

S. Bátori [a] and A. Messmer\*

Central Research Institute for Chemistry,  
H-1525 Budapest, P. O. Box 17, Hungary  
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New  $\nu$ -triazolo[1,5-*a*]- and  $\nu$ -triazolo[1,5-*c*]pyrimidinium salts **12a-e**, **13a-c** have been synthesized *via* oxidation (*i.e.* cyclodehydrogenation) of the appropriate pyrimidyl ketone arylhydrazones **3a-e**, **6a-c** using TBB (2,4,4,6-tetrabromocyclohexa-2,5-dien-1-one) as the reagent. The arylhydrazones were obtained by standard reactions; the Grignard reaction of 2-cyano- and 4-cyanopyrimidine **1a,b**, **4a-c** gave 2-pyrimidyl- and 4-pyrimidyl ketones **2a-e**, **5a-c**, which reacted with arylhydrazines to yield the desired ketone arylhydrazones **3a-e**, **6a-c**.

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The first bridgehead-nitrogen containing  $\nu$ -triazolo[1,5-*a*]pyrimidine derivative was described by Birr *et al.* [2] in 1952. Since then numerous publications have dealt with the synthesis of  $\nu$ -triazolo[1,5-*a*]pyrimidines [3,4] and  $\nu$ -triazolo[1,5-*c*]pyrimidines [5] as well as with the study of their reactions [6-9]. Tsuiguk *et al.* [10] reported that 4-amino- $\nu$ -triazole when reacted with  $\beta$ -difunctional compounds gave fully aromatic, quaternary  $\nu$ -triazolo[1,5-*a*]pyrimidinium salts.

We now prepared new  $\nu$ -triazolopyrimidinium salts using the procedure developed earlier by us [11,12] for cyclodehydrogenation of arylhydrazones of nitrogen-containing heteroaromatic ketones with 2,4,4,6-tetrabromocyclohexa-2,5-dien-1-one (tribromophenol bromine; "TBB").

For the synthesis of the desired arylhydrazones **3a-e**, **6a-c**, 2- and 4-pyrimidyl ketones **2a-d**, **5a-c** have been prepared from the known cyanopyrimidines **1a,b**, **4a-c** [13-17] by Grignard reaction in a yield of 60 to 80 per cent.

4,6-dichloro derivative **10** *via* reaction with phosphorus oxychloride. The exchange of the chloro substituents for methoxy groups afforded then 4,6-dimethoxy derivative **11** and the oxidation of this latter compound by chromic anhydride yielded ketone **2e** [19].

Scheme 2

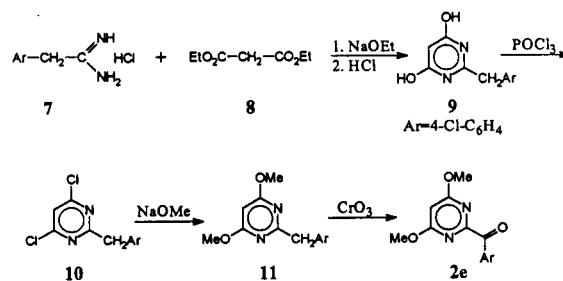
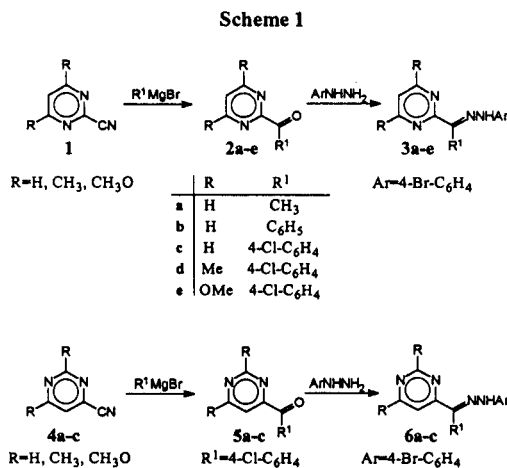
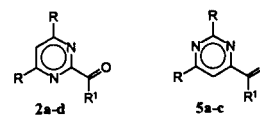


Table 1

Physical data of 2- and 4-pyrimidyl ketones



4-Chlorophenyl 4,6-dimethoxy-2-pyrimidyl ketone **2e** was prepared in a different but more convenient way as follows. According to the procedure described [18] for the synthesis of 2-benzyl-4,6-dichloropyrimidine, 4,6-dihydroxy-2-(4-chlorobenzyl)pyrimidine (**9**) was synthesized starting from 4-chlorophenylacetamide (**7**) and diethyl malonate (**8**, Scheme 2). The product **9** was converted into

