Studies on the Reaction of α-Chloroformylarylhydrazine Hydrochloride[1] with N-heterocyclic Compounds

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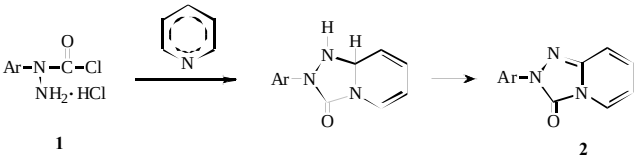
In addition to pyridines, α-chloroformylarylhydrazine hydrochloride **1** can also react with some N-heterocyclic compounds. The cycloaddition of **1** with isoquinoline was achieved to obtain **3**. The production of **4**, **5**, **6** given by cycloaddition of **1** with pyridazine was dependent on the reaction condition. Some heterocyclic compounds bearing an X-C=N (X:S, N) group on the ring can react with **1** to gain the derivatives of 2,4-dihydro-1,2,4-triazol-3-one. **7**, **8**, **9** and **10** were given by reaction of **1** with 1,3,5-triazine, 1,4,5,6-tetrahydropyrimidine, 1,3-thiazole and 2-amino-1,3-thiazole, respectively. The reactions for 2-amino-1,3,4-thiadiazole and 3-amino-1,2,4-triazole had the same product **11**.

INTRODUCTION

α-Chloroformylarylhydrazine hydrochloride[1] **1** developed by our lab was an active compound possessing both amino and chloroformyl groups. Many heterocyclic compounds exhibiting biological and pharmacological activities could be synthesized through **1**. In our past research,[2] **1** reacted with pyridines to give 2-aryl-2*H*-[1,2,4]triazolo[4,3-*a*]pyridin-3-ones **2** (Scheme I). It was reported that heterocyclic compounds bearing 2,4-dihydro-1,2,4-triazol-3-one exhibited various medical properties.[3,4,6] Most of these compounds are applied as insecticides.[5] Since the cycloadditon reaction of **1** with pyridines was done with a good yield under mild conditions, we thought the reaction for some other aromatic compounds bearing the C=N group could also take place in such a reaction system. Focusing on this aspect, it was very interesting to study the reaction of **1** with many other N-heterocyclic compounds. In this paper, we proceeded with the cycloaddition of **1** with many N-heterocyclic compounds including six-member and five-member rings.

Scheme I



1 **2**

RESULTS AND DISCUSSION

Reaction of α-chloroformylarylhydrazine hydrochloride **1** with:

A. isoquinoline

Compound **1** reacted with isoquinoline at 80 °C under an open system and when the reaction was completed, we found only one major compound was obtained. The structure of this product was ascertained as 2-aryl-2*H*-[1,2,4]triazolo-[3,4-*a*]isoquinolin-3-one **3** shown in Fig. 1 by X-ray spectrum analysis. According to this result, we found the reaction was a cycloaddition reaction which was similar to that of **1**

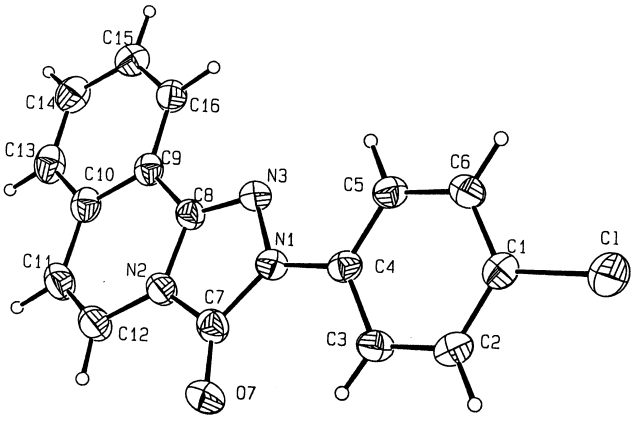
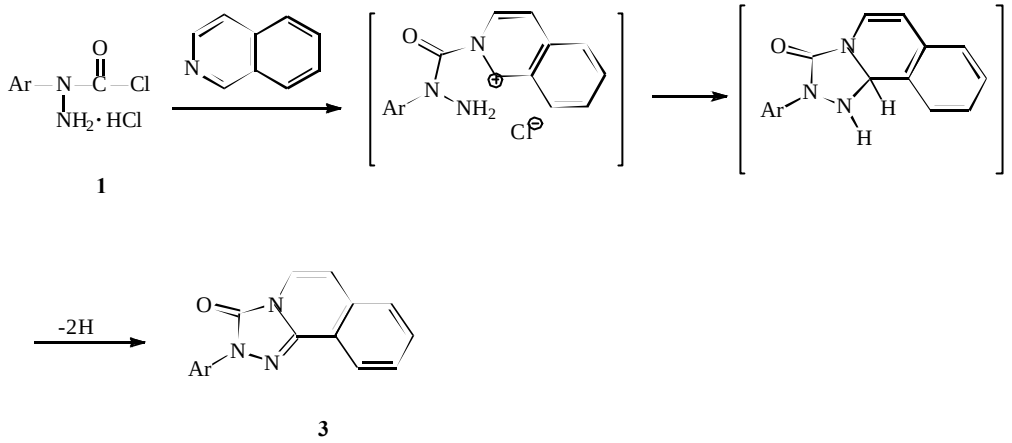


