

Mikhajlo Onysko\*, Igor Filak and Vasyl Lendel

# Halogenoheterocyclization of terminally substituted 2-allylthio(seleno)quinoline-3-carbaldehydes

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**Abstract:** Electrophilic heterocyclization of 2-alkenylthioquinoline-3-carbaldehydes or 2-alkenylselenoquinoline-3-carbaldehydes **2**, **3** under the action of iodine or bromine non-regioselectively leads to the formation of fused quinolinium trihalogenides **4**, **5**. Type of the chalcogen atom does not affect regiochemistry of halogenation.

**Keywords:** 2-alkenylselanyl; 2-alkenylsulfanyl; electrophilic cyclization; haloheterocyclization; 3-quinolinecarbaldehyde.

## Introduction

Electrophilic halocyclization of unsaturated thioethers of heterocycles is a convenient method for annellation of heterocycles and formation of condensed polycyclic compounds [1–20]. Regioselectivity of heterocyclization may be controlled by steric factors, nature of unsaturated alkenyl or alkynyl moiety [2–20], nature of electrophile [18] and by the presence of additional nucleophilic centers [7–9, 19, 20].

## Results and discussion

In our previous studies, it was indicated that halocyclization of terminal non-substituted 2-allylthio(oxy)quinoline carbaldehydes leads to the formation of a fused thiazoline(oxazoline) system [14–16]. The purpose of this study is to examine the impact of aryl and alkyl substituents at the terminal carbon atom in an allyl fragment on regioselectivity of halocyclization. The

2-cinnamylthio(seleno)-3-carbaldehydes and 2-(3-methyl-2-butenylthio(seleno)quinoline-3-carbaldehydes **2**, **3** were used as model substrates (Scheme 1). These compounds were obtained by alkylation of quinolines **1** in an alkaline medium [14, 15]. Bromination and iodination of the terminally substituted thio(seleno)ethers **2**, **3** were carried out in chloroform with a two-fold excess of halogen. It was found that cyclization of thio(seleno)ethers **2a–c** leads to the formation of thiazino(selenazino)[3,2-*a*]quinolinium trihalohenides **4a–d**, while the cyclization of thio(seleno)ethers **3a–c** results in the formation of thiazolo(selenazolo)[3,2-*a*]quinolinium trihalohenides **5a–d**. The yields of selenazino[3,2-*a*]quinolinium triiodide **4d** (54%) and selenazolo[3,2-*a*]quinolinium tribromide **5d** (45%) are lower than the yields of the corresponding thiazino **4a–c** (67%–71%) and thiazolo analogues **5a–c** (70%–74%). This outcome may be caused by greater solubility of **4d** and **5d** in chloroform.

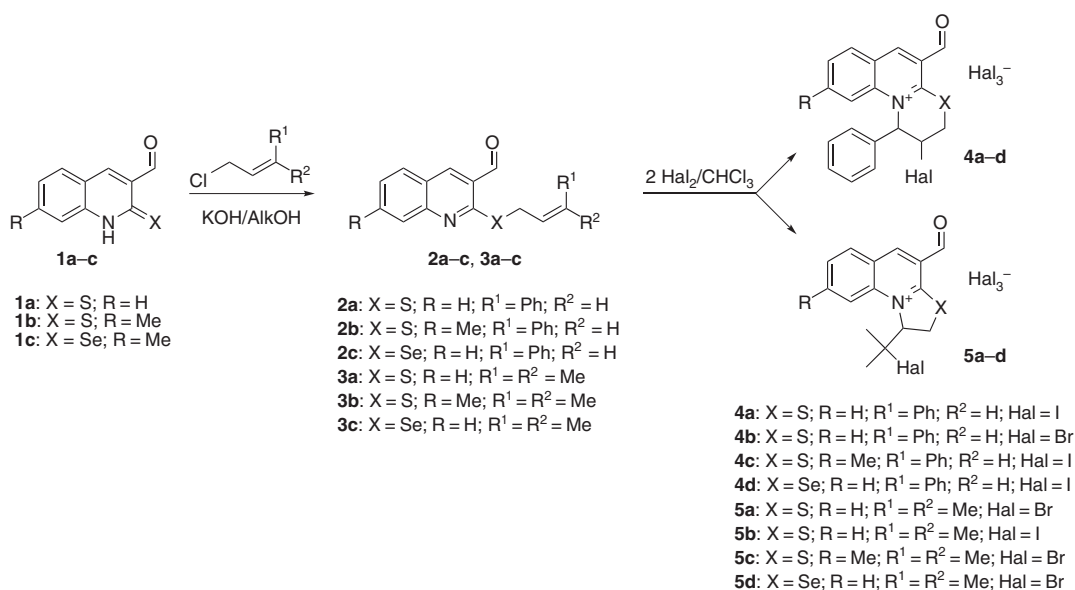
It can be suggested that polarization of a multiple bond and steric factors affect the regioselectivity of electrophilic heterocyclization of terminally substituted propenyl thioethers of quinoline-3-carbaldehyde. Spectral data confirm the formation of trihalohenides **4**, **5**. Annellation to a thiazine or selenazine system upon halogenation of unsaturated thio(seleno)ethers **2a–c** is consistent with the literature data [4, 7–9, 18]. However, in contrast to the first report [4], which indicates the formation of a thiazine, the cyclization of thio(seleno)ethers **3a–c** leads to annellation to the thiazoline or selenazoline. This fact is fully confirmed by analysis of chemical shifts of a methine group in <sup>1</sup>H NMR and <sup>13</sup>C NMR spectra, that are observed at 6.59–9.6.64 ppm (<sup>1</sup>H NMR) and 68 ppm (<sup>13</sup>C NMR) for compounds **5a–d**. These spectral data are in good agreement with the previously reported values for thiazolinoquinolines [14].