No	R	R <sup>1</sup>	Mp (°C)	Yield (%)	Analysis (Calcd./Found)			IR (KBr) (cm <sup>-1</sup> )	
					Formula (Mw)	C	H		N
2a	H	CH <sub>3</sub>	52-53	62	C <sub>6</sub> H <sub>6</sub> N <sub>2</sub> O (122.13)	59.01	4.95	22.94	1680
[a]			[c]			59.16	5.07	22.93	
2b	H	C <sub>6</sub> H <sub>5</sub>	83-85	65	C <sub>11</sub> H <sub>8</sub> N <sub>2</sub> O (184.20)	71.73	4.38	15.21	1665
						71.54	4.39	15.38	
2c	H	4-Cl-C <sub>6</sub> H <sub>4</sub>	90-91	84	C <sub>11</sub> H <sub>7</sub> ClN <sub>2</sub> O (218.65)	60.42	3.23	12.81	1670
[b]						60.74	3.33	12.60	
2d	CH <sub>3</sub>	4-Cl-C <sub>6</sub> H <sub>4</sub>	56-58	79	C <sub>13</sub> H <sub>11</sub> ClN <sub>2</sub> O (246.70)	63.29	4.49	11.36	1680
			[d]			63.09	4.53	11.45	
5a	H	4-Cl-C <sub>6</sub> H <sub>4</sub>	113-114	63	C <sub>11</sub> H <sub>7</sub> ClN <sub>2</sub> O (218.65)	60.43	3.23	12.81	1670
						60.20	3.44	12.67	
5b	CH <sub>3</sub>	4-Cl-C <sub>6</sub> H <sub>4</sub>	127-128	78	C <sub>13</sub> H <sub>11</sub> ClN <sub>2</sub> O (246.70)	63.29	4.49	11.36	1670
						63.09	4.26	11.18	
5c	CH <sub>3</sub> O	4-Cl-C <sub>6</sub> H <sub>4</sub>	129-131	83	C <sub>13</sub> H <sub>9</sub> ClN <sub>2</sub> O <sub>3</sub> (278.70)	56.02	3.98	10.05	1675
						55.89	4.14	10.17	

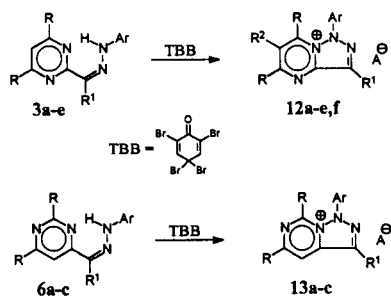
[a] Ref [17] m p 52°; [b] ref [21] mp 86-88°; [c] ethanol-ether; [d] petroleum ether

Reactions of ketones **2a-e**, **5a-c** with 4-bromophenylhydrazine under acidic conditions afforded isomeric (*E/Z*)

mixtures of arylhydrazones **3a-e**, **6a-e** in about 70% yield. The isomeric pair of hydrazone **3c** was separated by column chromatography (alumina, Brockman I, eluent:benzene), mp of the pure *Z*-isomer ( $R_f = 0.8$ ) 163-164°, mp of the pure *E*-isomer ( $R_f = 0.5$ ) 143-145°. The assignment of the  $^1\text{H}$  nmr spectra of the pure isomers gave the following values for the NH group:  $\delta = 13.3$  ppm (*Z*-isomer, intramolecular  $\text{NH}\cdots\text{N}$  bridge) and  $\delta = 7.9$  ppm (*E*-isomer).

The hydrazones **3a-e** and **6a-c** have been cyclized by oxidation with 3 (or 4) equivalents of TBB in dry dichloromethane, and *v*-triazolo[1,5-*a*]pyrimidinium perbromides **12a-e** ( $A = \text{Br}_3$ ) as well as *v*-triazolo[1,5-*c*]pyrimidinium perbromides **13a-c** ( $A = \text{Br}_3$ ) have been isolated in 35-90% yield. The pure isomers of **3c** were reacted separately with TBB. While the pure *Z*-isomer reacted even at 0° within a few minutes, the *E*-isomer gave the same cyclized product only after a few hours of reaction time.

Scheme 3

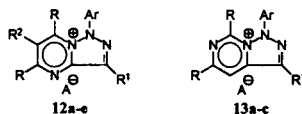


The labile perbromide salts were converted into the more stable fluoborate salts **12a-e**, **13b,c** ( $A = \text{BF}_4$ ) by treatment first with cyclohexene (to transfer the perbromide to bromide) and then with silver fluoborate under water free conditions.

The ring-closed structure of the new salts **12a-e** and **13b,c** was unambiguously proved by microanalytical, ir (absence of NH bands which were characteristic for hydrazones; and presence of the band of fluoborate anion at 1080  $\text{cm}^{-1}$ ) and  $^1\text{H}$  nmr data (characteristic downfield shift at  $\delta = 9.53$  ppm of H-7 adjacent to the positive bridge-head-nitrogen of compound **12c** and similarly, at  $\delta = 8.75$  ppm of H-4 of compound **13b**).

The pyrimidine ring was found to undergo simultaneous bromination at position C-5 (according to the numbering of the parent pyrimidine ring) in the ring-closure reaction leading to compounds **12a-c** ( $R = \text{H}$ ,  $R_2 = \text{Br}$ , Scheme 3). The bromination of pyrimidine ring failed in the cases of cyclization of hydrazones **3d,e** and **6a-c** probably because of the steric hindrance of substituents adjacent to position 5. It is known [20] that the bromination of pyrimidine with bromine yields 5-bromopyrimidine. Similarly, it seemed probable that on influence of potential bromo cation derived from TBB, first the bromination of the pyrimidine ring of hydrazones **3a-c** took place (Scheme 4), because an electrophilic substitution of a positively charged ring system like **12** is less likely. In that case the resulting 5-bromo-2-pyrimidyl ketone hydrazones **14a-c** ( $R_3 = \text{H}$ ) would have cyclized on influence of additional amount of TBB.