Fig. 1. Molecular structure of 2-(*p*-chlorophenyl)-2*H*-[1,2,4]triazolo[4,3-*b*]isoquinolin-3-one **3c**.

Scheme II



with pyridine and the cycloaddition reaction site was at the number 1 carbon of isoquinoline, but not at the number 3 carbon (Scheme II). This reaction selectivity for isoquinoline agreed with those reported in most other reactions. The yield of this reaction is demonstrated in Table 1.

B. Pyridazine

The products of cycloaddition reaction of **1** with pyridazine were dependent on reaction conditions. Under the first condition: 25°C, low ratio of pyridazine (pyridazine/**1** = 1:1), adding tributylamine and using *i*PrOH as reaction solvent, **1a** and **1b** could be converted to 2,7-diaryl-2,3,3a,5a,6,7-hexahydro-[1,2,4]triazolo[4,3-*a*]pyridin-3-ones **5**; but under the same conditions, 2-(*p*-chlorophenyl)-2,8a-dihydro-1*H*-[1,2,4]-triazolo[4,3-*b*]pyridazin-3-one **4c** was produced from **1c**. The structures of **4c** and **5a** were confirmed by X-ray spectrum analysis (Fig. 2, Fig. 3). Under the second condition: the same as the first condition but with a high ratio of pyridazine (pyridazine/**1** = 5:1) and in absence of tributylamine, only **4c** was isolated. Under the third condition: the same as the second condition but at higher temperature (60 °C), 2-aryl-2*H*-[1,2,4]triazolo[4,3-*b*]pyridazin-3-one **6** was given by **1a**, **1b** and **1c**. The yield of all reactions is shown in Table 2. The above reaction routes demonstrated in Scheme III could suggest that **1** reacted with pyridazine to produce **4** at first and then **4** underwent cycloaddition reaction with the second molecule **1** to obtain **5** or dehydrogenation to gain **6**. Therefore, when lowering the concentration of pyridazine in reactant mixtures, it was advantageous for **1** to proceed to two times cycloaddition with one pyridazine molecule to obtain **5**. Because **4c** was difficult to dissolve in reaction solvent *i*PrOH, cycloaddition reaction of **1c** with pyridazine was stopped on **4c** under the first condition. **4** obtained from one

Table 1. Reaction of **1** with Isoquinoline

Product	Ar	Yield/ %
3a	C_6H_5	76
3b	p-$CH_3C_6H_4$	82
3c	p-ClC_6H_4	81

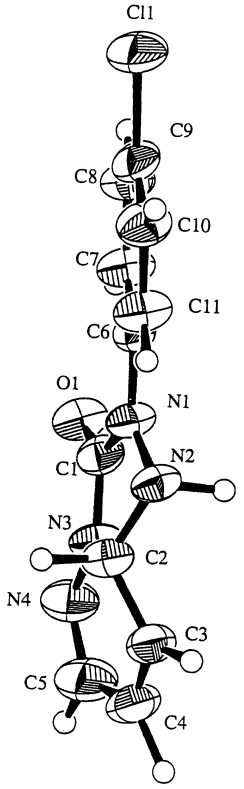


Fig. 2. Molecular structure of 2-(*p*-chlorophenyl)-2,8a-dihydro-1*H*-[1,2,4]triazolo[4,3-*b*]pyridazin-3-one **4c**.

