Communication

A Novel Approach for the Solid-Phase Organic Synthesis of 1,3-Disubstituted Uracils

Mei-Hong Wei (魏梅紅), Shu-Ying Lin (林淑英), Sheng-Ri Sheng* (盛壽日), Qing Wang (王　青) and Ming-Zhong Cai (蔡明中)
College of Chemistry and Chemical Engineering, Jiangxi Normal University, Nanchang 330027, P. R. China

A novel procedure for solid-phase organic synthesis of 1,3-disubstituted uracils using a cyclization-cleavage strategy from Wang-acrylate resin, amines and isocyanates. An acrylate ester resin is reacted in turn with PhSeBr and primary amines in one-pot to afford *N*-substituted α-phenylseleno-β-aminoesters followed by treatment with isocyanates to form α-phenylseleno-β-ureidoester resin. Following oxidation-elimination with excess of 30% hydrogen peroxide and intramolecular cyclization cleavage of the Wang resin using potassium ethoxide as a base to furnish 1,3-disubstituted uracils in good yields (80-86%) and high purities (92-96%).

Keywords: Uracil; Solid-phase organic synthesis; Wang-acrylate resin; Intramolecular cyclization; Cleavage.

INTRODUCTION

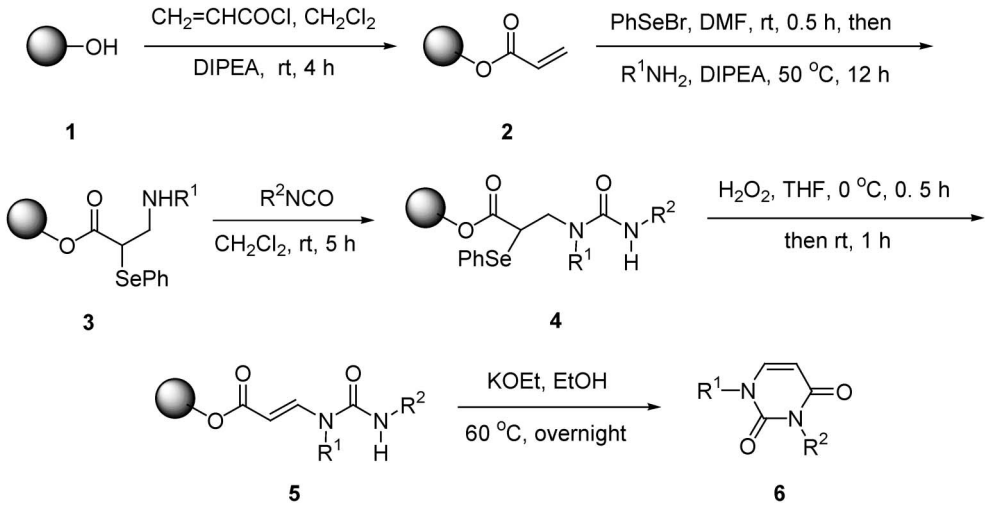
Combinatorial chemistry is now being increasingly applied in the facile preparation of chemical libraries for the discovery of novel biologically active compounds.[1] Heterocycles are important elements in many pharmacologically active compounds. Solid-phase organic synthesis (SPOS) is a powerful technique for the high-speed synthesis of heterocycles.[2] The pyrimidinedione ring system is particularly attractive since it is known to be a core structural element of some discovered fungicides[3] and herbicides.[4] Among the heterocycles containing pyrimidinedione moiety, uracils have been widely used as bioactive compounds such as 5-iodouridine,[5a] (*S*)-willardiine,[5b] zidovudine,[5c] and tifluridine.[6] It is therefore out of question that these compounds have been both widely studied and used, specially have received attention in combinatorial synthesis and several SPOS methods for their preparations have been reported.[7] Although SPOS of uracils and their derivatives are well documented, efforts are continuing for the development of more efficient methods with experimental simplicity. In connection with our interest in SPOS of heterocyclic compounds based on polymeric reagents,[8] we wish here to report another convenient and efficient SPOS method for 1,3-disubstituted uracils (Scheme I).

