

## SYNTHESIS AND BIOLOGICAL ACTIVITY OF SEVERAL MODIFIED 5 $\alpha$ -ANDROSTANOLONE DERIVATIVES

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Several new N-containing epiandrosterone derivatives modified by phenylacetic acid chloride were synthesized for biological activity studies. Compounds with antiviral activity were discovered among them and 3 $\beta$ -hydroxy-1'-aryl-3'-methyl-5 $\alpha$ -androstano[17,16-d]pyrazolines prepared by us earlier.

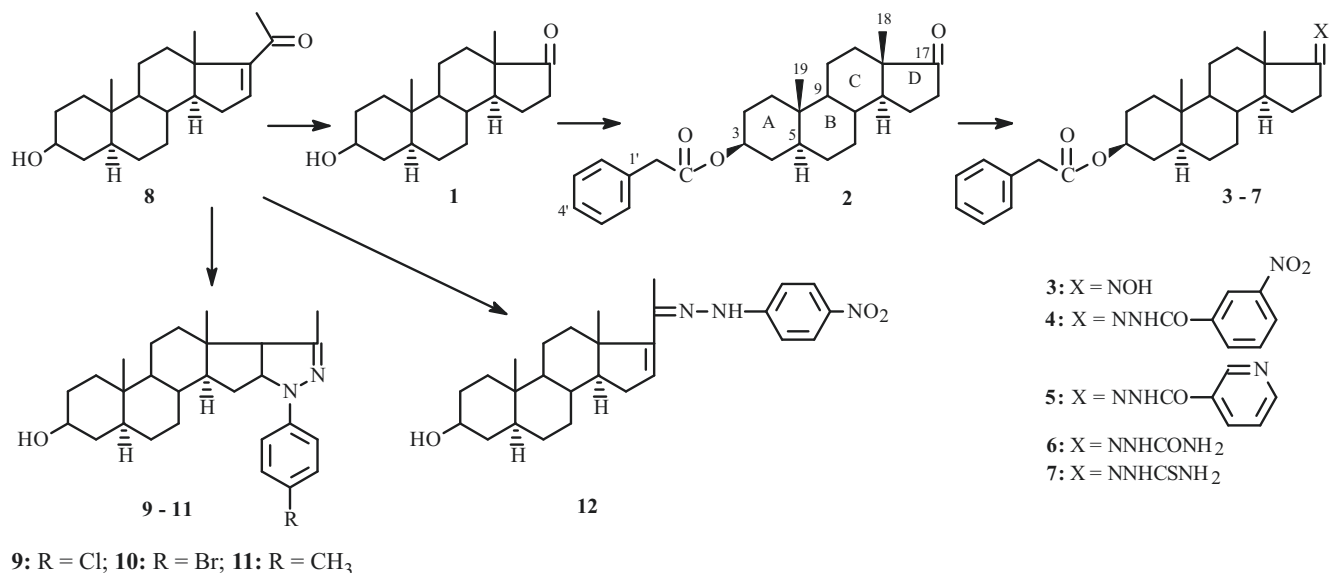
**Keywords:** antiviral activity, epiandrosterone, modification, phenylacetic acid, hydrazones, pyrazolines.

Syntheses of biologically active oximes, hydrazones, or carbazones of steroidal ketones have been the subject of much research [1–4]. Several hydrazones and oximes of 5 $\alpha$ -steroids that were previously synthesized by us also exhibited high antituberculosis, antiviral, and anti-inflammatory activity [5–7].

Addition of fragments of natural compounds to organic molecules is known to produce new and previously unknown biological properties.

Phenylacetic acid synthesized by plants can exhibit auxin-like activity according to some reports [8, 9]. Steroidal esters of phenylacetic acid derivatives exhibited characteristic antitumor activity [10]. The drug perandren is a phenylacetate ester of testosterone that is used for osteoporosis, breast cancer, etc.