Scheme III

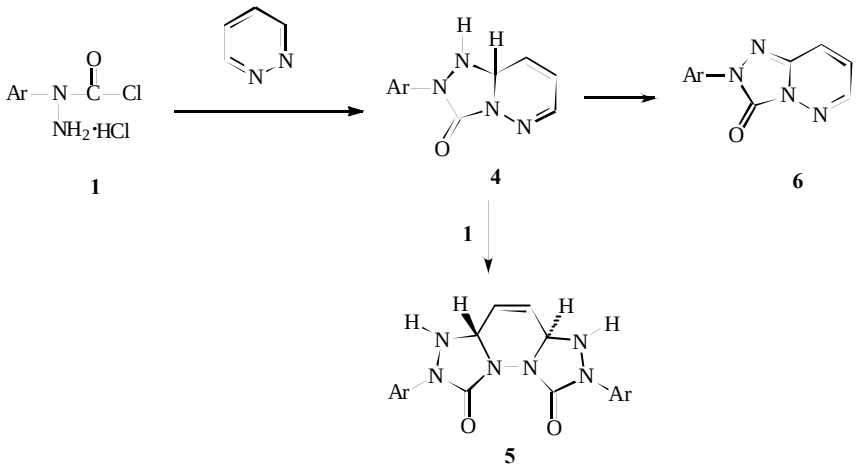


Table 2. Reaction of **1** with Pyridazine

Product	Ar	25 °C, **1**/ pyridazine = 1:1 Yield/%	25 °C, **1**/ pyridazine = 1:5 Yield/%	60 °C, **1**/ pyridazine = 1:5 Yield/%
4c	*p*-ClC_6H_4	80	85	-----
5a	C_6H_5	57	-----	-----
5b	*p*-$CH_3C_6H_4$	24	-----	-----
6a	C_6H_5	-----	-----	64
6b	*p*-$CH_3C_6H_4$	-----	-----	72
6c	*p*-ClC_6H_4	-----	-----	78

cycloaddition reaction was favored by enhancing the concentration of pyridazine in reactant mixtures; but **4a** and **4b** could not be isolated easily, because their solubility in water was too good to be separated from pyridazine. When enhancing the temperature and the concentration of pyridazine, **6** was produced through one cycloaddition and then dehydrogenation from intermediate **4**. This synthetic route could become true by converting **4c** to **6c** at a higher temperature (60 °C) and the yield obtained was ninety two percents.

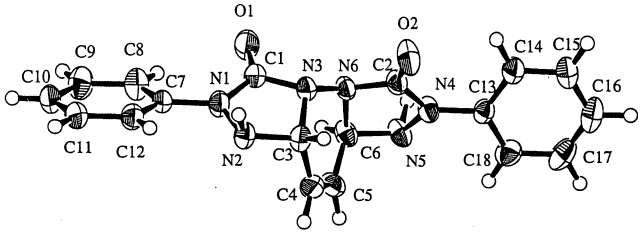


Fig. 3. Molecular structure of 2,7-diphenyl-2,3,3a,5a,6,7-hexahydro-2,3,6,7,8a,8b-hexaaza-as-indacene-1,8-dione **5a**.