RESULTS AND DISCUSSIONS

As outlined in Scheme I, treatment of Wang resin **1** loaded with 0.96 mmol/g with 5 equiv of acryloyl chloride in the presence of *N,N*-diisopropylethylamine (DIPEA) afforded acrylate resin **2** almost in quantitative yield. The Wang-acrylate resin **2** was characterized by single-bead microscopy FT-IR,[9] which showed complete disappearance of the hydroxyl OH stretch and the appearance of a C=O stretch at 1724 cm^{-1} and a C=C stretch at 1651 cm^{-1}. The resin-bound acrylate **2** was then smoothly reacted with 2.0 equivalents of benzeneselenenyl bromide in DMF at room temperature to afford resin-bound 3-bromo-2-seleno-ester intermediate, which was further treated with primary amine at 50 °C in the presence of in the presence of *N,N*-diisopropylethylamine (DIPEA) in one-pot to furnish the corresponding yellow *N*-substituted α-phenylseleno-β-aminoester resins **3**, which were monitored by their FT-IR spectra featuring the ester carbonyl absorptions at 1728-1733 cm^{-1} and a moderate strong N-H stretch between 3280-3350 cm^{-1}, with the complete disappearance the band at 1651 cm^{-1}, corresponding to the C=C olefin absorption of the resin **2**. Additionally, no bromine was found by microanalysis of resin **3**, indicating the conversion of the resin **2** to the resin **3** was complete. It should be noted that, in the

* Corresponding author. E-mail: shengsr@jxnu.edu.cn

Scheme I Solid-phase synthetic route to 1,3-disubstituted uracils



case of α-branched amine (Entries **9** and **10**, Table 1) required longer reaction time or higher temperature to drive the reaction to completion than those unhindered alkyl amines.

Progress of the reaction of resin **3** with an isocyanate was monitored by the isatin test.[10] The reactions were generally complete in 4 h using a two-fold excess of isocyanate in CH_2Cl_2. FT-IR spectra of the α-phenylseleno-β-ureido-ester resin **4** revealed the presence of the carbonyl stretch at 1728-1733 cm^{-1} for the ester group and a new strong carbonyl absorption at 1655-1672 cm^{-1}, corresponding to the amide carbonyl group, as well as a broad N-H stretch between 3300-3400 cm^{-1}.

It is well known that phenylseleno group is readily converted to a leaving group giving access to carbon-carbon double bond *via* oxidation followed by β-elimination under extremely mild conditions.[11] As expected, treatment of the resin **4** with 30% hydrogen peroxide at 0 °C and then at room temperature afforded the corresponding β-ureido acrylate ester of Wang's resin **5**, which was found to have lost all its selenium by elemental analysis indicating the oxidation-elimination was complete. After accomplishment of the oxidation-elimination reaction, the intramolecular cyclization and cleavage of resin-bound **5**, the key for the success of this protocol was investigated. When NaH was used in DMF as the previously described method at 0 °C for 30 min,[7b] and at room temperature in our experiments, or at reaction temperature of 60-70 °C for 1 h or even for longer time, the reaction was not complete as monitored by FT-IR study of the residual resin, which still exhibited carbonyl absorptions. Treatment with K_2CO_3 in DMF gave a better yield of product **6**. However, successful intramolecular cyclization and cleavage of resin **5** was accomplished by treatment with KOEt (0.1 M) in EtOH overnight at 60 °C to afford 1,3-disubstituted uracils **6a**-**6k** containing a variety of R^1 (alkyl, allyl or benzyl) and R^2 (alkyl or aryl) substituent groups in good yields (80-86%) and high purities (92-96%), as shown in Table 1.

Table 1. The yields and purities of 1,3-disubstituted uracils (**6a-6k**)

Entry	R^1	R^2	Product	Yield (%)[a]	Purity (%)[b]
1	$C_6H_5CH_2$	C_6H_5	**6a**	82	93
2	$C_6H_5CH_2$	4-$MeOC_6H_4$	**6b**	85	94
3	$C_6H_5CH_2$	4-ClC_6H_4	**6c**	83	93
4	$C_6H_5CH_2$	n-C_4H_9	**6d**	82	95
5	n-C_4H_9	C_6H_5	**6e**	86	93
6	n-C_4H_9	n-C_4H_9	**6f**	83	92
7	n-C_3H_7	C_6H_5	**6g**	81	92
8	n-C_3H_7	n-C_4H_9	**6h**	85	96
9	i-C_3H_7	C_6H_5	**6i**	82	93
10	i-C_3H_7	n-C_4H_9	**6j**	83	95
11	CH_2=$CHCH_2$	n-C_4H_9	**6k**	80	90

[a] Overall yields based on the loading of Wang's resin.
[b] Determined by HPLC of crude cleavage product.

