-3-carboxylic acid.

7-[4-(Benzothiazol-2-ylaminomethyl)-piperazin-1-yl]-1- cyclopropyl-6-fluoro-4-oxo-1,4-dihydro-quinoline-3-carboxylic acid.

7-(4-{[4-Amino-5-(3,4,5-trimethoxy-benzyl)-pyrimidin-2- ylamino]-methyl}-piperazin-1-yl)-1-cyclopropyl-6-fluoro-4-oxo- 1,4-dihydro-quinoline-3-carboxylic acid.

7-(4-{[5-Amino-6-(2,3-dichloro-phenyl)-[1,2,4]triazin-3-ylamino]-

methyl}-piperazin-1-yl)-1-cyclopropyl-6-fluoro-4-oxo-1,4- dihydro-quinoline-3-carboxylic acid.

NH2 Cl Cl

 O

7-{4-[(4-Acetyl-phenylamino)-methyl]-piperazin-1-yl}-1-

CF-PAA

H2N

NH2

C CH3

OCH 3

cyclopropyl-6-fluoro-4-oxo-1,4-dihydro-quinoline-3-carboxylic acid.

 N

1-Cyclopropyl-6-fluoro-7-{4-[(4-nitro-phenylamino)-methyl]-

CF-PNA

NF-2A4PT

H2N N

H 2 N

S

N

CH2

OCH 3

OCH 3

piperazin-1-yl}-4-oxo-1,4-dihydro-quinoline-3-carboxylic acid.

1-Ethyl-6-fluoro-4-oxo-7-{4-[(4-phenyl-thiazol-2-ylamino)- methyl]-piperazin-1-yl}-1,4-dihydro-quinoline-3-carboxylic acid.

NF-SG

H2N

 O NH 7-(4-{[4-(Diaminomethylene-sulfamoyl)-phenylamino]-methyl}-

NH piperazin-1-yl)-1-ethyl-6-fluoro-4-oxo-1,4-dihydro-quinoline-3-

 S

NF-SA

H2N

O NH2

O

 S

OH

O

NH2

N

N

carboxylic acid.

1-Ethyl-6-fluoro-4-oxo-7-{4-[(4-sulfo-phenylamino)-methyl]- piperazin-1-yl}-1,4-dihydro-quinoline-3-carboxylic acid.

NF-TRM

H2N

CH2

OCH3

OCH3 OCH3

7-(4-{[4-Amino-5-(3,4,5-trimethoxy-benzyl)-pyrimidin-2- ylamino]-methyl}-piperazin-1-yl)-1-ethyl-6-fluoro-4-oxo-1,4- dihydro-quinoline-3-carboxylic acid.

NF-LTG

H2N

N N

N

NH2 Cl Cl

7-(4-{[5-Amino-6-(2,3-dichloro-phenyl)-[1,2,4]triazin-3-ylamino]- methyl}-piperazin-1-yl)-1-ethyl-6-fluoro-4-oxo-1,4-dihydro- quinoline-3-carboxylic acid.

NF-PAA

H2N

O

C CH3

7-{4-[(4-Acetyl-phenylamino)-methyl]-piperazin-1-yl}-1-ethyl-6- fluoro-4-oxo-1,4-dihydro-quinoline-3-carboxylic acid.

**Compound**

**Code H 2N - R\* IUPAC Name**

NF-PNA

SF-2A4PT

NH2

N

2

H2N CH N

S

N

H 2N

OCH3

OCH3 OCH3

1-Ethyl-6-fluoro-7-{4-[(4-nitro-phenylamino)-methyl]-piperazin- 1-yl}-4-oxo-1,4-dihydro-quinoline-3-carboxylic acid.

5-Amino-1-cyclopropyl-7-{3,5-dimethyl-4-[(4-phenyl-thiazol-2- ylamino)-methyl]-piperazin-1-yl}-6,8-difluoro-4-oxo-1,4-dihydro- quinoline-3-carboxylic acid.

SF-SG

H2N

 O

S NH

NH 5-Amino-1-cyclopropyl-7-(4-{[4-(diaminomethylene-sulfamoyl)- phenylamino]-methyl}-3,5-dimethyl-piperazin-1-yl)-6,8-difluoro-

SF-SA

H 2N

NH2

N

O NH2

O

S

OH

O

OCH3

1. oxo-1,4-dihydro-quinoline-3-carboxylic acid.
2. Amino-1-cyclopropyl-7-{3,5-dimethyl-4-[(4-sulfo- phenylamino)-methyl]-piperazin-1-yl}-6,8-difluoro-4-oxo-1,4- dihydro-quinoline-3-carboxylic acid.