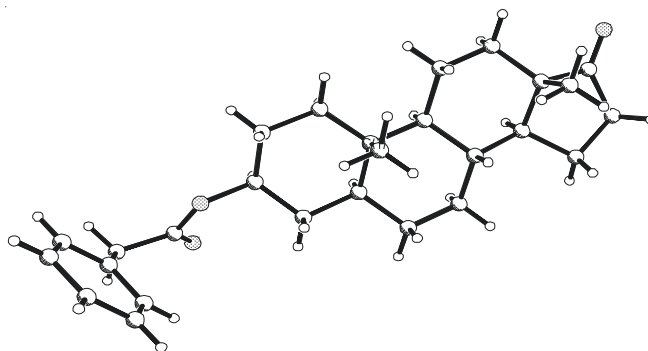
The structure–activity relationship was studied using esterification of epiandrosterone (1) by phenylacetic acid chloride to produce modified ketone 2. Reactions of 2 with hydroxylamine, *m*-nitrobenzoic or nicotinic acid hydrazides, and semi- or thiosemicarbazides synthesized derivatives 3–7.



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TABLE 1. Main Crystallographic and X-ray Structure Analysis Parameters for **2**

Parameter	<b>2</b>	Parameter	<b>2</b>
Molecular formula	C <sub>27</sub> H <sub>36</sub> O <sub>3</sub>	$\rho$ , g/cm <sup>3</sup>	1.184
MM, g/mol	408.6	Crystal size, mm	0.3 × 0.4 × 0.4
System	Orthorhombic	Scan range	3.31 ≤ $\theta$ ≤ 75.78°
Space group	P 2 <sub>1</sub> 2 <sub>1</sub> 2 <sub>1</sub>	$\mu_{\text{exp}}$ , cm <sup>-1</sup>	0.587
Z	4	Number of reflections	3907
a, Å	6.1398 (2)	Number of reflections with I > 2 $\sigma$ (I)	2884
b, Å	16.5469 (5)	R <sub>1</sub> (I > 2 $\sigma$ (I) and total)	0.0485 (0.0668)
c, Å	22.5683 (8)	WR <sub>2</sub>	0.1250 (0.1388)
$\alpha$	90.00	GOOF	0.868
$\beta$	90.00	Electron-density difference peaks (eÅ <sup>-3</sup> )	0.13 and -0.16
$\gamma$	90.00	CCDC	1570849
V, Å <sup>3</sup>	2292.8 (2)		

Fig. 1. Molecular structure of **2**.

Herein, the antiviral activities of new **3–7** and steroids **9–12** that were prepared by us earlier from pregnenolone **8** [11] are reported. The structures were 3 $\beta$ -hydroxy-1'-*p*-chlorophenyl- (**9**), 3 $\beta$ -hydroxy-1'-*p*-bromophenyl- (**10**), 3 $\beta$ -hydroxy-1'-*p*-methylphenyl-3'-methyl-5 $\alpha$ -androstano[17,16-*d*]pyrazoline (**11**), and 5 $\alpha$ -preg-16-en-3 $\beta$ -ol-20-one *p*-nitrophenylhydrazone (**12**).

The structures of **2–7** were confirmed using IR, NMR, and mass spectra. The IR spectrum of ketone **2** showed C=O absorption bands at 1700 and 1750 cm<sup>-1</sup>. Singlets for angular 18- and 19-CH<sub>3</sub> protons in the PMR spectrum (in CDCl<sub>3</sub>) appeared at  $\delta$  0.86 and 1.27 ppm; a multiplet for the 3 $\alpha$ -proton, 4.72; aromatic protons, 7.28–7.33; and phenylacetoxymethyl proton, 3.60. The <sup>13</sup>C NMR spectrum of **2** had resonances for phenyl-ring C atoms in the range 126.9–134.3 ppm; for O–C=O and C=O, 171.1 and 221.3, respectively.

IR spectra of **3–5** contained absorption bands for ester C=O at 1735, 1729, and 1728 cm<sup>-1</sup>, respectively; NHCO groups (hydrazones **4** and **5**), 1665 and 1651; C=N- and aromatic C=C stretching vibrations, 1680, 1640, and 1610 and 1524, 1531, and 1589, respectively; and NH (hydrazones **4** and **5**) and OH groups (oxime **3**), 3450, 3370, and 3260. The IR spectrum of **4** also had characteristic bands for Ar–NO<sub>2</sub> stretching vibrations at 1500 and 1348 cm<sup>-1</sup>.