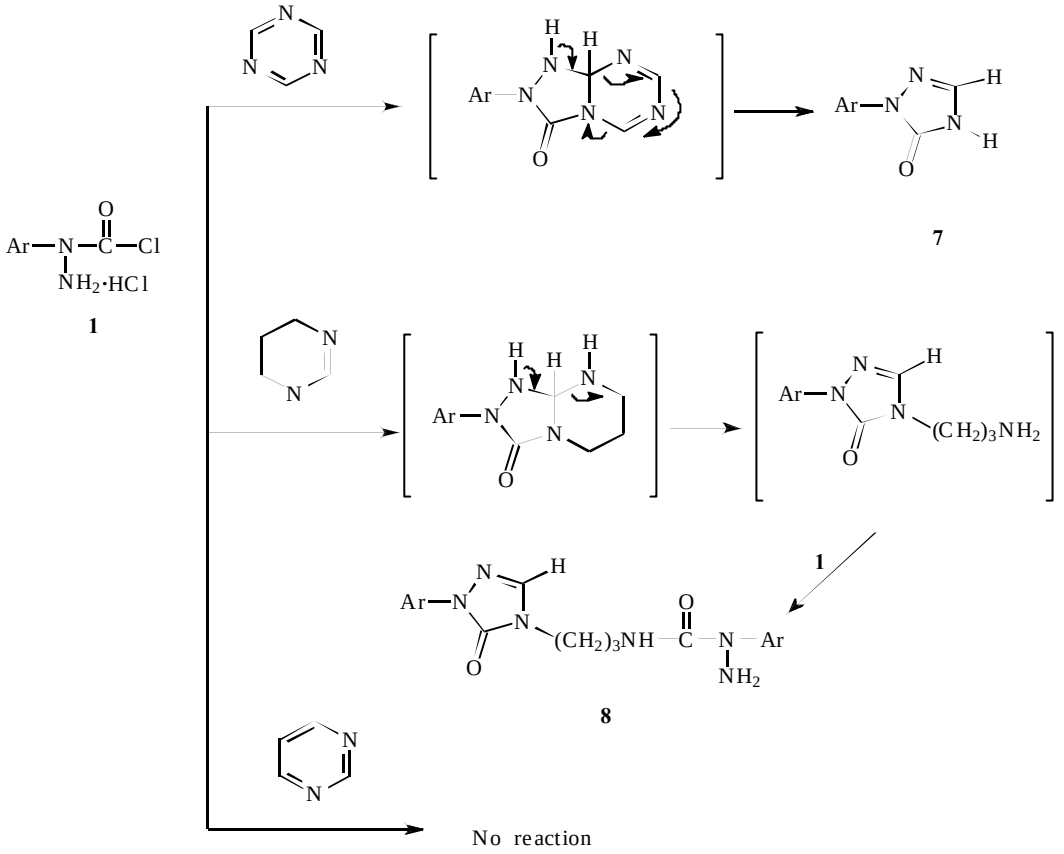
C. 1,3,5-triazine

Using isopropyl alcohol as reaction solvent, **1** was stirred with 1,3,5-triazine at room temperature. When the reaction was completed, the reaction mixture was poured into ice water and the precipitate obtained was analyzed by elemental analysis, ^{1}H NMR and MASS spectrum analysis. We found this compound could be ascertained as 2-aryl-2,4-dihydro-1,2,4-triazol-3-one **7** by comparing it with the spectrum of the same compound which had been reported.[7-8] This result was not expected for us because of the difference from the above two reactions. The reaction route shown in Scheme IV, we thought, was that the cycloaddition of **1** with 1,3,5-triazine was done first and then the 1,3,5-triazine ring of cycloadduct was broken into **7**.

D. 1,4,5,6-tetrahydropyrimidine

When the above suggested reaction route was investigated, it was an interesting guess that the reactions for

Scheme IV



N-heterocyclic com pounds pos sess ing an N-C=N group were in volved in the ring-opening of a cycloadduct in ter me di ate. Therefore, 1,4,5,6-tetrahydropyrimidine which possesses one N-C=N group was tested to re act with **1** at 60 °C in the pres ence of tributylamine. The ma jor prod uct was iso lated and con firmed as 4-[3-(2-aryl-2,4-dihydro-1,2,4-triazol-3-on-4-yl)propyl]-2-arylsemicarbazide **8**. Ac cord ing to the struc ture of **8**, the re ac tion route could be guessed as shown in Scheme IV and, we found, was also in volved in the ring-opening of the cycloadduct in ter me di ate. For an other test for py rim i dine, the an tic i pated re sult was not found. The rea son, we thought, might be that the ba sic ity of py rim i dine was too weak for this re ac tion sys tem to pro ceed to cycloaddition with **1**.

The re sults of the above re ac tions cre ated more in ter est in the re ac tion of **1** with other heterocyclic com pounds pos-sess ing an X-C=N (X:S, N) group on the ring. In this study, we searched for some five-member heterocyclic com pounds bear ing X-C=N (X:S, N) group to un dergo re ac tion with **1**.