**Table 2**  
Physical and spectral data of *v*-triazolo[1,5-*a*]pyrimidinium **12a-e** and *v*-triazolo[1,5-*c*]pyrimidinium salts **13a-c**

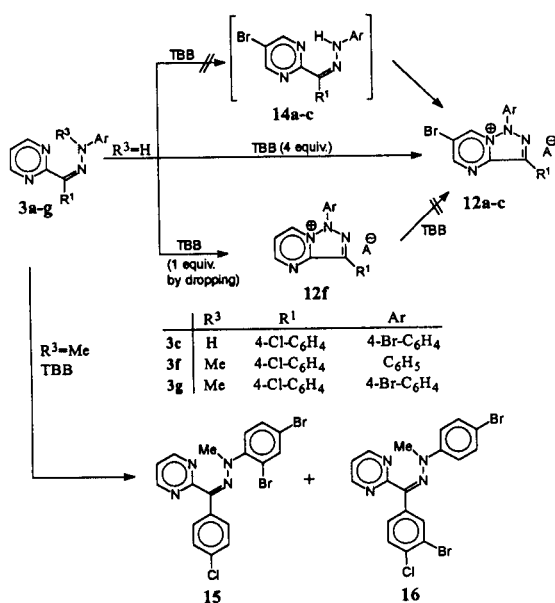


No	$A = \text{Br}_3$				$A = \text{BF}_4$				IR (KBr) ( $\text{cm}^{-1}$ )
	Mp (°C)	Yield (%)	Mp (°C)	Yield (%)	Analysis (Calcd/Found)				
					Formula (Mw)	C	H	N	
<b>12a</b>	140-142	68	198-199	83	$\text{C}_{12}\text{H}_9\text{BBr}_2\text{F}_4\text{N}_4$ (456.90)	31.55 31.35	2.21 2.37	12.26 12.01	3050, 2920, 1600, 1480, 1390, 1080
<b>12b</b>	160-161	81	221-222	76	$\text{C}_{17}\text{H}_{11}\text{BBr}_2\text{F}_4\text{N}_4$ (515.96)	39.42 39.25	2.14 2.31	10.82 11.04	3060, 1600, 1480, 1420, 1380, 1080
<b>12c</b>	146-147	90	215-216	87	$\text{C}_{17}\text{H}_{10}\text{BBr}_2\text{ClF}_4\text{N}_4$ (552.41)	36.96 36.72	1.82 1.92	10.14 9.94	3000, 1615, 1555, 1415, 1100
<b>12d</b>	173-175	61	234-236	91	$\text{C}_{19}\text{H}_{13}\text{BBrClF}_4\text{N}_4$ (501.55)	45.50 45.35	3.01 2.91	11.17 11.00	3010, 2950, 1620, 1555, 1490, 1090
<b>12e</b>	150-152	81	206-208	88	$\text{C}_{19}\text{H}_{15}\text{BBrClF}_4\text{N}_4\text{O}_2$ (533.55)	42.77 42.79	2.83 2.91	10.50 10.73	3010, 2860, 1635, 1560, 1520, 1100
<b>13a</b>	93-95	38	[a]						
<b>13b</b>	144-146	53	276-278	66	$\text{C}_{19}\text{H}_{13}\text{BBrClF}_4\text{N}_4$ (501.55)	45.50 45.82	3.01 3.22	11.17 10.95	3020, 2870, 1620, 1560, 1490, 1100
<b>13c</b>	99-101	35	158-160	87	$\text{C}_{19}\text{H}_{15}\text{BBrClF}_4\text{N}_4\text{O}_2$ (533.55)	42.77 43.02	2.83 2.98	10.50 10.32	3030 2950, 1630, 1560, 152, 1090

[a] This fluoborate salt could not have been isolated.

However, a detailed study of the reaction excluded this supposition. Thus, the reaction of 4-chlorophenyl 2-pyrimidyl ketone *N*-methyl-*N*-phenylhydrazone (**3f**, prepared from ketone **2c** by *N*-methyl-*N*-phenylhydrazine) with 1 equivalent of TBB resulted in the exclusive bromination of the phenyl group to give 4-bromophenylhydrazone derivative **3g** in 60% yield. Consequently, if the ring closure is not possible, the pyrimidine ring will not be brominated!

Scheme 4



The reaction of this latter compound (**3g**, synthesized also in a different way, by methylation of the anion generated from **3c** by sodium hydride in dry DMF) with a further equivalent of TBB resulted in, again, no bromination at the pyrimidine ring; only the brominated hydrazones **15** (37%) and **16** (25%) have been isolated. The same hydrazones **15** and **16** were also obtained in the presence of potassium carbonate with a slightly different product ratio (50%:17%).

The lack of bromination of the pyrimidine ring of *N*-methylated hydrazones **3f,g** allowed us to suppose that one of the intermediates would be brominated during the ring closure process.

We have succeeded in avoiding the bromination of pyrimidine ring during the ring closure process taking into account the above reaction pattern. The concentration of TBB was kept at low level throughout the reaction (by slow dropping of a dilute solution of TBB in dichloromethane into the solution of **3c** in dichloromethane). The unsubstituted pyrimidine ring containing bromide salt **12f** (R = R<sub>2</sub> = H, A = Br, Scheme 3) was obtained in this way in 73% yield. The fluoborate salt **12f** (A = BF<sub>4</sub>) was prepared by treating of the bromide salt **12f** (A = Br) with one equivalent of silver fluoborate.

The bromination of the pyrimidine moiety of fluoborate salt **12f** was excluded by the following experiment: the salt was stirred with 3 equivalents of TBB for 16 hours at room temperature. After that, the starting material was recovered (without any changes) in 75% yield.