PMR spectra of **3–7** showed singlets for angular 18- and 19-CH<sub>3</sub> groups at 0.83, 0.77, 0.85, 0.82, 0.84, and 0.89, 0.82, 0.87, 0.88, 0.90 ppm, respectively; multiplets for 3 $\alpha$ -protons of 3 $\beta$ -esters, 4.69, 4.61, 4.61, 4.59; phenyl aromatic protons, in the range 7.17–7.34. Singlets for the phenylacetoxymethyl protons appeared at  $\delta$  3.58–3.50 ppm; aromatic protons of steroid hydrazones **4** and **5**, 7.32–8.93. The NH protons gave two singlets for the *cis*-conformers at 8.93 and 10.32 ppm, respectively; *trans*-conformer, 8.48 and 10.25. The oxime hydroxyl proton of **3** appeared as a broad singlet at 7.93 ppm. The NH protons of **6** and **7** were found at 8.54 and 9.55 ppm, respectively. The NH<sub>2</sub> protons of semicarbazone **6** appeared as a broad singlet at 5.81 ppm; thiosemicarbazone **7**, two broad singlets at 7.03 and 7.79. The <sup>13</sup>C NMR spectrum of **3** contained peaks for phenyl-ring C atoms in the range 126.9–134.3 ppm; C=N and C=O, 171.1 and 171.3, respectively. The <sup>13</sup>C NMR spectrum of hydrazone **4** had resonances for all aromatic C atoms in the range 125.8–147.4 ppm; amide C atom, 166.7; C=N and O–C=O, 168.3 and 171.2, respectively. The <sup>13</sup>C NMR spectrum of **7** had resonances for phenyl-ring C atoms in the range 126.9–134.3 ppm; C=N, C=O, and C=S, 167.4, 171.2, and 178.9, respectively. The molecular ions *m/z* [M + H]<sup>+</sup> for steroids **2–7** agreed with the empirical formulas.

The structure of **2** was also confirmed by an X-ray crystal structure analysis (XSA) (Fig. 1 and Table 1).

TABLE 2. Data for *in vitro* Screening of Antiviral Activity of 3–7 and 9–12

Compound	<i>Polio virus</i> (Pirodavidir)			<i>SARS corona virus</i> (M128533)			<i>Rift Valley fever virus</i> (Ribavirin)			<i>Tacaribe virus</i> (Ribavirin)		
	EC <sub>50</sub>	CC <sub>50</sub>	SI <sub>50</sub>	EC <sub>50</sub>	CC <sub>50</sub>	SI <sub>50</sub>	EC <sub>50</sub>	CC <sub>50</sub>	SI <sub>50</sub>	EC <sub>50</sub>	CC <sub>50</sub>	SI <sub>50</sub>
	Visual (cytopathic effect/toxicity)											
3	2.8	3.2	1.1	>3.2	3.2	0	3.2	8.6	2.7	3.2	3.2	1
4	0.32	100	310	3.2	15	4.7	31	68	2.2	31	46	1.5
5	1	10	10	6.8	32	4.7	3.2	13	4.1	3.2	15	4.7
6	22	100	4.5	>32	32	0	>100	>100	0	32	42	1.3
7	3.4	12	3.5	3.7	28	7.6	3.2	5.6	1.8	>13	13	0
9	3.2	22	6.9	>5.2	5.2	0	1.8	12	6.7	12	24	2
10	2.4	>100	>42	>28	28	0	1.9	14	7.4	>30	30	0
11	32	>100	>3.1	>32	32	0	>100	>100	0	>100	>100	0
12	0.32	10	31	>19	19	0	3.2	10	3.1	5	18	3.6
Control	0.32	>10	>31	0.68	>100	>150	6.8	>1000	>150	6.5	>1000	>150
	Neutral red (cytopathic effect/toxicity)											
3	2.8	3.6	1.3	>4.3	4.3	0	6.6	7.5	1.1	>4.8	4.8	0
4	0.35	>100	>290	4.6	24	5.2	>56	56	0	>32	32	0
5	0.52	20	38	2.2	21	9.5	1.2	5.2	4.3	4.1	18	4.4
6	92	>100	>1.1	>100	>100	0	>100	>100	0	>100	>100	0
7	7	26	3.7	>17	17	0	3.2	3.9	1.2	>24	24	0
9	2.2	100	45	>28	28	0	1.7	14	8.2	25	28	1.1
10	3.1	15	4.8	3.2	4.5	1.4	2.3	14	6.1	12	27	2.3
11	30	>100	>3.3	36	63	1.8	>100	>100	0	>100	>100	0
12	0.28	19	68	>5.5	5.5	0	2.8	5	1.8	7	20	2.9
Control	0.3	>10	>33	1.8	>100	>56	8.6	>1000	>120	7.1	>1000	>140