## Conclusions

Halocyclization of terminally substituted allylthioethers or allylseleno analogues of quinoline-3-carbaldehydes leads to the formation of regioisomers depending on the type of substituents – alkyl or aryl. The type of chalcogen atom does not affect regiochemistry.

\*Corresponding author: Mikhajlo Onysko, Organic Synthesis Laboratory, Uzhhorod National University, Uzhhorod 88000, Ukraine, e-mail: muonysko@gmail.com

Igor Filak and Vasyl Lendel: Organic Synthesis Laboratory, Uzhhorod National University, Uzhhorod 88000, Ukraine



Scheme 1

## Experimental

<sup>1</sup>H NMR (400 MHz) and <sup>13</sup>C NMR (100 MHz) spectra were recorded in DMSO-*d*<sub>6</sub> on a Varian Mercury-400 instrument. Melting points were determined on a Stuart SMP30 instrument. Elemental analyses were performed on an Elementar Vario MICRO cube analyzer. All reagents were obtained from commercial suppliers and used without any further purification. Dry solvents were prepared according to the standard methods. 3-Formylquinolin-2-thiones **1a,b** were synthesized as previously described [21]. Formylquinolin-2-selenone **1c** was synthesized according to reference [22].

### General method for synthesis of thioethers and selenoethers **2, 3**

A solution of potassium hydroxide (0.012 mol) in water (5 mL) was added to a solution of thione **1a,b** or selenone **1c** (0.01 mol) in ethanol or isopropanol (20 mL). The mixture was stirred and treated with an alkenylhalogenide (0.012 mol). The resultant precipitate was filtered and crystallized from ethanol.

**2-(3-Phenyl-2-propenylsulfanyl)-3-quinolinecarbaldehyde (2a)** Yield 53%; mp 103–104°C; <sup>1</sup>H NMR: δ 4.17 (d, *J* = 7 Hz, 2H), 6.45–6.49 (m, 1H), 6.80 (d, *J* = 15.6 Hz, 1H), 7.21 (d, *J* = 7 Hz, 1H), 7.29 (t, *J* = 7 Hz, 2H), 7.40 (d, *J* = 7 Hz, 2H), 7.63 (t, *J* = 7 Hz, 1H), 7.93 (t, *J* = 7 Hz, 1H), 8.03 (d, *J* = 8 Hz, 1H), 8.11 (d, *J* = 8 Hz, 1H), 8.92 (s, 1H), 10.19 (s, 1H); <sup>13</sup>C NMR: δ 32.1, 125.0, 125.9, 126.8, 127.1, 127.7, 128.2, 129.3, 130.3, 133.6, 134.2, 137.2, 146.1, 149.2, 158.1, 192.0. Anal. Calcd for C<sub>19</sub>H<sub>15</sub>NOS: C, 74.73; H, 4.95; N, 4.59. Found: C, 74.20; H, 4.75; N, 4.43.