We have succeeded in elaborating an easy and rapid synthesis for both *v*-triazolopyrimidinium salts by cyclodehydrogenation of the appropriate arylhydrazones with TBB. The observation of extra bromination during the reaction and the successful avoiding of this bromination provides further information concerning the mechanism of cyclodehydrogenation which has not been entirely clarified as yet.

The study of some interesting reactions of these new heteroaromatic salts is in progress.

## EXPERIMENTAL

Melting points were determined by a Büchi apparatus and are uncorrected. IR spectra were recorded on Specord IR-75 equipment. The <sup>1</sup>H and <sup>13</sup>C nmr spectra were measured on Varian XL-100 and XL-400 instruments at ambient temperature using TMS as internal standard.

General Procedure for Synthesis of 2- and 4-Pyrimidyl Ketones **2a-d**, **5a-c**.

To the stirred solution of the 2- or 4-cyanopyrimidine derivative **1a,b** and **4a-c** (0.1 mole) in dry ether (100 ml) was dropped a solution of the appropriate Grignard reagent (0.15 mole) in dry ether (250 ml) at 0°. Stirring was continued for 2 hours at 0° and the reaction mixture was left in a refrigerator for a night. It was poured then on ice containing ammonium chloride (10 g) and the mixture was acidified with 20% sulfuric acid to pH = 1. After being shaken up several times, the mixture was neutralized with 20% sodium hydroxide solution. The layers were separated and the water was extracted with ether (3 x 50 ml). The combined extract was concentrated and the crude product was recrystallized from ethanol to give 2- and 4-pyrimidyl ketones **2a-d** and **5a-c**. (See Table 1 and 4).

General Procedure for Synthesis of 4-Bromophenylhydrazones of 2- and 4-Pyrimidyl Ketones **3a-e**, **6a-c**.

A solution of the 2- or 4-pyrimidyl ketones **2a-e**, **5a-c** (0.1 mole) in dry ethanol (250 ml) was refluxed with 4-bromo-phenylhydrazine hydrochloride (0.13 mole) and a few drops of ethanol saturated with hydrochloric acid for 3 hours [a]. The reaction mixture was cooled, mixed with 20% sodium hydroxide (40 ml) and water (400 ml) and then it was extracted with dichloromethane (3 x 60 ml). The extract was concentrated and the crude product was recrystallized from chloroform-ethanol to give **3a-e** and **6a-c**. See Table 3 and 4. [a] In the case of methoxy derivatives **2e** and **5c**, the reaction was performed at 65° for 1 hour. Prolonged heating resulted in the substitution of one of methoxy groups by 4-bromophenylhydrazine. The substituted product can be separated by column chromatography.

4,6-Dihydroxy-2-(4-chlorobenzyl)pyrimidine **9**.

To the stirred solution of **7** (13.2 g, 64 mmoles) in dry ethanol (100 ml), a solution of sodium (4 g, 175 mmoles) in dry ethanol (100 ml) was added dropwise first and then diethyl malonate (**8**,

11 g, 10.5 ml, 69 mmoles) was added. The reaction mixture was refluxed for 3 hours and it was allowed to stand at room temperature overnight, then concentrated to dryness. The residue was dissolved in water and acidified with concentrated hydrochloric acid. The crystals were filtered off, washed with water to give 12.8 g (80%) of white powder, mp >300°; ir (potassium bromide): 3350, 3000, 2850 cm<sup>-1</sup>.

*Anal.* Calcd. for C<sub>11</sub>H<sub>9</sub>ClN<sub>2</sub>O<sub>2</sub>: C, 55.83; H, 3.83; N, 11.84. Found: C, 55.67; H, 3.94; N, 11.73.

#### 4,6-Dichloro-2-(4-chlorobenzyl)pyrimidine **10**.

A stirred suspension of **9** (10.1 g, 51 mmoles) in phosphorus oxychloride (100 ml) was refluxed for 3 hours, then the excess of phosphorus oxychloride was evaporated *in vacuo*. The residue was poured onto ice, the precipitate was filtered off and recrystallized from ethanol to give 10.5 g (75%) of white prisms, mp 107-108°; ir (potassium bromide): 3010, 2870 cm<sup>-1</sup>; <sup>1</sup>H nmr (deuteriochloroform): δ 7.30 (s, 4H, 4-Cl-C<sub>6</sub>H<sub>4</sub>), 7.24 (s, 1H, H-5), 4.19 (s, 2H, CH<sub>2</sub>).

*Anal.* Calcd. for C<sub>11</sub>H<sub>7</sub>Cl<sub>3</sub>N<sub>2</sub>: C, 48.30; H, 2.58; N, 10.24. Found: C, 48.40; H, 2.69; N, 10.30.

#### 4,6-Dimethoxy-2-(4-chlorobenzyl)pyrimidine **11**.

To a stirred solution of sodium (3.5 g, 150 mmoles) in dry methanol (100 ml), chloro compound **10** (10.5 g, 38 mmoles) was added. Stirring was continued for 1 hour at room temperature. The reaction mixture was then concentrated and the residue was mixed with water (50 ml), filtered off and the crude product was recrystallized from ethanol to give 9.8 g (97%) of colorless prisms, mp 62-63°; ir (potassium bromide): 3000, 2920, 2880 cm<sup>-1</sup>; <sup>1</sup>H nmr (deuteriochloroform): δ 7.30 (m, 4H, 4-Cl-C<sub>6</sub>H<sub>4</sub>), 5.87 (s, 1H, H-5), 4.03 (s, 2H, CH<sub>2</sub>), 3.90 (s, 6H, OCH<sub>3</sub>).