EC<sub>50</sub> is the compound concentration inhibiting virus replication by 50%; CC<sub>50</sub>, compound concentration reducing cell survival by 50%; SI<sub>50</sub> = CC<sub>50</sub>/EC<sub>50</sub>.

The orientation of the oxy substituent was 3 $\beta$ -equatorial; of the C10 and C13 methyls,  $\beta$ -axial. This was confirmed by the Flack parameter of  $-0.5(4)$  that became  $0.8(3)$  for the inverted calculation. The molecule of **2** had a ketone [C17=O, 1.207(3) Å] according to the bond length. As expected, the ring fusions were A/B-, B/C-, and C/D-*trans*. Rings A, B, and C had canonical chair conformations; five-membered ring D, C14-envelope.

Antiviral activity of 3–7 and 9–12 was studied and showed that hydrazone **4** had high; **5**, **10**, and **12**, moderate; and pyrazoline **9**, weak antiviral activity against *Polio virus* (Vero 76 cell culture, strain Type 3, WM-3) (Table 2). The other steroids were inactive. Hydrazones **4** and **5** were weakly active against *Sars corona virus* (Vero 76 cell culture, strain Urbani). The other compounds were inactive. Compounds **5**, **9**, and **12** were weakly active whereas the other steroids were inactive against *Rift valley fevevirus* (Vero 76 cell culture, strain MP-12). Only hydrazone **5** exhibited weak activity against *Takaribe virus* (Vero cell culture, strain TRVL-11573). All steroids 3–7 and 9–12 were inactive against *Venezuelan equine encephalitis virus*, *Respiratory syncytial virus*, *Influenza A virus* H<sub>1</sub>N<sub>1</sub>, and *Dengue virus* (Vero cell culture, MA-104, MDCK; Vero 76; strains TC-83; A-2; California 07.2009; Type 2, New Guinea C, respectively).

## EXPERIMENTAL

PMR and <sup>13</sup>C NMR spectra were recorded from CDCl<sub>3</sub> and DMSO-d<sub>6</sub> solutions with TMS internal standard on a Bruker Avance 400 instrument (400.13 MHz for <sup>1</sup>H and 100.61 MHz for <sup>13</sup>C). IR spectra were taken from KBr pellets on a Varian 660 FTIR spectrometer. Mass spectra were obtained on an HPLC-APCIMS (positive mode)-Agilent 1100 Series with an Inertsil PREP-ODS column (6.0 × 250 mm) and elution of steroids by H<sub>2</sub>O–MeCN (20:80). Melting points were determined on a NAGEMA apparatus. The course of reactions and purity of synthesized compounds were monitored by TLC on Silufol UV-254 plates using C<sub>6</sub>H<sub>6</sub>–Me<sub>2</sub>CO (10:1, 6:1). Chromatograms were detected using phosphomolybdic acid solution (10%) in EtOH followed by heating.

**3 $\beta$ -Phenylacetoxy-5 $\alpha$ -androstan-17-one (2).** A solution of epiandrosterone **1** (0.3 g, 1 mmol) in anhydrous C<sub>6</sub>H<sub>6</sub> (20 mL) and anhydrous Py (0.3 mL) was treated with phenylacetic acid chloride (0.19 g, 1.2 mmol), refluxed for 6 h, cooled