E. 1,3-thiazole

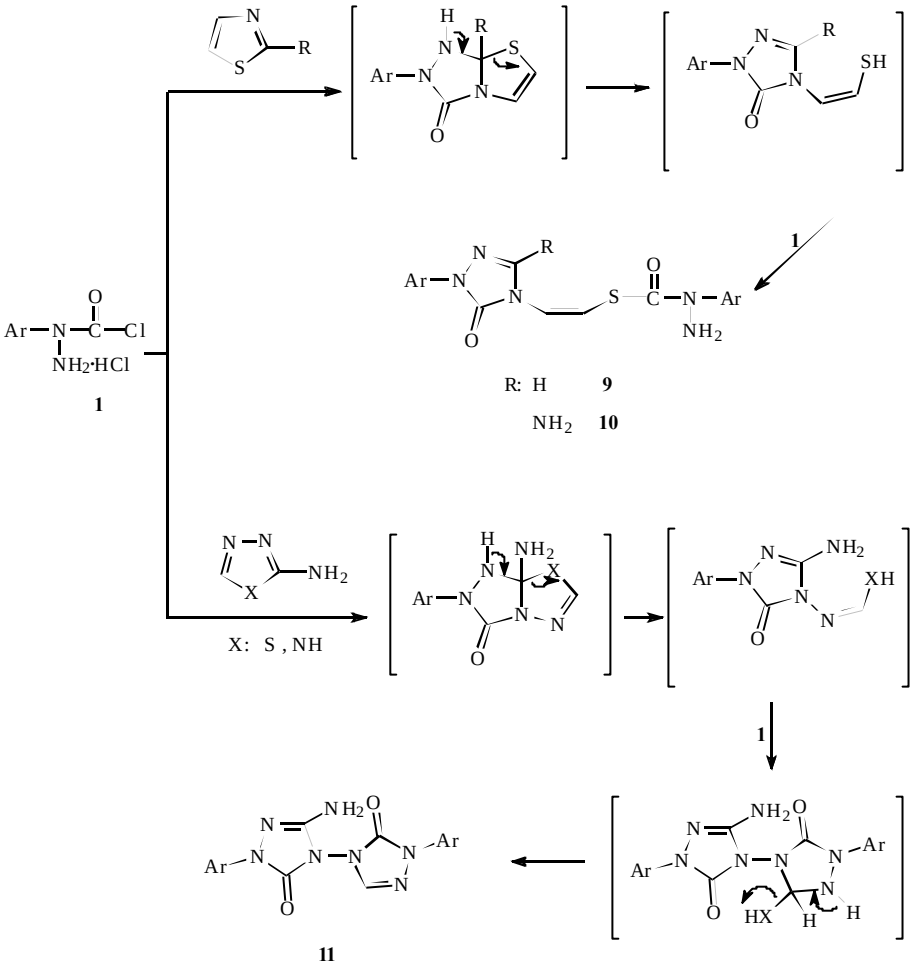
1 was stirred with 1,3-thiazole at a ratio of 1/3 in isopropyl al co hol at 0 °C for 30 min utes. The mix ture was poured into ice wa ter and the pre cip i tate recrystalized from THF + isopropyl al co hol was iden ti fied as (1-arylhydrazino) carboxylic acid (2-(2-aryl-2,4-dihydro-1,2,4-triazol- 3-on-4-yl)vinyl)thiolate **9** by el e men tal anal y sis, ^{1}H NMR and MASS spec trum anal y sis. The pro posed re ac tion route dem-on strated in Scheme V re sem bled that for 1,4,5,6-tetra hy-dropyrimidine. As a sul fur atom has better nucleophility, the sec ond in ter me di ate in which the cycloadduct in ter me di ate was bro ken into also un der went nucleophilic re ac tion with **1**.

F. 2-amino-1,3-thiazole

Fol low ing the above re ac tion steps but at room tem per-a ture, we could ob tain (1-arylhydrazino) carboxylic acid (2-(2-aryl-4-amino-2,4-dihydro-1,2,4-triazol-3-on-4-yl)vinyl)-thiolate **10**. This re sult was sur pris ing be cause the amino group of 2-amino-1,3-thiazole was re tained over the re ac tion. The rea son why the re ac tion took place in the C=N not the NH_2 group, we thought, was that the ni tro gen atom of the C=N group which ac cepted the res o nance ef fect of the amino group was more ba sic than that of the amino group.

G. 2-amino-1,3,4-thiadiazole

Scheme V



2-Amino-1,3,4-thiadiazole whose structure was similar to 2-amino-1,3-thiazole was tested to react with **1** by the same reaction steps. The isolated product was verified as 5-amino-bis(2-aryl-2,4-dihydro-1,2,4-triazol-3-on-4-yl) **11** by elemental analysis, ^{1}H NMR and MASS spectrum analysis. This result was different from that for 2-amino-1,3-thiazole. As the proposed synthetic route (Scheme V) indicated, the second intermediate underwent cycloaddition but not nucleophilic substitution with the second molecule **1**.

H. 3-amino-1,2,4-triazole

3-Amino-1,2,4-triazole, another compound resembling 2-amino-1,3,4-thiadiazole in structure, was chosen to react with **1**. The obtained product was the same as **11**. According to this result, we thought this reaction followed the same reaction route as that for 2-amino-1,3,4-thiadiazole (Scheme V). The yields of the reactions for 1,3,5-triazine, 1,4,5,6-tetrahydropyrimidine, 1,3-thiazole, 2-amino-1,3-thiazole, 2-amino-1,3,4-thiadiazole and 3-amino-1,2,4-triazole are demonstrated in Table 3.