**7-Methyl-2-(3-phenyl-2-propenylsulfanyl)-3-quinolinecarbaldehyde (2b)** Yield 90%; mp 114–115°C; <sup>1</sup>H NMR: δ 2.55 (s, 3H), 4.15 (d, *J* = 7 Hz, 2H), 6.43–6.47 (m, 1H), 6.77 (d, *J* = 16 Hz, 1H), 7.21 (d, *J* = 7 Hz, 1H), 7.28 (t, *J* = 7 Hz, 2H), 7.39 (d, *J* = 7 Hz, 2H), 7.45 (d, *J* = 8 Hz, 1H), 7.81

(s, 1H), 7.98 (d, *J* = 8 Hz, 1H), 8.82 (s, 1H), 10.14 (s, 1H). Anal. Calcd for C<sub>20</sub>H<sub>17</sub>NOS: C, 75.21; H, 5.36; N, 4.39. Found: C, 75.08; H, 5.19; N, 4.28.

**2-(3-Phenyl-2-propenylselanyl)-3-quinolinecarbaldehyde (2c)** Yield 43%; mp 95–96°C; <sup>1</sup>H NMR: δ 4.14 (d, *J* = 8 Hz, 2H), 6.51–6.54 (m, 1H), 6.73 (d, *J* = 16 Hz, 1H), 7.18 (d, *J* = 7 Hz, 1H), 7.27 (t, *J* = 7 Hz, 2H), 7.36 (d, *J* = 8 Hz, 2H), 7.67 (t, *J* = 7 Hz, 1H), 7.95 (t, *J* = 7 Hz, 1H), 8.09 (d, *J* = 8 Hz, 1H), 8.15 (d, *J* = 8 Hz, 1H), 8.96 (s, 1H), 10.18 (s, 1H). Anal. Calcd for C<sub>19</sub>H<sub>15</sub>NOSe: C, 64.79; H, 4.29; N, 3.98. Found: C, 64.92; H, 4.21; N, 3.81.

**2-(3-Methyl-2-butenylsulfanyl)-3-quinolinecarbaldehyde (3a)** Yield 55%; mp 60–61°C; <sup>1</sup>H NMR: δ 1.69 (s, 3H), 1.76 (s, 3H), 3.94 (d, *J* = 8 Hz, 2H), 5.39 (t, *J* = 7 Hz, 1H), 7.61 (t, *J* = 7 Hz, 1H), 7.91 (m, 2H), 8.10 (d, *J* = 8 Hz, 1H), 8.89 (s, 1H), 10.17 (s, 1H). Anal. Calcd for C<sub>15</sub>H<sub>15</sub>NOS: C, 70.01; H, 5.87; N, 5.44. Found: C, 69.83; H, 5.65; N, 5.31.

**7-Methyl-2-(3-methyl-2-butenylsulfanyl)-3-quinolinecarbaldehyde (3b)** Yield 63%; mp 82–83°C; <sup>1</sup>H NMR: δ 1.68 (s, 3H), 1.74 (s, 3H), 2.52 (s, 3H), 3.90 (d, *J* = 8 Hz, 2H), 5.38 (t, *J* = 8 Hz, 1H), 7.41 (d, *J* = 8 Hz, 1H), 7.69 (s, 1H), 7.94 (d, *J* = 8 Hz, 1H), 8.76 (s, 1H), 10.12 (s, 1H). Anal. Calcd for C<sub>16</sub>H<sub>17</sub>NOS: C, 70.82; H, 6.31; N, 5.16. Found: C, 70.56; H, 6.15; N, 5.01.

**2-(3-Methyl-2-butenylselanyl)-3-quinolinecarbaldehyde (3c)** Yield 72%; mp 65–66°C; <sup>1</sup>H NMR: δ 1.69 (s, 3H), 1.75 (s, 3H), 3.93 (d, *J* = 8 Hz, 2H), 5.47 (t, *J* = 7 Hz, 1H), 7.66 (t, *J* = 7 Hz, 1H), 7.97 (m, 2H), 8.14 (d, *J* = 8 Hz, 1H), 8.94 (s, 1H), 10.18 (s, 1H). Anal. Calcd for C<sub>15</sub>H<sub>15</sub>NOSe: C, 59.23; H, 4.97; N, 4.60. Found: C, 59.56; H, 4.76; N, 4.52.