to room temperature, diluted with H<sub>2</sub>O, and extracted with Et<sub>2</sub>O (3 × 20 mL). The Et<sub>2</sub>O extracts were washed with H<sub>2</sub>O, Na<sub>2</sub>CO<sub>3</sub> solution, and H<sub>2</sub>O; dried over Na<sub>2</sub>SO<sub>4</sub>; and evaporated to isolate **2** (0.31 g, 74%), mp 160–162°C. IR spectrum (KBr,  $\nu$ , cm<sup>-1</sup>): 1750, 1700 (C=O), 1535 (arom. ring). <sup>1</sup>H NMR spectrum (CDCl<sub>3</sub>,  $\delta$ , ppm): 0.86 (3H, s, 18-CH<sub>3</sub>), 1.27 (3H, s, 19-CH<sub>3</sub>), 2.20–2.45 (2H, m, H-16), 3.60 (2H, s, CH<sub>2</sub>C<sub>6</sub>H<sub>5</sub>), 4.72 (1H, m, H-3), 7.28–7.33 (5H, m, C<sub>6</sub>H<sub>5</sub>). <sup>13</sup>C NMR spectrum (CDCl<sub>3</sub>,  $\delta$ , ppm): 12.2, 13.8, 20.4, 21.7, 27.3, 28.2, 29.6, 30.8, 31.5, 33.8, 35.0, 35.4, 36.7, 41.7 (CH<sub>2</sub>C<sub>6</sub>H<sub>5</sub>), 44.6, 47.7, 51.3, 54.3, 74.0 (C-3), 126.9 (C-4'), 128.5 (C-3', 5'), 129.2 (C-2', 6'), 134.3 (C-1'), 171.1 (O–C=O), 221.3 (C=O). LC-MS  $m/z$  409.6 [M + H]<sup>+</sup>. C<sub>27</sub>H<sub>36</sub>O<sub>3</sub>. MM 408.6.

**17-Hydroxyimino-3 $\beta$ -phenylacetoxy-5 $\alpha$ -androstan-17-one (3).** A mixture of ketone **2** (0.5 g, 1.44 mmol) and hydroxylamine hydrochloride (0.1 g, 1.47 mmol) in Py (5 mL) was heated for 3 h at 65°C, cooled, and poured into ice water (30 mL). The precipitate was filtered off, rinsed with H<sub>2</sub>O, and dried. Crystallization from MeOH produced oxime **3** (0.45 g, 86%), mp 154–156°C. IR spectrum (KBr,  $\nu$ , cm<sup>-1</sup>): 3260 (OH), 1735 (C=O), 1680 (C=N), 1524 (arom. ring). <sup>1</sup>H NMR spectrum (CDCl<sub>3</sub>,  $\delta$ , ppm): 0.83 (3H, s, 18-CH<sub>3</sub>), 0.89 (3H, s, 19-CH<sub>3</sub>), 2.40–2.56 (2H, m, H-16), 3.58 (2H, s, CH<sub>2</sub>C<sub>6</sub>H<sub>5</sub>), 4.69 (1H, m, H-3), 7.26–7.34 (5H, m, C<sub>6</sub>H<sub>5</sub>), 7.93 (1H, br.s, C=N–OH). <sup>13</sup>C NMR spectrum (CDCl<sub>3</sub>,  $\delta$ , ppm): 12.2, 17.2, 20.7, 23.1, 25.0, 27.3, 28.3, 31.4, 33.9, 34.0, 34.8, 35.6, 36.6, 41.7 (CH<sub>2</sub>C<sub>6</sub>H<sub>5</sub>), 44.0, 44.6, 53.8, 54.3, 74.1 (C-3), 126.9 (C-4'), 128.4 (C-3', 5'), 129.1 (C-2', 6'), 134.3 (C-1'), 171.1 (C=N), 171.3 (O–C=O). LC-MS  $m/z$  424.6 [M + H]<sup>+</sup>. C<sub>27</sub>H<sub>37</sub>NO<sub>3</sub>. MM 423.6.