Table 3. Reaction of **1** with 1,3,5-Triazine (A); 1,4,5,6-Tetrahydropyrimidine (B); 1,3-Thiazole (C); 2-Amino-1,3-thiazole (D); 2-Amino-1,3,4-thiadiazole (E); 3-Amino-1,2,4-triazole (F)

Product	Ar	Reagent	Yield/%
7a	C_6H_5	A	87
7b	*p*-$CH_3C_6H_4$	A	84
7c	*p*-ClC_6H_4	A	88
8a	C_6H_5	B	72
8b	*p*-$CH_3C_6H_4$	B	78
8c	*p*-ClC_6H_4	B	77
9a	C_6H_5	C	88
9b	*p*-ClC_6H_4	C	92
10a	*p*-$CH_3C_6H_4$	D	85
10b	*p*-ClC_6H_4	D	91
11a	C_6H_5	E	78
11b	*p*-$CH_3C_6H_4$	E	84
11c	*p*-ClC_6H_4	E	73
11a	C_6H_5	F	67
11b	*p*-$CH_3C_6H_4$	F	65
11c	*p*-ClC_6H_4	F	54

CONCLUSION

In addition to pyridines, α-chloroformylarylhydrazine hydrochloride **1** can also react with some N-heterocyclic compounds. **3** was obtained through cycloaddition of **1** with isoquinoline. According to the structure of **3** analyzed by X-ray spectrum, the reaction site of isoquinoline was at the number 1 carbon which agreed with most other reactions. The production of **4**, **5**, **6** given by cycloaddition of **1** with pyridazine was dependent on the reaction conditions. **4** was favored at lower temperatures and a high ratio of pyridazine. **5** was obtained at lower temperatures and ratio of pyridazine. **6** was given at higher temperatures and ratio of pyridazine, and also obtained through **4** by enchancing the temperature. Some heterocyclic compounds bearing a X-C=N (X:S, N) group on the ring could react with **1** to gain the derivatives of 2,4-dihydro-1,2,4-triazol-3-one. **7**, **8**, **9** and **10** were given by reaction of **1** with 1,3,5-triazine, 1,4,5,6-tetrahydropyrimidine, 1,3-thiazole and 2-amino-1,3-thiazole, respectively. The reactions for 2-amino-1,3,4-thiadiazole and 3-amino- 1,2,4-triazole had the same product **11**.

EXPERIMENTAL SECTION

General

Melting points (Buchi 535 apparatus) are uncorrected. IR spectra were recorded on a Hitachi 270-30 infrared spectrophotometer. NMR spectra were measured on a Bruker AMX-200 NMR spectrometer with tetramethylsilane as internal standard. The mass spectra were registered on a Finnigan MAT TSQ-46C spectrometer at an ionizing potential of 70 eV. Elemental analyses were performed on Heraeus CHN-O-Rapid and Tacussel Coulomax 78 analyzers. X-ray analyses were made with a Nonius CAD-4 diffractometer. Column chromatography was carried out on silica gel (Kieselgel 100, 70-230 mesh, E. Merck).

Synthesis of 3 from Cycloaddition of 1 with Isoquinoline

Isoquinoline was heated to melting in hot water and then the molten liquid (6 mL) was stirred with 0.6 g (2.9 mmol) **1a** at 80 °C under an open system for 2 hours. The reaction mixture was poured into a 100 mL HCl solution (HCl/H_2O:1/10 V/V). The precipitate was recrystalized from THF + EtOAc to obtain **3a**. According to this procedure, cycloaddition reaction of various forms of **1** with isoquinoline was achieved.

2-Phenyl-2*H*-[1,2,4]triazolo[3,4-*a*]isoquinolin-3-one (**3a**): colorless needles; mp 139-139.5 °C; IR (KBr) 1703 cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.28-6.98 (m, 11H); EIMS (70 eV) *m/z*: 261 (M^+, 40), 204 (23), 190 (12), 111 (25), 91 (100), 77 (69). Anal. Calcd for $C_{16}H_{11}N_3O$: C, 73.56; H, 4.21; N, 16.09. Found: C, 73.50; H, 4.23; N, 16.01.

2-(*p*-Methylphenyl)-2*H*-[1,2,4]triazolo[3,4-*a*]isoquinolin-3-one (**3b**): colorless needles; mp 152-153 °C; IR (KBr) 1705 cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.28-6.98 (m, 10H), 2.33 (s, 3H); EIMS (70 eV) *m/z*: 275 (M^+, 100), 218 (20), 204 (10), 128 (23), 91 (42). Anal. Calcd for $C_{17}H_{13}N_3O$: C, 74.18; H, 4.72; N, 15.27. Found: C, 74.15; H, 4.70; N, 15.31.