5-Amino-7-(4-{[4-amino-5-(3,4,5-trimethoxy-benzyl)-pyrimidin-

SF-TRM

SF-2AP

GF-2A4PT

H2N CH2 N

H2N N

S

N

H2N

OCH3 OCH3

2-ylamino]-methyl}-3,5-dimethyl-piperazin-1-yl)-1-cyclopropyl- 6,8-difluoro-4-oxo-1,4-dihydro-quinoline-3-carboxylic acid.

5-Amino-1-cyclopropyl-7-[3,5-dimethyl-4-(pyridin-2- ylaminomethyl)-piperazin-1-yl]-6,8-difluoro-4-oxo-1,4-dihydro- quinoline-3-carboxylic acid.

1-Cyclopropyl-6-fluoro-8-methoxy-7-{3-methyl-4-[(4-phenyl- thiazol-2-ylamino)-methyl]-piperazin-1-yl}-4-oxo-1,4-dihydro- quinoline-3-carboxylic acid.

GF-SG

H2N

NH 1-Cyclopropyl-7-(4-{[4-(diaminomethylene-sulfamoyl)-

NH phenylamino]-methyl}-3-methyl-piperazin-1-yl)-6-fluoro-8-

 O

 S

O NH2

methoxy-4-oxo-1,4-dihydro-quinoline-3-carboxylic acid.

### Table No. 03: Physical Constant of Synthesized Compounds

27 26 5 3

|  |  |  |  |
| --- | --- | --- | --- |
| **Compound code Molecular formula M W** | **M p (°C)** | **R value****f** | **Percentage yield** |
| CF-2A4PT C H FN O S 519.59 | 220- 224 | 0.64 | 51.96 |
| CF-SG C H FN O S 557.60 | 244-248 | 0.66 | 55.6 |
| CF-SA C H FN O S 516.54 | 262-265 | 0.68 | 81.08 |
| CF-2ABT C H FN O S 493.55 | 258-264 | 0.72 | 68.96 |
| CF-TRM C H FN O 633.67 | 250-254 | 0.67 | 34.72 |
| CF-LTG C H Cl FN O 599.44 | 252-258 | 0.69 | 70.07 |
| CF-PAA C H FN O 478.52 | 226-230 | 0.54 | 62.7 |
| CF-PNA C H FN O 481.48 | 220-225 | 0.66 | 72.76 |
| NF-2A4PT C H FN O S 507.58 | 248-252 | 0.60 | 19.7 |
| NF-SG C H FN O S 545.59 | 258-260 | 0.62 | 75.09 |
| NF-SA C H FN O S 504.53 | 260-262 | 0.67 | 29.73 |
| NF-TRM | C31H36FNO6 | 621.66 | 260-265 | 0.70 | 64.44 |
| NF-LTG | C26H25Cl12FN8O3 | 587.43 | 255-260 | 0.74 | 37.48 |
| NF-PAA | C25H27FN4O4 | 466.51 | 260-264 | 0.63 | 42.87 |
| NF-PNA | C23H24FN5O5 | 469.47 | 220-224 | 0.78 | 72.42 |
| SF-2A4PT | C29H30F2N6O3S | 580.65 | 274-278 | 0.65 | 34.44 |
| SF-SG | C27H32F2N8O5S | 618.66 | 262-265 | 0.64 | 50.11 |
| SF-SA | C26H29F2N5O6S | 577.60 | 265-270 | 0.70 | 72.71 |
| SF-TRM | C34H40F2N8O6 | 694.73 | 258-262 | 0.66 | 66.22 |
| SF-2AP | C25H28F2N6O3 | 498.53 | 268-272 | 0.70 | 56.17 |
| GF-2A4PT | C29H30F2N6O4S | 563.64 | 235-240 | 0.62 | 67.42 |
| GF-SG | C27H32FN7O6S | 601.65 | 240-242 | 0.67 | 60.87 |