In summary, we have developed a novel, convenient and effective approach for the SPOS of 1,3-disubstituted uracils based on Wang resin-bound acrylate, primary amines and isocyanates. These uracil derivatives were prepared in five steps providing good overall yields and excel-

lent purities. The simple work-up procedure is suitable for application to the automated synthesis of diverse uracil-based compounds.

EXPERIMENTAL SECTION

General Procedure

Melting points were determined on X_4 melting point apparatus and are uncorrected. ^{1}H NMR (400 MHz) and ^{13}C NMR (100 MHz) spectra were recorded on a Bruker Avance (400 MHz) spectrometer using $CDCl_3$ as the solvent and TMS as an internal standard. FT-IR spectra were taken on a Perkin-Elmer SP One FT-IR spectrophotometer. Microanalyses were performed with a Carlo Erba 1106 elemental analyzer. HPLC analysis was performed on Agilent 1100 automated system having a PDA detector using a gradient with CH_3CN/H_2O (1 mL/min) on a RP-18e column (150 × 4.6 mm). Wang resin (0.96 mmol/g) and other starting materials were purchased from commercial suppliers and used without further purification. 1,2-Dichloroethane was refluxed with phosphorus pentoxide and distilled. N,N-Dimethylformamide (DMF) was refluxed with calcium hydride and distilled under reduced pressure, then dried over molecular sieves 4 Å prior to use.

Preparation of Wang-acrylate resin 2

Wang resin (1.0 g, 0.96 mmol/g) was swollen in CH_2Cl_2 (10 mL), DIPEA (0.65 g, 5.0 mmol) and acryloyl chloride (0.45 g, 5.0 mmol) were added and the reaction mixture was shaken at room temperature for 4 h. After which, the mixture was filtered and the resin washed sequentially with DMF, H_2O, MeOH, CH_2Cl_2, and Et_2O (2 × 10 mL of each) and dried overnight in a vacuum oven at 40 °C to afford resin **2**. IR (KBr): ν = 3060, 3025, 2922, 1724, 1651, 1585, 1569, 1495, 1454, 1351, 1250, 1144, 1106, 950, 840 cm^{-1}.

General preparation of 1,3-disubstituted uracils 6a-6k

To a suspension of the swollen resin **2** (1.0 g) in anhydrous DMF (10 mL) was added PhSeBr (2.0 mmol) added. After 30 min with shaking at room temperature, primary amines (5.0 mmol) and DIPEA (5.0 mmol) were added, and the mixture was allowed to shake at 50 °C for 12 h. After which, the mixture was filtered and the resin washed sequentially with DMF, H_2O, THF, MeOH and CH_2Cl_2 (2 × 10 mL of each), and dried overnight in a vacuum oven at 40 °C to afford the yellow *N*-substituted α-phenylseleno-β-aminoester resin **3**, which was swelled in anhydrous CH_2Cl_2 (10 mL) at room temperature for 30 min followed by addition of isocyanate (2.0 mmol). After 4 h with shaking at room temperature, washing thoroughly successively with CH_2Cl_2, MeOH, CH_2Cl_2 and Et_2O (2 × 5 mL of each) to afford the α-phenylseleno-β-ureidoester resin **4**. The washed resin **4** was then suspended in THF (10 mL), and 30% hydrogen peroxide (0.5 mL, 5.8 mmol) was added; the mixture was stirred for 30 min at 0 °C, followed by 1 h at room temperature. After completion of the reaction, the resin **5** was then filtered and washed successively with THF/H_2O (1:1), THF, MeOH and Et_2O (2 × 5 mL of each). Then the resin **5** was cleaved in a solution of KOEt (0.1 mol/L) in EtOH (30 mL) at 60 °C overnight. After cooling, the resin was filtered and washed with THF/H_2O (1/1) (3 × 10 mL), EtOH (3 × 5 mL) and Et_2O (3 × 5 mL). Evaporation of the solvent from the filtrate afforded crude products **6a**-**6k** with 92-96% purity determined by HPLC, which were further purified by passing the crude product through silica gel chromatographic column (ethyl acetate-hexane as the eluent, 1:3) affording the pure products for their structure analyses.