*Anal.* Calcd. for C<sub>13</sub>H<sub>13</sub>ClN<sub>2</sub>O<sub>2</sub>: C, 58.98; H, 4.95; N, 10.58. Found: C, 59.10; H, 4.86; N, 10.43.

#### 4-Chlorophenyl 4,6-Dimethoxy-2-pyrimidyl Ketone **2e**.

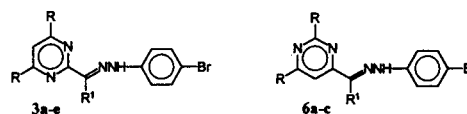
A solution of **11** (10 g, 38 mmoles) in acetic acid (40 ml) was added dropwise to a stirred solution of chromic anhydride (5.7 g, 57 mmoles) in a mixture of acetic acid (45 ml) and water (5 ml). Stirring was continued for 5 hours at 85°, water was then added and the mixture was neutralized with ammonium hydroxide and extracted with chloroform (3 x 50 ml). Evaporation and recrystallization from ethanol gave 7.8 g (74%) of colorless needles, mp 102-103°; ir (potassium bromide): 3020, 2910, 2890, 1675 cm<sup>-1</sup>; <sup>1</sup>H nmr (deuteriochloroform): δ 8.00 and 7.45 (AA'BB', 4H, 4-Cl-C<sub>6</sub>H<sub>4</sub>), 6.18 (s, 1H, H-5), 4.00 (s, 6H, OCH<sub>3</sub>).

*Anal.* Calcd. for C<sub>13</sub>H<sub>11</sub>ClN<sub>2</sub>O<sub>3</sub>: C, 56.02; H, 3.98; N, 10.05. Found: C, 55.86; H, 3.86; N, 9.87.

#### 4-Chlorophenyl 2-Pyrimidyl Ketone *N*-Methyl-*N*-phenylhydrazine **3f**.

A mixture of **2c** (2.19 g, 10 mmoles) and *N*-methyl-*N*-phenylhydrazine (1.83 g, 1.75 ml, 15 mmoles) in ethanol (22 ml) was refluxed with a saturated solution of hydrochloric acid in ethanol (5 ml) for 12 hours. The reaction mixture was concentrated to dryness, mixed with water (50 ml) and with 20% sodium hydroxide solution (10 ml) and extracted then with chloroform (3 x 20 ml). The extract was purified by column chromatography (silica gel, eluent, dichloromethane). The first (yellow) fraction was recrystallized from ethanol to give 1.56 g (48%) of yellow prisms, mp 103-105°; ir (potassium bromide): 3020, 2920, 2890, 1590, 1530,

**Table 3**  
Physical data of 2- and 4-pyrimidyl ketone 4-bromophenylhydrazones



No	Mp (°C)	Yield (%)	Analysis (Calcd./Found)			IR (KBr) (cm <sup>-1</sup> )	
			Formula (Mw)	C	H		N
<b>3a</b>	157-159	69	C <sub>12</sub> H <sub>11</sub> BrN <sub>4</sub> (291.17)	49.50 49.73	3.81 3.62	19.24 19.03	3210 3130
			<b>3b</b>	150-152	71	C <sub>17</sub> H <sub>13</sub> BrN <sub>4</sub> (353.24)	57.80 57.64
<b>3c</b>	143-145 [a] 163-164 [b]	83	C <sub>17</sub> H <sub>12</sub> BrClN <sub>4</sub> (387.69)	52.67 52.84	3.12 3.01	14.45 14.59	3260, 3130
			<b>3d</b>	154-156	75	C <sub>19</sub> H <sub>16</sub> BrClN <sub>4</sub> (415.74)	54.89 54.97
<b>3e</b>	175-177	67	C <sub>19</sub> H <sub>16</sub> BrClN <sub>4</sub> O <sub>2</sub> (447.74)	50.97 51.17	3.60 3.67	12.51 12.32	3090
<b>6a</b>	141-143	78	C <sub>17</sub> H <sub>12</sub> BrClN <sub>4</sub> (387.69)	52.67 52.83	3.13 3.31	14.45 14.31	3250
			<b>6b</b>	148-150	84	C <sub>19</sub> H <sub>16</sub> BrClN <sub>4</sub> (415.74)	54.89 55.04
<b>6c</b>	178-180	68	C <sub>19</sub> H <sub>16</sub> BrClN <sub>4</sub> O <sub>2</sub> (447.74)	50.97 50.75	3.60 3.78	12.51 12.34	3250

[a] Pure E isomer; [b] Pure Z isomer;

1480, 1400, 1290, 1090 cm<sup>-1</sup>; <sup>1</sup>H nmr (deuteriochloroform): δ 8.81 (d, J = 5.0 Hz, 2H, H-4,6), 7.39 and 7.32 (AA'BB', 4H, 4-Cl-C<sub>6</sub>H<sub>4</sub>), 7.30 (m, 4H, H-2,3,5,6 (phenyl)), 7.20 (t, J = 5.0 Hz, 1H, H-5), 6.97 (m, 1H, H-4 (phenyl)), 3.08 (s, 3H, CH<sub>3</sub>).

*Anal.* Calcd. for C<sub>18</sub>H<sub>15</sub>ClN<sub>4</sub>: C, 66.95; H, 4.64; N, 17.36. Found: C, 67.11; H, 4.74; N, 17.48.