**3 $\beta$ -Phenylacetoxy-5 $\alpha$ -androstan-17-one *m*-nitrobenzoylhydrazone (4)** was prepared by the literature method [5]. Yield 72%, mp 184–186°C. IR spectrum (KBr,  $\nu$ , cm<sup>-1</sup>): 3450 (NH), 1729 (C=O), 1665 (NH–CO), 1640 (C=N), 1531 (arom. ring), 1500 and 1348 (Ar–NO<sub>2</sub>). <sup>1</sup>H NMR spectrum (CDCl<sub>3</sub>,  $\delta$ , ppm, J/Hz): 0.77 (3H, s, 18-CH<sub>3</sub>), 0.82 (3H, s, 19-CH<sub>3</sub>), 2.23–2.37 (2H, m, H-16), 3.51 (2H, s, CH<sub>2</sub>C<sub>6</sub>H<sub>5</sub>), 4.61 (1H, m, H-3), 7.17–7.25 (5H, m, C<sub>6</sub>H<sub>5</sub>), 7.54 (1H, t, J = 8.1, H-5''), 8.10 (1H, d, J = 7.1, H-6''), 8.26 (1H, d, J = 7.3, H-4''), 8.40 (1H, s, H-2''), 8.48 (1H, br.s, *trans*-NH), 8.93 (1H, br.s, *cis*-NH). <sup>13</sup>C NMR spectrum (CDCl<sub>3</sub>,  $\delta$ , ppm): 12.3, 16.9, 20.7, 23.4, 25.2, 27.4, 28.4, 30.8, 31.4, 33.9, 34.9, 35.7, 36.8, 41.8 (CH<sub>2</sub>C<sub>6</sub>H<sub>5</sub>), 44.7, 51.5, 53.5, 54.4, 74.3 (C-3), 125.8 (C-2''), 126.2 (C-4''), 127.0 (C-4'), 128.5 (C-3', 5'), 130.1 (C-5''), 129.2 (C-2', 6'), 133.6 (C-6''), 134.4 (C-1'), 136.5 (C-1''), 147.4 (C-3''), 166.7 (NHCO), 168.3 (C=N), 171.2 (O–C=O). LC-MS  $m/z$  572.8 [M + H]<sup>+</sup>. C<sub>34</sub>H<sub>41</sub>N<sub>3</sub>O<sub>5</sub>. MM 571.8.

Steroids **5–7** were prepared analogously.

**3 $\beta$ -Phenylacetoxy-5 $\alpha$ -androstan-17-one Nicotinoylhydrazone (5).** Yield 81%, mp 108–110°C. IR spectrum (KBr,  $\nu$ , cm<sup>-1</sup>): 3370 (NH), 1728 (CO), 1651 (NHCO), 1610 (C=N), 1589 (arom. ring), 1535 (Py ring). <sup>1</sup>H NMR spectrum (DMSO-d<sub>6</sub>,  $\delta$ , ppm): 0.85 (3H, s, 18-CH<sub>3</sub>), 0.87 (3H, s, 19-CH<sub>3</sub>), 2.34–2.56 (2H, m, H-16), 3.51 (2H, s, CH<sub>2</sub>C<sub>6</sub>H<sub>5</sub>), 4.61 (1H, m, H-3), 7.17–7.30 (5H, m, C<sub>6</sub>H<sub>5</sub>), 7.32–8.93 (4H, m, C<sub>5</sub>H<sub>4</sub>), 10.25 (1H, br.s, *trans*-NH), 10.32 (1H, br.s, *cis*-NH). LC-MS  $m/z$  528.3 [M + H]<sup>+</sup>. C<sub>33</sub>H<sub>41</sub>N<sub>3</sub>O<sub>3</sub>. MM 527.3.

**3 $\beta$ -Phenylacetoxy-5 $\alpha$ -androstan-17-one Semicarbazone (6).** Yield 79%, mp 250–252°C. IR spectrum (KBr,  $\nu$ , cm<sup>-1</sup>): 3479, 3194 (NH<sub>2</sub>, NH), 1726, 1697 (CO), 1630 (C=N), 1581 (arom. ring). <sup>1</sup>H NMR spectrum (DMSO-d<sub>6</sub>,  $\delta$ , ppm): 0.82 (3H, s, 18-CH<sub>3</sub>), 0.88 (3H, s, 19-CH<sub>3</sub>), 2.18–2.37 (2H, m, H-16), 3.50 (2H, s, CH<sub>2</sub>C<sub>6</sub>H<sub>5</sub>), 4.59 (1H, m, H-3), 5.81 (2H, br.s, NH<sub>2</sub>), 7.17–7.30 (5H, m, C<sub>6</sub>H<sub>5</sub>), 8.54 (1H, s, NH). LC-MS  $m/z$  466.3 [M + H]<sup>+</sup>. C<sub>28</sub>H<sub>39</sub>N<sub>3</sub>O<sub>3</sub>. MM 465.3.