1-Benzyl-3-phenylpyrimidine-2,4-dione (6a)

White solid, mp 152-154 °C (lit.[12] 153-155); ^{1}H NMR: δ = 7.50-7.33 (m, 8 H), 7.26-7.22 (m, 3 H), 5.85 (d, *J* = 7.9 Hz, 1 H), 4.94 (s, 2 H); ^{13}C NMR: δ = 163.0, 151.7, 142.3, 135.0, 134.8, 129.2, 129.0, 128.8, 128.5, 128.3, 128.1, 102.3, 52.5; IR (KBr): ν = 3060, 2925, 1715, 1660, 1445, 1385, 1226, 698 cm^{-1}; Anal. Calcd for $C_{17}H_{14}N_2O_2$: C, 73.37; H, 5.07; N, 10.07. Found: C, 73.43; H, 5.16; N, 10.11.

1-Benzyl-3-(4-methoxyphenyl)pyrimidine-2,4-dione (6b)

White solid, mp 158-160 °C (lit.[7c] 158-160 °C); ^{1}H NMR: δ = 7.38-7.25 (m, 6 H), 7.16 (d, *J* = 8.8 Hz, 2 H), 7.01 (d, *J* = 8.8 Hz, 2 H), 5.81 (d, *J* = 7.9 Hz, 1 H), 4.91 (s, 2 H), 2.84 (s, 3 H); ^{13}C NMR: δ = 163.0, 159.3, 151.8, 142.3, 135.2, 129.2, 129.0, 128.6, 128.2, 127.5, 114.5, 102.2, 55.1, 52.1; IR (KBr): ν = 3062, 1712, 1661, 1510, 1390, 1445, 1248, 825 cm^{-1}; Anal. Calcd for $C_{18}H_{16}N_2O_3$: C, 70.12; H, 5.23; N, 9.09. Found: C, 70.19; H, 5.30; N, 9.17.

1-Benzyl-3-(4-chlorophenyl)pyrimidine-2,4-dione (6c)

White solid, mp 155-157 °C; ^{1}H NMR: δ = 7.53 (d, *J* = 8.4 Hz, 2 H), 7.40-7.28 (m, 6 H), 7.22 (d, *J* = 8.4 Hz, 2 H), 5.82 (d, *J* = 7.8 Hz, 1 H), 4.88 (s, 2 H); ^{13}C NMR: δ = 163.8, 151.5, 143.0, 136.2, 132.5, 130.6, 129.2, 129.0, 128.8, 128.3, 102.4, 120.9, 52.6; IR (KBr): ν = 3063, 1717, 1665, 1445, 1388, 1350, 1225, 834, 700 cm^{-1}; Anal. Calcd for $C_{17}H_{13}ClN_2O_2$: C, 65.29; H, 4.19; N, 8.96. Found: C, 65.37; H, 4.25; N, 8.99.

1-Benzyl-3-butylpyrimidine-2,4-dione (6d)

Colorless oil (lit.[7c] oil); ^{1}H NMR: δ = 7.40-7.27 (m, 5 H), 7.15 (d, *J* = 7.8 Hz, 1 H), 5.70 (d, *J* = 7.8 Hz, 1 H), 4.91 (s, 2 H), 3.95 (t, *J* = 7.6 Hz, 2 H), 1.62-1.60 (m, 2 H), 1.37-1.34 (m, 2 H), 0.95 (t, *J* = 7.5 Hz, 3 H); ^{13}C NMR: δ = 162.5, 151.3, 141.5, 135.3, 128.8, 128.2, 127.7, 102.0, 52.1, 41.2, 29.5, 20.2, 13.5; IR (neat): ν = 3055, 2966, 1712, 1655, 1455, 1357, 1238, 804 cm^{-1}; Anal. Calcd for $C_{15}H_{18}N_2O_2$: C, 69.74; H, 7.02; N, 10.84. Found: C, 69.82; H, 7.13; N, 10.72.