#### 4-Chlorophenyl 2-Pyrimidyl Ketone *N*-Methyl-*N*-(4-bromophenyl)hydrazone **3g**.

##### Method A.

A solution of **3f** (0.32 g, 1 mmole) in dichloromethane (10 ml) was stirred with TBB (0.41 g, 1 mmole) at room temperature for 30 minutes. The reaction mixture was mixed with dichloromethane (15 ml) and extracted with 10% sodium hydroxide solution (3 x 5 ml) then with water (5 ml). The organic layer was dried on magnesium sulfate, filtered and evaporated to dryness. The residue was recrystallized from ethanol to give 0.22 g (60%) of yellow prisms, mp 109-111°; ir (potassium bromide): 3020, 2900, 1570, 1530, 1480, 1390, 1290, 1080 cm<sup>-1</sup>; <sup>1</sup>H nmr (deuteriochloroform): δ 8.78 (d, J = 5.0 Hz, 2H, H-4,6), 7.42 and 7.33 (AA'BB', 4H, 4-Cl-C<sub>6</sub>H<sub>4</sub>), 7.39 and 7.18 (AA'BB', 4H, 4-Br-C<sub>6</sub>H<sub>4</sub>), 7.24 (t, J = 5.0 Hz, 1H, H-5), 3.02 (s, 3H, CH<sub>3</sub>).

*Anal.* Calcd. for C<sub>18</sub>H<sub>14</sub>BrClN<sub>4</sub>: C, 53.82; H, 3.51; N, 13.95. Found: C, 53.86; H, 3.45; N, 13.84.

##### Method B.

A suspension of 4-chlorophenyl 2-pyrimidyl ketone (4-bromophenyl)hydrazone (**3c**, 1.16 g, 3 mmoles) in dry DMF (10 ml) was stirred with 50% dispersion of sodium hydride in oil (0.15 g, 3.5 mmoles) at room temperature for 30 minutes, then methyl iodide (0.45 g, 0.2 ml, 3.2 mmoles) was added and stirring was continued for 2 hours. After standing at room temperature overnight, water (50 ml) was added and the mixture was extracted with chloroform (3 x 15 ml). The combined extract was washed with water (4 x 20 ml), dried over magnesium sulfate, filtered and evaporated. The

residue was recrystallized from 96% ethanol (5 ml) to give 1.0 g (83%) of yellow prisms, mp 109-111°. The product was identical with that obtained by Method A.

Reaction of 4-Chlorophenyl 2-Pyrimidyl Ketone *N*-Methyl-*N*-(4-bromophenyl)hydrazine (**3f**) with TBB. Formation of 4-Chlorophenyl 2-Pyrimidyl Ketone *N*-Methyl-*N*-(2,4-dibromophenyl)hydrazine **15** and 3-Bromo-4-chlorophenyl 2-Pyrimidyl Ketone *N*-Methyl-*N*-(4-bromophenyl)hydrazine **16**.

#### Method A.

A solution of **3g** (0.2 g, 0.5 mmole) in dichloromethane (5 ml) was stirred with TBB (0.21 g, 0.5 mmole) at room temperature for 30 minutes. The reaction mixture was extracted with saturated solution of sodium carbonate (2 x 3 ml) and water (3 x 3 ml), dried over magnesium sulfate, filtered and evaporated. The residue was separated by column chromatography on silica gel.

The elution by dichloromethane gave 90 mg (37%) of pale yellow crystals of **15**, mp 86-88° (petroleum ether); ir (potassium bromide): 3100, 3050, 3010, 2970, 2900, 1590, 1550, 1480, 1455, 1410, 1390 cm<sup>-1</sup>; <sup>1</sup>H nmr (deuteriochloroform): δ 8.66 (d, J<sub>4,5</sub> and J<sub>5,6</sub> = 5.0 Hz, 2H, H-4,6), 7.44 and 7.27 (AA'BB', 4H, 4-Cl-C<sub>6</sub>H<sub>4</sub>), 7.42 (d, J<sub>3,5</sub> = 2.5 Hz, 1H, H-3' (2,4-dibromophenyl)), 7.23 (dd, J<sub>3,5</sub> = 2.5 Hz, J<sub>5,6</sub> = 8.8 Hz, 1H, H-5'), 7.15 (d, J<sub>5,6</sub> = 8.8 Hz, 1H, H-6'), 7.07 (t, J = 5.0 Hz, H-5), 3.23 (s, 3H, CH<sub>3</sub>) ppm.

Anal. Calcd. for C<sub>18</sub>H<sub>13</sub>Br<sub>2</sub>ClN<sub>4</sub>: C, 44.98; H, 2.73; N, 7.38. Found: C, 45.12; H, 2.69; N, 7.45.

The elution with a mixture of dichloromethane:ethanol = 95:5 gave 60 mg (25%) of pale yellow crystals of **16**, mp 146-148° (ethanol); ir (potassium bromide): 3070, 3000, 2980, 2940, 1590, 1565, 1545, 1480, 1460, 1430, 1410, 1400 cm<sup>-1</sup>; <sup>1</sup>H nmr (deuteriochloroform): δ 8.76 (d, J<sub>4,5</sub> and J<sub>5,6</sub> = 5.0 Hz, 2H, H-4,6), 7.49 (d, J<sub>2,6</sub> = 2.2 Hz, 1H, H-2'), 7.23 (dd, J<sub>2,6</sub> = 2.2 Hz, J<sub>5,6</sub> = 8.5 Hz, 1H, H-6'), 7.22-7.17 (m, 4H, H-5,5' and AA'(4-Br-C<sub>6</sub>H<sub>4</sub>)), 7.14 (BB', 2H, 4-Br-C<sub>6</sub>H<sub>4</sub>), 3.32 (s, 3H, CH<sub>3</sub>) ppm.