**3 $\beta$ -Phenylacetoxy-5 $\alpha$ -androstan-17-one Thiosemicarbazone (7).** Yield 84%, mp 215–217°C. <sup>1</sup>H NMR spectrum (DMSO-d<sub>6</sub>,  $\delta$ , ppm): 0.84 (3H, s, 18-CH<sub>3</sub>), 0.90 (3H, s, 19-CH<sub>3</sub>), 2.32–2.55 (2H, m, H-16), 3.50 (2H, s, CH<sub>2</sub>C<sub>6</sub>H<sub>5</sub>), 4.59 (1H, m, H-3), 7.18–7.32 (5H, m, C<sub>6</sub>H<sub>5</sub>), 7.03 (1H, br.s, NH<sub>2</sub>) and 7.79 (1H, br.s, NH<sub>2</sub>), 9.55 (1H, s, NH). <sup>13</sup>C NMR spectrum (CDCl<sub>3</sub>,  $\delta$ , ppm): 12.2, 17.0, 20.6, 23.3, 26.0, 27.3, 28.2, 31.3, 33.8, 33.9, 34.9, 35.6, 36.7, 41.7 (CH<sub>2</sub>C<sub>6</sub>H<sub>5</sub>), 44.6, 44.9, 53.3, 54.3, 74.0 (C-3), 126.9 (C-4'), 128.5 (C-3', 5'), 129.1 (C-2', 6'), 134.3 (C-1'), 167.4 (C=N), 171.2 (O–C=O), 178.9 (C=S). LC-MS  $m/z$  482.7 [M + H]<sup>+</sup>. C<sub>28</sub>H<sub>39</sub>N<sub>3</sub>O<sub>2</sub>S. MM 481.7.

**Antiviral activity** of the synthesized compounds was studied in the framework of the international program “AACF Antiviral Testing in Animals” at the Division of Microbiology and Infectious Diseases, National Institute of Allergy and Infectious Diseases, University of Utah, USA. In particular, all newly tested compounds were evaluated initially a) for inhibition of virus cytopathic effects (CPE assay) and b) for uptake of neutral red dye (NR Dye Uptake Assay) that stained undamaged virus cells. The color intensity was determined spectrophotometrically. The experimental results from a) were used to calculate the 50% inhibitory (cytotoxic) concentration CC<sub>50</sub>; from b), the 50% effective concentration EC<sub>50</sub>. Antiviral activity of each tested compounds was characterized by the selectivity index (SI<sub>50</sub>), which was the ratio of CC<sub>50</sub> to EC<sub>50</sub>. As a rule, SI<sub>50</sub> values of 10 or more indicated the presence of antiviral activity for the compound. The method was described in detail before [12].

**XSA.** A single crystal of **2** for the XSA was obtained by slow evaporation of an appropriate solvent at room temperature. Unit-cell constants of the crystal of **2** were determined and refined on a CCDXcalibur Ruby diffractometer (Oxford Diffraction) using Cu K $\alpha$ -radiation (300 K, graphite monochromator) [13]. A three-dimensional dataset of reflections was obtained on the

same diffractometer. Absorption corrections for the crystals were made semi-empirically using the SADABS program [14]. Table 1 presents the main XSA and refinement parameters for the structure of **2**.

The structure was solved by direct methods using the SHELXS-97 program suite and refined using the SHELXL-97 program [15]. All nonhydrogen atoms were refined by full-matrix anisotropic least-squares methods (over  $F^2$ ). Positions of H atoms were found geometrically and refined with fixed isotropic thermal factors  $U_{iso} = nU_{eq}$ , where  $n = 1.5$  for methyls and 1.2 for others and  $U_{eq}$  is the equivalent isotropic thermal factor of the corresponding C atom.

Results from the XSA were deposited as a CIF-file in the Cambridge Crystallographic Data Centre (CCDC).

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