1-Butyl-3-phenylpyrimidine-2,4-dione (6e)

White solid, mp 99-101 °C (lit.[7c] 98-100 °C); ^{1}H NMR: δ = 7.50-7.46 (m, 2 H), 7.40 (d, *J* = 7.6 Hz, 1 H), 7.24-7.20 (m, 3 H), 5.81 (d, *J* = 7.6 Hz, 1 H), 3.75 (t, *J* = 7.5 Hz, 2 H), 1.69-1.67 (m, 2 H), 1.37-1.35 (m, 2 H), 0.98 (t, *J* = 7.3 Hz, 3 H); ^{13}C NMR: δ = 163.0, 151.5, 143.1, 134.9, 129.3, 128.5, 128.1, 101.7, 50.1, 31.2, 19.5, 13.5; IR (KBr): ν = 3056, 2962, 1710, 1660, 1445, 1116, 696 cm^{-1}; Anal. Calcd for $C_{14}H_{16}N_2O_2$: C, 68.83; H, 6.60; N, 11.47. Found: C, 68.91; H, 6.69; N, 11.50.

1,3-Dibutylpyrimidine-2,4-dione (6f)

Colorless oil (lit.[12] oil); ^{1}H NMR: δ = 7.10 (d, *J* = 7.7 Hz, 1 H), 5.69 (d, *J* = 7.7 Hz, 1 H), 3.95 (t, *J* = 7.6 Hz, 2 H), 3.73 (t, *J* = 7.5 Hz, 2 H), 1.68-1.59 (m, 4 H), 1.41-1.34 (m, 4 H), 0.97-0.91 (m, 6 H); ^{13}C NMR: δ = 163.2, 151.3, 142.0, 101.4, 49.6, 41.0, 30.9, 29.5, 20.3, 19.8, 13.6, 13.5; IR (neat): ν = 3050, 2960, 2872, 1705, 1655, 1456, 1356, 1225, 805 cm^{-1}; Anal. Calcd for $C_{12}H_{20}N_2O_2$: C, 64.26; H, 8.99; N, 12.49. Found: C, 64.33; H, 9.08; N, 12.54.

1-Phenyl-3-propylpyrimidine-2,4-dione (6g)

White solid, mp 135-136 °C (lit.[7c] 134-136 °C); ^{1}H NMR: δ = 7.51-7.46 (m, 2 H), 7.40 (d, *J* = 7.8 Hz, 1 H), 7.24-7.20 (m, 3 H), 5.81 (d, *J* = 7.8 Hz, 1 H), 3.71 (t, *J* = 7.4 Hz, 2 H), 1.76-1.74 (m, 2 H), 0.95 (t, *J* = 7.4 Hz, 3 H); ^{13}C NMR: δ = 163.2, 151.5, 142.9, 135.1, 129.2, 128.6, 128.2, 101.8, 51.4, 22.0, 10.7; IR (KBr): ν = 3052, 2967, 1709, 1662, 1445, 1336, 1245, 698 cm^{-1}; Anal. Calcd for $C_{13}H_{14}N_2O_2$: C, 67.81; H, 6.13; N, 12.17. Found: C, 67.90; H, 6.21; N, 12.12.

1-Butyl-3-propylpyrimidine-2,4-dione (6h)

Colorless oil (lit.[7c] oil); ^{1}H NMR: δ = 7.08 (d, *J* = 7.8 Hz, 1 H), 5.66 (d, *J* = 7.8 Hz, 1 H), 3.89 (t, *J* = 7.5 Hz, 2 H), 3.66 (t, *J* = 7.3 Hz, 2 H), 1.69-1.66 (m, 2 H), 1.58-1.54 (m, 2 H), 1.33-1.30 (m, 2 H), 0.96-0.90 (m, 6 H); ^{13}C NMR: δ = 163.2, 151.3, 142.0, 101.5, 51.5, 40.9, 30.1, 22.3, 20.0, 13.8, 10.7; IR (neat): ν = 3052, 2964, 1707, 1660, 1455, 1354, 1239, 802 cm^{-1}; Anal. Calcd for $C_{11}H_{18}N_2O_2$: C, 62.83; H, 8.63; N, 13.32. Found: C, 62.94; H, 8.75; N, 13.39.