2-(*p*-Chlorophenyl)-2*H*-[1,2,4]triazolo[3,4-*a*]isoquinolin-3-one (**3c**): colorless needles; mp 183-183.5°C; IR (KBr) 1708 cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.29-6.99 (m, 10H); EIMS (70 eV) *m/z*: 297 (M^++2, 31), 295 (M^+, 100), 240 (6), 238 (18), 128 (37), 111 (35). Anal. Calcd for $C_{16}H_{10}ClN_3O$: C, 64.98; H, 3.41; Cl, 11.9; N, 14.21. Found: C, 65.04; H, 3.37; Cl, 11.92; N, 14.24.

Synthesis of 4, 5, 6 from Cycloaddition of 1 with Pyridazine

Synthesis of 4

0.6 g (2.48 mmol) **1c** and 0.25 g (2.48 mmol) pyridazine were dissolved in 6 mL isopropyl alcohol and then 0.5 mL n-Bu_3N was added in an ice bath. The mixture was stirred at room temperature for 1 hour and then was poured into 150 mL of ice water. The precipitate was dried and recrystalized from EtOAc + THF to obtain **4c**.

2-(*p*-Chlorophenyl)-2,8a-dihydro-1*H*-[1,2,4]triazolo-[4,3-*b*]pyridazin-3-one (**4c**): colorless needles; mp 210-210.5 °C; IR (KBr) 3190, 1716 cm^{-1}; ^1H NMR (DMSO-d_6) δ 7.68 (d, *J* = 9.0 Hz, 2H), 7.42 (d, *J* = 9.0 Hz, 2H), 7.31-7.28 (m, 1H), 6.78 (d, *J* = 14.4 Hz, 1H), 6.37-6.17 (m, 2H), 5.22 (dd, *J* = 2.0, 14.4 Hz, 1H); EIMS (70eV) *m/z*: 250 (M^++2, 15), 248 (M^+, 52), 246 (22), 193 (2), 191 (5), 181 (1), 179 (4), 155 (9), 141 (5), 139 (14), 127 (6), 125 (16), 113 (14), 111 (44), 90 (18), 81 (100). Anal. Calcd for $C_{11}H_9ClN_4O$: C, 53.13; H, 3.65; Cl, 14.26; N, 22.53. Found: C, 53.14; H, 3.71; Cl, 14.28; N, 22.55.

Synthesis of 5

0.6 g (2.90 mmol) **1a** and 0.30 g (2.90 mmol) pyridazine were dissolved in 6 mL isopropyl alcohol and then 0.5 mL n-Bu_3N was added in an ice bath. The mixture was stirred at 25 °C for 1 hour and then was poured into 150 mL of ice water. The precipitate was recrystalized from EtOAc + THF to obtain **5a**. According to this procedure, cycloaddition reac-

tion of **1b** with pyridazine was achieved to give **5b**.

2,7-Diphenyl-2,3,3a,5a,6,7-hexahydro-2,3,6,7,8a,8b-hexaaza-as-indacene-1,8-dione (**5a**): colorless needles; mp 201-201.5 °C; IR (KBr) 3208, 1740 cm^{-1}; ^1H NMR (DMSO-d_6) δ 7.64-7.06 (m, 10H), 7.04 (d, *J* = 6.4 Hz, 2H), 6.03 (s, 2H), 5.14 (d, *J* = 6.4 Hz, 2H); EIMS (70 eV) *m/z*: 348 (M^+, 35), 157 (20), 145 (12), 119 (28), 105 (21), 80 (43), 77 (100). Anal. Calcd for $C_{18}H_{16}N_6O_2$: C, 62.06; H, 4.63; N, 24.12. Found: C, 62.06; H, 4.69; N, 24.10.

2,7-Di(*p*-methylphenyl)-2,3,3a,5a,6,7-hexahydro-2,3,6,7,8a,8b-hexaaza-as-indacene-1,8-dione (**5b**): colorless needles; mp 233-233.5 °C; IR (KBr) 3214, 1731 cm^{-1}; ^1H NMR (DMSO-d_6) δ 7.48 (d, *J* = 8.5 Hz, 4H), 7.14 (d, *J* = 8.5 Hz, 4H), 7.02 (d, *J* = 6.7 Hz, 2H), 6.01 (s, 2H), 5.09 (d, *J* = 6.5 Hz, 2H), 2.27 (s, 6H); EIMS (70 eV) *m/z*: 376 (M^+, 50), 171 (30), 159 (19), 105 (45), 91 (100). Anal. Calcd for $C_{20}H_{20}N_6O_2$: C, 63.82; H, 5.36; N, 22.33. Found: C, 63.74; H, 5.37; N, 22.10.