Anal. Calcd. for C<sub>18</sub>H<sub>13</sub>Br<sub>2</sub>ClN<sub>4</sub>: C, 44.98; H, 2.73; N, 7.38. Found: C, 45.07; H, 2.84; N, 7.32.

#### Method B.

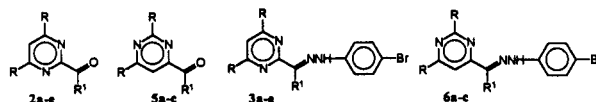
The above reaction was carried out under the same conditions with the use of potassium carbonate (0.14 g, 1 mmole) to give after chromatography 120 mg (50%) of **15** and 40 mg (17%) of **16**.

General Procedure for Cyclization of 2- and 4-Pyrimidyl Ketone 4-Bromophenylhydrazones. Synthesis of 1-(4-Bromophenyl)-3,5,7-substituted-*v*-triazolo[1,5-*a*]pyrimidinium Salts **12a-e** and 1-(4-Bromophenyl)-3,5,7-substituted-*v*-triazolo[1,5-*c*]pyrimidinium Salts **13a-c**.

Into a stirred and ice-cooled solution of **3a-e**, **6a-c** (5 mmoles) in dry dichloromethane (20 ml) was dropped a solution of TBB (6.15 g, 15 mmoles) in dry dichloromethane (90 ml) [a][b][c] in an inert atmosphere. Stirring was continued at 0° for 30 minutes, then the reaction mixture was concentrated to a volume of 20 ml and mixed with dry ether (50 ml). The precipitated crystals were filtered off to give perbromide salts **12a-e** and **13a-c** (A = Br<sub>3</sub>). (see Tables 2 and 5). [a] In the case of **3a-c**, a solution of 8.2 g (20 mmoles) of TBB in 120 ml of dichloromethane. [b] In the case of **3d**, the solution of TBB was added dropwise very slowly (approximately within 2 hours) to avoid the bromination of the methyl

groups. [c] To the stirred suspension of hydrazone **6c** in dry dichloromethane was added crystalline TBB one portion at -15°.

**Table 4**  
<sup>1</sup>H nmr spectra of 2- and 4-pyrimidyl ketones **2a-e**, **5a-c** and their 4-bromophenylhydrazones **3a-e**, **6a-c** [a]



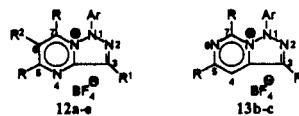
No	2-R	4-R	H-5	6-R	R <sup>1</sup>	Ar
<b>2a</b>	--	8.96 (d)	7.50 (t)	8.96 (d)	2.87 (s)	--
<b>2b</b>	--	8.94 (d)	7.7-7.4 (m)	8.94 (d)	7.7-7.4 (m)	--
<b>2c</b>	--	8.93 (d)	7.47 (t)	8.93 (d)	8.0, 7.5 [b]	--
<b>2d</b>	--	2.62 (s)	7.23 (s)	2.62 (s)	8.1, 7.5 [b]	--
<b>2e</b>	--	4.0 (s)	6.18 (s)	4.0 (s)	8.0, 7.5 [b]	--
<b>5a</b>	9.48 (s)	--	8.01 (s)	9.11 (d)	8.2, 7.5 [b]	--
<b>5b</b>	2.62 (s)	--	7.52 (s)	2.79 (s)	8.1, 7.5 [b]	--
<b>5c</b>	4.07 (s)	--	6.97 (s)	4.07 (s)	8.2, 7.5 [b]	--
<b>3a</b>	--	8.87 (d)	7.21 (t)	8.87 (d)	2.49 (s)	7.4, 7.1 [b]
<b>3b</b>	--	8.89 (d)	7.7-7.0 (m)	8.89 (d)	7.70	7.00 (m)
<b>3c</b> [c]	--	8.86 (d)	7.23 (t)	8.86 (d)	7.7, 7.4 [b]	7.4, 7.2 [b]
<b>3c</b> [d]	--	8.77 (d)	7.13 (t)	8.77 (d)	7.6, 7.3 [b]	7.4, 7.1 [b]
<b>3d</b>	--	2.54 [e]	8.0-6.9 (m)	2.54 [e]	8.0	6.9 (m)
			2.47			
<b>3e</b>	--	3.94 (s)	6.03 (s)	3.94 (s)	7.7, 7.3 [b]	7.4, 7.1 [b]
<b>6a</b>	9.61 (s)	--	7.28 (d)	8.81 (d)	7.49 (s)	7.5, 7.2 [b]
<b>6b</b>	2.43 (s)	--	6.89 (s)	2.79 (s)	7.43 (s)	7.4, 7.1 [b]
<b>6c</b>	4.16 [e]	--	6.32 (s)	4.06 [e]	7.6	7.0 (m)
	4.06			3.86		

[a] Solvent: deuteriochloroform; [b] AA'BB'; [c] Z-isomer (δ<sub>NH</sub> = 13.3 ppm); [d] E-isomer (δ<sub>NH</sub> = 7.9 ppm); [e] Two possible isomers.