### General method for synthesis of compounds **4, 5**

A solution of bromine or iodine (7.2 mmol) in chloroform was added to a solution of thio(seleno)ether **2** or **3** (3.6 mmol) in chloroform (15 mL) under constant stirring. After 5 h (for bromine) or 2 days (for

iodine) the precipitated yellow or brown product was filtered and washed with chloroform.

**5-Formyl-2-iodo-1-phenyl-2,3-dihydro-1*H*-[1,3]thiazino[3,2-*a*]quinolin-11-ium triiodide (4a)** Yield 69%; mp 168–170°C; <sup>1</sup>H NMR: δ 4.30 (d, *J* = 7 Hz, 2H), 5.87 (d, *J* = 7 Hz, 1H), 6.78 (m, 1H), 7.11 (m, 3H), 7.42 (m, 2H), 7.79 (t, *J* = 7 Hz, 1H), 7.98 (t, *J* = 7 Hz, 1H), 8.07 (d, *J* = 8 Hz, 1H), 8.37 (d, *J* = 7 Hz, 1H), 9.68 (s, 1H), 10.28 (s, 1H); <sup>13</sup>C NMR: δ 29.3, 37.6, 72.2, 126.1, 126.8, 129.2, 129.4, 129.5, 130.4, 132.4, 138.1, 138.3, 139.2, 152.8, 164.7, 190.0. Anal. Calcd for C<sub>19</sub>H<sub>15</sub>I<sub>4</sub>NOS: C, 28.07; H, 1.86; I, 62.44; N, 1.72. Found: C, 28.20; H, 1.78; I, 62.04; N, 1.68.

**2-Bromo-5-formyl-1-phenyl-2,3-dihydro-1*H*-[1,3]thiazino[3,2-*a*]quinolin-11-ium tribromide (4b)** Yield 67%; mp 192–194°C; <sup>1</sup>H NMR: δ 3.36 (d, *J* = 15 Hz, 1H), 3.66 (d, *J* = 15 Hz, 1H), 5.90 (d, *J* = 3 Hz, 1H), 7.40–7.46 (m, 6H), 7.99 (t, *J* = 7 Hz, 1H), 8.15–8.22 (m, 2H), 8.55 (d, *J* = 8 Hz, 1H), 9.71 (s, 1H), 10.34 (s, 1H); <sup>13</sup>C NMR: δ 31.0, 42.4, 66.6, 79.9, 118.1, 125.7, 126.7, 128.7, 129.2, 129.7, 130.5, 133.8, 135.6, 138.8, 141.4, 152.1, 163.3, 189.5. Anal. Calcd for C<sub>19</sub>H<sub>15</sub>I<sub>4</sub>NOS: C, 38.51; H, 2.42; Br, 51.14; N, 2.24. Found: C, 38.26; H, 2.50; Br, 50.89; N, 2.12.

**5-Formyl-2-iodo-9-methyl-1-phenyl-2,3-dihydro-1*H*-[1,3]thiazino[3,2-*a*]quinolin-11-ium triiodide (4c)** Yield 71%; mp 165–167°C; <sup>1</sup>H NMR: δ 2.54 (s, 3H), 4.30 (d, *J* = 7 Hz, 2H), 5.79 (d, *J* = 8 Hz, 1H), 6.79 (m, 1H), 7.03 (m, 3H), 7.35 (m, 2H), 7.57 (d, *J* = 8 Hz, 1H), 7.83 (s, 1H), 8.18 (d, *J* = 8 Hz, 1H), 9.55 (s, 1H), 10.23 (s, 1H); <sup>13</sup>C NMR: δ 22.8, 28.8, 37.8, 72.0, 119.9, 124.0, 125.8, 128.6, 129.2, 130.3, 130.8, 131.6, 138.3, 139.3, 150.0, 151.9, 163.7, 189.9. Anal. Calcd for C<sub>20</sub>H<sub>17</sub>I<sub>4</sub>NOS: C, 29.05; H, 2.07; I, 61.38; N, 1.69. Found: C, 28.91; H, 2.00; I, 61.43; N, 1.55.