1-Phenyl-3-(*i*-propyl)pyrimidine-2,4-dione (6i)

White solid, mp 130-132 °C; ^{1}H NMR: δ = 7.50-7.46 (m, 2 H), 7.38 (d, *J* = 7.7 Hz, 1 H), 7.24-7.18 (m, 3 H), 5.80 (d, *J* = 7.7 Hz, 1 H), 3.78-3.76 (m, 1 H), 1.20 (d, *J* = 6.6 Hz, 6 H); ^{13}C NMR: δ = 163.6, 151.6, 142.7, 135.3, 129.42, 128.7, 128.1, 101.2, 44.5, 22.5; IR (KBr): ν = 3050, 2965, 1710, 1663, 1446, 1387, 1370, 1245, 695 cm^{-1}; Anal. Calcd for $C_{13}H_{14}N_2O_2$: C, 67.81; H, 6.13; N, 12.17. Found: C, 67.92; H, 6.20; N, 12.14.

1-Butyl-3-(*i*-propyl)pyrimidine-2,4-dione (6j)

Colorless oil; ^{1}H NMR: δ = 7.05 (d, *J* = 7.8 Hz, 1 H), 5.64 (d, *J* = 7.8 Hz, 1 H), 3.80-3.78 (m, 1 H), 3.73 (t, *J* = 7.5 Hz, 2 H), 1.71-1.69 (m, 2 H), 1.38-1.35 (m, 2 H), 1.21 (d, *J* = 6.6 Hz, 6 H), 0.96 (t, *J* = 7.6 Hz, 3 H); ^{13}C NMR: δ = 163.0, 151.5, 142.3, 101.3, 50.5, 43.9, 30.9, 22.2, 20.0, 13.6; IR (neat): ν = 3052, 2964, 1707, 1660, 1455, 1354, 1385, 1370, 1240, 810 cm^{-1}; Anal. Calcd for $C_{11}H_{18}N_2O_2$: C, 62.83; H, 8.63; N, 13.32. Found: C, 62.90; H, 8.73; N, 13.40.

1-Allyl-3-butylpyrimidine-2,4-dione (6k)

Colorless oil (lit.[7c] oil); ^{1}H NMR: δ = 7.08 (d, *J* = 7.7 Hz, 1 H), 5.89-5.87 (m, 1 H), 5.74 (d, *J* = 7.7 Hz, 1 H), 5.34-5.25 (m, 2 H), 4.36 (d, *J* = 5.5 Hz, 2 H), 3.94 (t, *J* = 7.6 Hz, 2 H), 1.61-1.59 (m, 2 H), 1.37 (m, 2 H), 0.94 (t, *J* = 7.5 Hz, 3 H); ^{13}C NMR: δ = 163.0, 151.5, 141.5, 131.6, 119.1, 101.9, 51.1, 41.0, 29.5, 20.3, 13.9; IR (neat): ν = 3045, 2928, 2856, 1708, 1664, 1455, 1230, 805 cm^{-1}; Anal. Calcd for $C_{11}H_{16}N_2O_2$: C, 63.44; H, 7.74; N, 13.45. Found: C, 63.53; H, 7.85; N, 13.57.

ACKNOWLEDGEMENTS

We gratefully acknowledge financial support from the Natural Science Foundation of Jiangxi Province of China (No. 2008GZH0029) and the Research Program of Jiangxi Province Department of Education (No. GJJ08165).

Received November 1, 2009.

REFERENCES

1. Balkenhohl, F.; voc dem Bussche-Hünnefeld, C.; Lansky, A.; Zechel, C. *Angew. Chem., Int. Ed. Engl.* **1996**, *35*, 2288.
2. Recent reviews on SPOS, see: (a) Guillier, F.; Orain, D.; Bradley, M. *Chem. Rev.* **2000**, *100*, 2091. (b) Sammelson, R. E.; Kurth, M. J. *Chem. Rev.* **2001**, *101*, 137. (c) Dolle, R. E. *J. Comb. Chem*. **2002**, *4*, 369. (d) Blaney, P.; Grigg, R.; Sridharan, V. *Chem. Rev.* **2002**, *102*, 2607.