#### General Procedure for Preparation of Fluoborate Salts **12a-e**, **13b,c** (A = BF<sub>4</sub>).

To the solution of the appropriate perbromide salt **12a-e** and **13b,c** (5 mmoles) in dry nitromethane (20 ml), cyclohexene (0.62 g, 0.76 ml, 7.5 mmoles) was added at room temperature [a]. The reaction mixture was stirred for 1 hour then silver fluoborate (0.97 g, 5 mmoles) was added and stirring was continued for 30 minutes. The reaction mixture was filtered, the mother liquor was mixed with dry ether (100 ml), then filtered off and the crude product was recrystallized from dry acetonitrile-dry ether (see Tables 2 and 5). [a] In the case of **13c** (A = Br<sub>3</sub>), 2.91 g (15 mmoles) of silver fluoborate was added to the solution, without use of cyclohexene.

**Table 5**  
<sup>1</sup>H nmr spectra of *v*-triazolo[1,5-*a*]pyrimidinium **12a-e** and *v*-triazolo[1,5-*c*]pyrimidinium fluoborate salts **13a-c** [a]



No	H-4	5-R	H-6	7-R	R <sup>1</sup>	Ar
<b>12a</b>	--	9.42 (d)	--	9.56 (d)	2.92 (s)	8.1, 7.8 [c]
<b>12b</b> [b]	--	9.41 (d)	--	9.54 (d)	8.5, 7.6 [c]	8.05, 7.7 [c]
<b>12c</b>	--	9.42 (d)	--	9.53 (d)	8.4, 7.7 [c]	8.0, 7.6 [c]
<b>12d</b> [b]	--	2.98 (s)	7.70 (s)	2.54 (s)	8.55, 7.6 [c]	7.95, 7.6 [c]
<b>12e</b>	--	4.11 (s)	6.84 (s)	4.37 (s)	8.5, 7.7 [c]	7.9, 7.7 [c]
<b>13b</b> [b]	8.75 (s)	3.12 (s)	--	2.94 (s)	8.58, 7.6 [c]	7.9, 7.6 [c]
<b>13c</b>	7.76 (s)	4.27 (s)	--	4.18 (s)	7.73 (m)	7.9, 7.6 [c]

[a] Solvent: dry deuterioacetonitrile; [b] Solvent: trifluoroacetic acid; [c] AA'BB'

1-(4-Bromophenyl)-3-(4-chlorophenyl)-*v*-triazolo[1,5-*a*]pyrimidinium Bromide **12f** (A = Br) and Fluoborate **12f** (A = BF<sub>4</sub>).

To a stirred solution of **3c** (3.88 g, 10 mmoles) in dry dichloromethane (50 ml) was dropped a solution of TBB (4.1 g, 10 mmoles) in dry dichloromethane (150 ml) at room temperature (within 3 hours). The separated crystals were filtered off, washed with dichloromethane and diethyl ether to give 3.4 g (73%) of pale yellow crystals, mp 233-235°.

This bromide salt (**12f**, R = R<sub>2</sub> = H, A = Br) was converted in fluoborate salt as follows: a suspension of bromide salt **12f** (1.16 g, 2.5 mmoles) in nitromethane (10 ml) was stirred at room temperature with silver fluoborate (0.5 g, 2.5 mmoles) for 15 minutes. The reaction mixture was filtered, washed with nitromethane and the mother liquor was evaporated *in vacuo* to dryness. The residue was recrystallized from acetonitrile-diethyl ether to give 0.95 g (81%) of colorless needles, mp 242-244°; ir (potassium bromide): 3080, 1605, 1595, 1540, 1520, 1480, 1450, 1410, 1370, 1050 cm<sup>-1</sup>; <sup>1</sup>H nmr (acetonitrile-d<sub>3</sub>): δ 9.43 (dd, J<sub>5,7</sub> = 1.7 Hz, J<sub>6,7</sub> = 4.6 Hz, 1H, H-7), 9.31 (dd, J<sub>5,7</sub> = 1.7 Hz, J<sub>5,6</sub> = 7.5 Hz, 1H, H-5), 8.43 and 7.71 (AA'BB', 4H, 4-Br-C<sub>6</sub>H<sub>4</sub>), 8.02 and 7.78 (AA'BB', 4H, 4-Cl-C<sub>6</sub>H<sub>4</sub>), 8.02 (dd, J<sub>5,6</sub> = 7.5 Hz, J<sub>6,7</sub> = 4.7 Hz, 1H, H-6) ppm.

Anal. Calcd. for C<sub>17</sub>H<sub>11</sub>BBrClF<sub>4</sub>N<sub>4</sub>: C, 43.12; H, 2.34; N, 11.83. Found: C, 42.96; H, 2.27; N, 11.67.

Attempted Reaction of 1-(4-Bromophenyl)-3-(4-chlorophenyl)-*v*-triazolo[1,5-*a*]pyrimidinium Fluoborate (**12f**) with TBB.

A solution of **12f** (A = BF<sub>4</sub>) (0.24 g, 0.5 mmole) in a mixture of dry dichloromethane (10 ml) and dry acetonitrile (10 ml) was stirred with TBB (0.62 g, 1.5 mmoles) at room temperature for 16 hours. The solvent was evaporated *in vacuo*, the residue was suspended in dichloromethane (20 ml) and mixed with diethyl ether (20 ml). The precipitated crystals were filtered, washed with dichloromethane and diethyl ether to give 0.18 g (75%) of colorless crystals, which were identical with the starting material **12f** (A = BF<sub>4</sub>).

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