**5-Formyl-2-iodo-1-phenyl-2,3-dihydro-1*H*-[1,3]selenazino[3,2-*a*]quinolin-11-ium triiodide (4d)** Yield 54%; mp 173–175°C; <sup>1</sup>H NMR: δ 4.35 (d, *J* = 7 Hz, 2H), 5.93 (d, *J* = 7 Hz, 1H), 6.81 (m, 1H), 7.13 (m, 3H), 7.40 (m, 2H), 7.80 (t, *J* = 7 Hz, 1H), 7.99 (t, *J* = 7 Hz, 1H), 8.05 (d, *J* = 8 Hz, 1H), 8.35 (d, *J* = 7 Hz, 1H), 9.67 (s, 1H), 10.28 (s, 1H); Anal. Calcd for C<sub>19</sub>H<sub>15</sub>I<sub>4</sub>NOSe: C, 26.54; H, 1.76; I, 59.04; N, 1.63. Found: C, 26.21; H, 1.59; I, 58.84; N, 1.55.

**1-(1-Bromo-1-methylethyl)-4-formyl-1,2-dihydro[1,3]thiazolo[3,2-*a*]quinolin-10-ium tribromide (5a)** Yield 70%; mp 145–147°C; <sup>1</sup>H NMR: δ 1.74 (s, 3H), 1.83 (s, 3H), 4.20 (m, 1H), 4.31 (d, *J* = 9 Hz, 1H), 6.64 (d, *J* = 9 Hz, 1H), 7.94 (t, *J* = 8 Hz, 1H), 8.24 (t, *J* = 7 Hz, 1H), 8.50 (d, *J* = 8 Hz, 1H), 8.68 (d, *J* = 8 Hz, 1H), 9.74 (s, 1H), 10.24 (s, 1H); <sup>13</sup>C NMR: δ 32.7, 33.0, 34.9, 68.4, 73.4, 121.8, 126.6, 129.4, 132.4, 137.3, 140.9, 153.2, 167.3, 189.9. Anal. Calcd for C<sub>15</sub>H<sub>15</sub>Br<sub>4</sub>NOS: C, 31.23; H, 2.62; Br, 55.40; N, 2.43. Found: C, 31.05; H, 2.50; Br, 55.08; N, 2.26.

**1-(1-Iodo-1-methylethyl)-4-formyl-1,2-dihydro[1,3]thiazolo[3,2-*a*]quinolin-10-ium triiodide (5b)** Yield 74%; mp 115–117°C; <sup>1</sup>H NMR: δ 1.89 (s, 3H), 1.92 (s, 3H), 4.31 (m, 1H), 4.36 (d, *J* = 9 Hz, 1H), 6.59 (d, *J* = 9 Hz, 1H), 7.96 (t, *J* = 7 Hz, 1H), 8.25 (t, *J* = 7 Hz, 1H), 8.50 (d, *J* = 7 Hz, 1H), 8.67 (d, *J* = 7 Hz, 1H), 9.72 (s, 1H), 10.26 (s, 1H). Anal. Calcd for C<sub>15</sub>H<sub>15</sub>I<sub>4</sub>NOS: C, 23.55; H, 1.98; I, 66.36; N, 1.83. Found: C, 23.32; H, 1.79; I, 66.41; N, 1.72.

**1-(1-Bromo-1-methylethyl)-4-formyl-8-methyl-1,2-dihydro[1,3]thiazolo[3,2-*a*]quinolin-10-ium tribromide (5c)** Yield 73%; mp 128–130°C; <sup>1</sup>H NMR: δ 1.73 (s, 3H), 1.84 (s, 3H), 2.69 (s, 3H), 4.19 (m, 1H), 4.29 (d, *J* = 8 Hz, 1H), 6.59 (d, *J* = 8 Hz, 1H), 7.80 (d, *J* = 8 Hz, 1H), 8.38 (d, *J* = 8 Hz, 1H), 8.56 (s, 1H), 9.66 (s, 1H), 10.22 (s, 1H). Anal. Calcd

for C<sub>16</sub>H<sub>17</sub>Br<sub>4</sub>NOS: C, 32.52; H, 2.90; Br, 54.08; N, 2.37. Found: C, 32.20; H, 2.81; Br, 53.96; N, 2.23.