3. Ishii, T.; Motoyoshi, M. Japanese Patent 63,290,867, 1988.
4. Wright, T. R.; Fuerst, E. P.; Ogg, A. G., Jr.; Nandihalli, U. B.; Lee, H. J. *Weed Sci.* **1995**, *43*, 47.
5. (a) Barral, K.; Courcambeck, J.; Pepe, G.; Balzarini, J.; Neyts, J.; Clercq, E. D.; Camplo, M. *J. Med. Chem.* **2005**, *48*, 450. (b) Dolman, N. P.; Troop, H. M.; More, J. C. A.; Alt, A.; Knauss, J. L.; Nistico, R.; Jack, S.; Morley, R. M.; Bortolotto, Z. A.; Roberts, P. J.; Bleakman, D.; Collingridge, G. L.; Jane, D. E. *J. Med. Chem.* **2005**, *48*, 7867. (c) Mai, A.; Sbardella, G.; Artico, M.; Ragno, R.; Massa, S.; Novellino, E.; Greco, G.; Lavecchia, A.; Musiu, C.; Colla, M. L.; Murgioni, C.; Colla, P. L.; Loddo, R. *J. Med. Chem.* **2001**, *44*, 2544.
6. Chu, C. K.; Baker, D. C. *Nucleosides and Nucleotides as Antitumor and Antiviral Agents*; Plenum Press: New York, 1993.
7. (a) Kolodziej, S. A.; Hamper, B. C. *Tetrahedron Lett.* **1996**, *37*, 5277. (b) Fustero, S.; Piera, J.; Sanz-Cervera, J. F.; Catalan, S.; Arellano, C. R. *Org. Lett.* **2004**, *6*, 1417. (c) Huang, X.; Cao, J. *Synthesis* **2007**, 2947.
8. (a) Huang, X.; Sheng, S.-R. *J. Comb. Chem*. **2003**, *5*, 273. (b) Sheng, S.-R.; Wang, P.-G.; Zhou, W.; Luo, H.-R.; Lin, S.-Y.; Liu, X.-L. *Synlett* **2004**, 2603. (c) Sheng, S.-R.; Xin, Q.; Liu, X.-L.; Sun, W.-K.; Guo, R.; Huang, X. *Synthesis* **2006**, 2293. (d) Sheng, S.-R.; Xu, L.; Zhang, X.-L.; Liu, X.-L.; Wei, M.-H. *J. Comb. Chem.* **2006**, *8*, 805. (e) Zhang, X.-L.; Sheng, S.-R.; Liu, X.-L.; Liu, X.-L. *Arkivoc* **2007**, *(xiii)*, 79. (f) Hu, Q.-S.; Sheng, S.-R.; Lin, S.-Y.; Wei, M.-H.; Xin, Q.; Liu, X.-L. *J. Chem. Res(S)*. **2007**, 74. (g) Fu, G.-Y.; Guo, L.; Mao, X.-C.; Sheng, S.-R.; Fei, S.-Y.; Cai, M.-Z. *Arkivoc* **2008**, *(ii)*, 287.
9. Yan, B.; Kumaravel, G.; Anjaria, H.; Wu, A.; Petter, R. C.; Jewell, C. F.; Wareing, J. R. *J. Org. Chem.* **1995**, *60*, 5736.
10. Kaiser, E.; Bossinger, C. D.; Colescott, R. L.; Olser, D. D. *Anal. Chim. Acta* **1980**, *118*, 149.
11. (a) Reich, H. J. *Acc. Chem. Res*. **1979**, *12*, 22. (b) Liotta, D. *Acc. Chem. Res*. **1984**, *17*, 28. (c) Paulmier, C. *Selenium Reagents and Intermediates in Organic Synthesis*; Pergamon Press: Oxford, 1986.
12. Bram, G.; Decodts, G.; Bensaid, Y.; Farnoux, C. C.; Galons, H.; Miocque, M. *Synthesis* **1985**, 543.