25 28 7 5

24 25 4 6

25 24 5 3

32 36 7 6

27 25 2 8 3

26 27 4 4

24 24 5 5

26 26 5 3

24 28 7 5

23 25 4 6

### Table No. 04: Anti-HIV activity and cytotoxicity of synthesised compounds in MT-4 cells.

**50 50**

**Compound code Strain IC a (µg/ml) CC b (µg/ml) Max. Protection**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 2A4PT | IIIB | >70.30 | 70.30±3.25 | 3 |
|  | ROD | >70.30 | 70.30±3.25 | 3 |
| 2ABT | IIIB | >11.50 | 11.50±0.71 | 1 |
|  | ROD | >11.50 | 11.50±0.71 | 2 |
| CF-2A4PT | IIIB | >34.75 | 34.75±16.93 | 1 |
|  | ROD | >34.75 | 34.75±16.93 | 4 |
| CF-SG | IIIB | >61.93 | 61.93±3.01 | 3 |
|  | ROD | >61.93 | 61.93±3.01 | 5 |
| NF-2A4PT | IIIB | >47.25 | 47.25±5.02 | 1 |
|  | ROD | >47.25 | 47.25±5.02 | 4 |
| NF-SA | IIIB | >46.10 | 46.10±3.25 | 0 |
|  | ROD | >46.10 | 46.10±3.25 | 7 |
| SF-2A4PT | IIIB | >66.33 | 66.33±5.18 | 4 |
|  | ROD | >66.33 | 66.33±5.18 | 7 |
| SF-SG | IIIB | >56.05 | 56.05±12.23 | 2 |
|  | ROD | >56.05 | 56.05±12.23 | 9 |
| GF-2A4PT | IIIB | >64.10 | 64.10±2.36 | 1 |
|  | ROD | >64.10 | 64.10±2.36 | 3 |
| CF-2A4PT-OMe | IIIB | >39.85 | 39.85±9.33 | 2 |
|  | ROD | >39.85 | 39.85±9.33 | 4 |
| CF-APH | IIIB | >2.39 | 2.39±0.43 | 0 |
|  | ROD | >2.39 | 2.39±0.43 | 3 |
| CF-PAA | IIIB | >56.73 | 56.73±14.45 | 1 |
|  | ROD | >56.73 | 56.73±14.45 | 4 |
| CF-PME-APH | IIIB | >3.47 | 3.47±2.01 | 1 |
|  | ROD | >3.47 | 3.47±2.01 | 3 |
| CF-SA | IIIB | >59.88 | 59.88±14.08 | 7 |
|  | ROD | >59.88 | 59.88±14.08 | 4 |
| NF-PME-APH | IIIB | >11.20 | 11.20±5.80 | 1 |
|  | ROD | >11.20 | 11.20±5.80 | 3 |
| NF-PAA | IIIB | >46.0 | 46.00±5.07 | 0 |
|  | ROD | >46.0 | 46.00±5.07 | 14 |
| SF-SA | IIIB | >53.85 | 53.85±6.61 | 0 |
|  | ROD | >53.85 | 53.85±6.61 | 5 |
| DDN/AZT | IIIB | 0.0022±0.0022 | >25.00 | 68 |
| Retrovir | ROD | 0.0022±0.0004 | >25.00 | 63 |

**a** Effective concentration of compound , achieving 50% protection of MT-4 cells against the cytopathic effect of HIV. **b** 50% Cytotoxic concentration of compound, required to reduce the viability of mock infected MT-4 cells by 50%. IIIB = HIV-1, ROD = HIV-2. All the values are SD of two independent experiment.

### Table No. 05: Cytotoxicity and antiviral activity of compounds in HEL cell.

**EC b (µg/ml)**

**Compound Minimum cytotoxic**

**a**

**concentration (µg/ml)**

**Hepes simplex**

**50**

**Herpes simplex Vaccinia**

**Herpes simplex virus-1 TK-KOS**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **virus-1 (KOS)** | **virus-2 (G)** | **virus** | **ACVr** |
| CF-2A4PT | >100 | >20 | >20 | >20 | >20 |
| CF-SG | >100 | >100 | >100 | >100 | >100 |
| NF-2A4PT | >100 | >100 | >100 | >100 | >100 |
| SF-2A4PT | >100 | >100 | >100 | >100 | >100 |
| GF-2A4PT | >100 | >100 | >100 | >100 | >100 |
| Brivudin | >250 | 0.02 | 183 | 10 | 50 |
| Cidofovir | >250 | 2 | 2 | 17 | 0.9 |
| Acyclovir | >250 | 0.4 | 0.4 | >250 | 50 |
| Ganciclovir | >100 | 0.03 | 0.03 | >100 | 10 |

**a** Required to cause a microscopically detectable alteration of normal cell morphology.

**b** Required to reduce virus-induced cytopathogenicity by 50%.

### Table No. 06: Anti-feline corona virus (FIPV) and anti-feline herpes virus activity and cytotoxicity in CRFK cell cultures.

|  |  |
| --- | --- |
|  | **EC b (µg/ml)****50** |
| **Compound** | **CC a (µg/ml)** | **Feline Corona Virus (FIPV)** | **Feline Herpes Virus** |
| CF-2A4PT | >100 | >100 | >100 |
| CF-SG | >100 | >100 | >100 |
| NF-2A4PT | 95.4 | >20 | >20 |
| SF-2A4PT | >100 | >100 | >100 |
| GF-2A4PT | >100 | >100 | >100 |
| HHA | >100 | 35.5 | 11.1 |
| UDA | >100 | 9.8 | 4.5 |
| Ganciclovir (µM) | >100 | >100 | 5.7 |

**50**

**a** 50% Cytotoxic concentration, as determined by measuring the cell viability with the colorimetric formazan-based MTS assay.