**1-(1-Bromo-1-methylethyl)-4-formyl-1,2-dihydro[1,3]selenazolo[3,2-*a*]quinolin-10-ium tribromide (5d)** Yield 45%; mp 160–162°C; <sup>1</sup>H NMR: δ 1.82 (s, 3H), 1.87 (s, 3H), 4.25 (m, 1H), 4.34 (d, *J* = 9 Hz, 1H), 6.62 (d, *J* = 9 Hz, 1H), 7.97 (t, *J* = 7 Hz, 1H), 8.25 (t, *J* = 7 Hz, 1H), 8.51 (d, *J* = 8 Hz, 1H), 8.70 (d, *J* = 8 Hz, 1H), 9.75 (s, 1H), 10.20 (s, 1H). Anal. Calcd for C<sub>15</sub>H<sub>15</sub>Br<sub>4</sub>NOSe: C, 28.88; H, 2.42; Br, 51.24; N, 2.25. Found: C, 28.29; H, 2.50; Br, 51.01; N, 2.13.

## References

- Godoi, B.; Schumacher, R. F.; Zeni, G. Synthesis of heterocycles via electrophilic cyclization of alkynes containing heteroatom. *Chem. Rev.* **2011**, *111*, 2937–2980.
- Jasiński, M.; Młostoń, G.; Heimgartner, H. Synthesis of 2,3-dihydroimidazo[2,1-*b*]thiazole derivatives via cyclization of *N*-allylimidazoline-2-thiones. *J. Heterocycl. Chem.* **2010**, *47*, 1287–1293.
- Slivka, M. V.; Krivovjaz, A. A.; Slivka, M. V.; Lendel, V. G. Stereoselective synthesis of (*E*)-halogenmethylidene[1,3]thiazolo[3,2-*a*]thieno[3,2-*e*]pyrimidinium and analogous [1,3]oxazolo[3,2-*a*]thieno[3,2-*e*]pyrimidinium halogenides from 3-*N*-Substituted 2-propargylthio(oxy)-thieno[2,3-*d*]pyrimidin-4-ones. *Heterocycl. Commun.* **2013**, *19*, 189–193.
- Slivka, N.; Gevaza, Yu. I.; Staninets, V. Halocyclization of substituted 2-(alkenylthio)pyrimidin-6-ones. *Chem. Heterocycl. Compd.* **2004**, *40*, 660–666.
- Kchripak, S. M.; Plesha, M. V.; Slivka, M. V.; Yakubets, V. I.; Krivovjaz, A. O. Synthesis and reactivity of 1-bromomethyl-5-oxo-4-phenyl-1,2,4,5,6,7,8,9-octahydrobenzo[4,5]thieno[3,2-*e*][1,3]oxazolo[3,2-*a*]pyrimidin-11-ium bromides. *Russ. J. Org. Chem.* **2004**, *40*, 1749–1750.
- Wippich, P.; Gutschow, M.; Leistner, S. Regioselective preparation of 1-(bromomethyl)-5*H*-thiazolo[3,2-*a*]quinazolin-5-ones and analogous 5*H*-thieno[3,2-*e*]thiazolo[3,2-*a*]pyrimidin-5-ones from fused 2-(alkenylthio)pyrimidin-4-ones. *Synthesis* **2000**, *5*, 714–720.
- Vas'kevich, R. I.; Dyachenko, I. V.; Vas'kevich, A. I.; Rusanov, E. B.; Vovk, M. V. Fused pyrimidine systems: XV. Intramolecular electrophilic cyclization of 2-allyl(propargyl, cinnamyl)aminopyrido[2,3-*d*]pyrimidin-4(3*H*)-ones. *Russ. J. Org. Chem.* **2015**, *51*, 556–565.
- Dyachenko, I. V.; Vas'kevich, R. I.; Vovk, M. V. Fused pyrimidine systems: XIII. Synthesis and some transformations of 1,3-thiazolo(thiazino)-fused pyrido[3,4-*d*]pyrimidines. *Russ. J. Org. Chem.* **2014**, *50*, 263–270.
- Dyachenko, I. V.; Vas'kevich, R. I.; Vas'kevich, A. I.; Shishkina, S. V.; Vovk, M. V. Fused pyrimidine systems: XVI. Electrophilic intramolecular cyclization of 2-(alkenylsulfanyl)pteridin-4(3*H*)-ones. *Russ. J. Org. Chem.* **2016**, *52*, 745–752.
- Onisko, M. Yu.; Svalyavin, O. V.; Lendel, V. G. Synthesis and halogenation of allylthioethers of pyrazolo[3,4-*d*]pyrimidine. *Chem. Heterocycl. Compd.* **2007**, *4*, 602–605.
- Onysko, M. Yu.; Svalyavin, O. V.; Turov, A. V.; Lendel, V. G. Synthesis and halogenation of propargyl pyrazolo[3,4-*d*]pyrimidine thioether. *Chem. Heterocycl. Compd.* **2008**, *7*, 1085–1089.

- [12] Svalyavin, O. V.; Onysko, M. Yu.; Turov, A. V.; Vlasenko, Yu. G.; Lendel, V. G. Peculiar electrophilic heterocyclization of 5-allyl-6-thioxopyrazolo[3,4-*d*]pyrimidin-4-one. *Chem. Heterocycl. Compd.* **2013**, *3*, 526–531.
- [13] Usenko, R. M.; Slivka, M. V.; Lendel, V. G. Electrophilic heterocyclization of 4,5-disubstituted 3-allylthio-4*H*-1,2,4-triazoles by the action of halogens. *Chem. Heterocycl. Compd.* **2011**, *47*, 1029–1036.
- [14] Onysko, M. Yu.; Filak, I. O.; Lendel, V. G. Halogenoheterocyclization of 2-(allylthio)-quinolin-3-carbaldehyde and 2-(propargylthio)-quinolin-3-carbaldehyde. *Heterocycl. Commun.* **2016**, *22*, 295–299.
- [15] Onysko, M. Yu.; Lendel, V. G. Haloheterocyclization of 2-methallyl(propargyl)-thioquinoline-3-carbaldehydes. *Chem. Heterocycl. Compd.* **2009**, *45*, 853–855.
- [16] Onysko, M. Yu.; Lendel, V. G. Haloheterocyclization of 2-allyl(propargyl)oxyquinoline-3-carbaldehydes. *Chem. Heterocycl. Compd.* **2007**, *43*, 1020–1023.
- [17] Kut, M. M.; Onysko, M. Yu.; Lendel, V. G. Heterocyclization of 5,6-disubstituted 3-alkenyl-2-thioxothieno[2,3-*d*]pyrimidin-4-one with *p*-alkoxyphenyltellurium trichloride. *Heterocycl. Commun.* **2016**, *22*, 347–350.
- [18] Slivka, M.; Korol, N.; Rusyn, I.; Lendel, V. Synthesis of [1,3]thiazolo[3,2-*b*][1,2,4]triazol-7-ium and [1,2,4]triazolo[5,1-*b*][1,3]thiazin-4-ium salts via regioselective electrophilic cyclization of 3-*S*-alkenylthio-4*H*-1,2,4-triazoles. *Heterocycl. Commun.* **2015**, *21*, 397–401.
- [19] Khripak, S.; Slivka, M.; Vilkov, R.; Usenko, R.; Lendel, V. Regioselectivity of the monohalogenation of 4-allyl-3-allylamino-1,2,4-triazole-5-thione. *Chem. Heterocycl. Compd.* **2007**, *43*, 781–785.
- [20] Fizer, M. M.; Slivka, M. V.; Rusanov, E. B.; Turov, A. V.; Lendel, V. G. [1,3]Thiazolo[2',3':3,4][1,2,4]triazolo[1,5-*a*]pyrimidines – a new heterocyclic system accessed via bromocyclization. *J. Heterocycl. Chem.* **2015**, *52*, 949–952.
- [21] Meth-Cohn, O.; Narine, B.; Tarnowski, B.; Hayes, R.; Keyzad, A.; Rhouati, S.; Robinson, A. A versatile new synthesis of quinolines and related fused pyridines. Part 9. Synthetic application of the 2-chloroquinoline-3-carbaldehydes. *J. Chem. Soc. Perkin Trans. 1.* **1981**, *1*, 2509–2517.
- [22] Raghavendra, M.; Bhojya Naik, H. S.; Bailure, S.; Sherigara, B. S. A facile one-pot microwave-induced synthesis of some novel selenolo[2,3-*b*]quinoline derivatives under solvent-free conditions. *Phosphorus, Sulfur, Silicon Relat. Elem.* **2008**, *183*, 1501–1509.