**b** 50% Effective concentration , or concentration producing 50% inhibition of virus-induced cytopathic effect, as determined by measuring the cell viability with the colorimetric formazan-based MTS assay

CRFK cells: Crandell-Rees Feline Kidney cells.

### Table No. 07: Cytotoxicity and antiviral activity of compounds in VERO cells.

**EC b (µg/ml)**

**Minimum cytotoxic**

 **50**

**Compound**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **virus** | **1** | **virus** | **virus** |
| CF-2A4PT | ≥20 | >20 | >20 | >20 | >20 |
| CF-SG | >100 | >100 | >100 | >100 | >100 |
| NF-2A4PT | 100 | >20 | >20 | >20 | >20 |
| SF-2A4PT | 100 | >20 | >20 | >20 | >20 |
| GF-2A4PT | ≥100 | >100 | >100 | >100 | >100 |
| DS-5000 | >100 | >100 | >100 | >100 | 100 |
| (S)-DHPA (µM) | >250 | >250 | >250 | >250 | >250 |
| Ribavirin (µM) | >250 | 50 | 146 | >250 | 112 |

**concentrationa (µg/ml)**

**Para-inflluenza-3**

**Reovirus-**

**Sindbis**

**Punta Toro**

**a** Required to cause a microscopically detectable alteration of normal cell morphology.

**b** Required to reduce virus-induced cytopathogenicity by 50%.

### Table No. 08a: Cytotoxicity and antiviral activity of compounds in HeLa cell cultures.

**EC b (µg/ml)**

**Minimum cytotoxic**

 **50**

**Compound**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **virus** | **virus** | **virus** |
| CF-2A4PT | **>**100 | **>**20 | **>**20 | **>**20 |
| CF-SG | 100 | **>**100 | **>**100 | **>**100 |
| NF-2A4PT | 100 | **>**20 | **>**20 | **>**20 |
| **SF-2A4PT** | **>100** | **7** | **>100** | **45** |
| **GF-2A4PT** | **≥100** | **12** | **>20** | **>100** |
| DS-5000 | **>**100 | 2 | 45 | 0.6 |
| (S)-DHPA(µM) | **>**250 | 112 | **>**250 | **>**250 |
| Ribavirin (µM) | **>**250 | 4 | **>**250 | 2 |

**concentrationa (µg/ml)**

**Vecicular stomatitis**

**Coxsackie**

**Respiratory syncytial**

### Table No. 08b: Cytotoxicity and antiviral activity of compounds in HeLa cell cultures.

**EC b (µg/ml)**

**Minimum cytotoxic**

 **50**

**Compound**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **virus** | **virus** | **virus** |
| **SF-2A4PT** | **>100** | **10** | **>100** | **45** |
| **GF-2A4PT** | **100** | **12** | **>20** | **>20** |
| DS-5000 | **>**100 | 2 | 45 | 2 |
| (S)-DHPA(µM) | **>**250 | 112 | **>**250 | **>**250 |
| Ribavirin (µM) | **>**250 | 4 | 85 | 5 |

**concentrationa (µg/ml)**

**Vesicular stomatitis**

**Coxsackie**

**Respiratory syncytial**

**a** Required to cause a microscopically detectable alteration of normal cell morphology.

**b** Required to reduce virus-induced cytopathogenicity by 50%.

### Table No. 09: Determination of CTC50 by using MTT assay in HepG2 cells (human liver cancer) cell cultures.

|  |  |  |
| --- | --- | --- |
| **Sl.No** | **Compound** | **CTC \* in (µg/ml)****50** |
| 1. | SF-2A4PT | 174.95 ± 3.28 |
| 2. | SF-SG | 164.93 ± 4.11 |
| 3. | SF-2AP | 177.93 ± 4.19 |
| 4. | CF-SG | 205.25 ± 4.66 |
| 5. | CF-TRM | 217.76 ± 3.53 |
| 6. | CF-2ABT | 216.31 ± 5.61 |
| 7. | CF-LTG | 203.20 ± 4.12 |
| 8. | NF-SA | 259.03 ± 5.15 |
| 9. | Cis-platin (STD) | 11.09 ± 0.59 |

\*CTC50 = 50% cytotoxic concentration

\* Average of six independent determinations, values are mean ± S.E.M.

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