Synthesis of 6

0.6 g (2.90 mmol) **1a** and 1.16 g (14.5 mmol) pyridazine were stirred in 10 mL isopropyl alcohol at 60 °C for 1 day and then the reaction mixture was poured into 150 mL of ice water. The precipitate was dried and recrystalized from EtOAc + THF to obtain **6a**. According to this procedure, cycloaddition reaction of various forms of **1** with pyridazine was achieved.

2-Phenyl-2*H*-[1,2,4]triazolo[4,3-*b*]pyridazin-3-one (**6a**): colorless needles; mp 195.5-196 °C; IR (KBr) 1725 cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.32 (d, *J* = 4.0 Hz, 1H), 8.07-7.28 (m, 5H), 7.91 (d, *J* = 8.8 Hz, 1H), 7.21 (dd, *J* = 4.0, 8.8 Hz, 1H); EIMS (70 eV) *m/z*: 212 (M^+, 100), 156 (15), 119 (4), 105 (11), 91 (16), 77 (89). Anal. Calcd for $C_{11}H_8N_4O$: C, 62.26; H, 3.77; N, 26.41. Found: C, 62.36; H, 3.79; N, 26.47.

2-*p*-Methylphenyl-2*H*-[1,2,4]triazolo[4,3-*b*]pyridazin-3-one (**6b**): colorless needles; mp 195-195.5 °C; IR (KBr) 1719 cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.29 (dd, *J* = 1.3, 4.0 Hz, 1H), 7.93-7.85 (m, 3H), 7.31 (dd, *J* = 4.0, 9.6 Hz, 1H), 2.33 (s, 3H); EIMS (70 eV) *m/z*: 226 (M^+, 100), 169 (18), 155 (15), 105 (64), 91 (87). Anal. Calcd for $C_{12}H_{10}N_4O$: C, 63.71; H, 4.46; N, 24.76. Found: C, 63.69; H, 4.43; N, 24.73.

2-*p*-Chlorophenyl-2*H*-[1,2,4]triazolo[4,3-*b*]pyridazin-3-one (**6c**): colorless needles; mp 132.5-133 °C; IR (KBr) 1731 cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.32 (d, *J* = 4.0 Hz, 1H), 8.07 (d, *J* = 9.0 Hz, 2H), 7.89 (d, *J* = 8.8 Hz, 1H), 7.58 (d, *J* = 9.0 Hz, 2H), 7.23 (dd, *J* = 4.0, 8.8 Hz, 1H); EIMS (70 eV) *m/z*: 248 (M^++2, 32), 246 (M^+, 100), 155 (39), 141 (3), 139 (12), 127 (6), 125 (19), 113 (24), 111 (75), 91 (15). Anal. Calcd for $C_{11}H_7ClN_4O$: C, 53.56; H, 2.86; Cl, 14.37; N, 22.71. Found: C, 53.55; H, 2.84; Cl, 14.39; N, 22.66.

Synthesis of 7 from Reaction of 1 with 1,3,5-Triazine

0.6 g (2.90 mmol) **1a** and 1.08 g (5.8 mmol) 1,3,5-triazine were stirred in 6 mL isopropyl alcohol at room temperature for 2 hours and then the reaction mixture was poured into 100 mL of ice water. The precipitate was dried and subjected to column separation (elution; EtOAc/hexane = 1/1). The isolated compound was recrystalized from EtOAc + isopropyl alcohol to obtain **7a**. According to this procedure, reaction of various forms of **1** with 1,3,5-triazine was achieved to give the expected product.

2-Phenyl-2,4-dihydro-1,2,4-triazol-3-one (**7a**): colorless needles; mp 178-179 °C; IR (KBr) 3166, 1707, 1683 cm^{-1}; ^1H NMR (DMSO-d_6) δ 11.92 (s, 1H), 8.05 (s, 1H), 7.79-7.23 (m, 5H); EIMS (70 eV) *m/z*: 161 (M^+, 72), 118 (20), 91 (100), 77 (18). Anal. Calcd for $C_8H_7N_3O$: C, 59.63; H, 4.35; N, 26.09. Found: C, 59.67; H, 4.34; N, 26.14.

2-(*p*-Methylphenyl)-2,4-dihydro-1,2,4-triazol-3-one (**7b**): colorless needles; mp 164-165 °C; IR (KBr) 3154, 1695 cm^{-1}; ^1H NMR (DMSO-d_6) δ 11.90 (s, 1H), 8.07 (s, 1H), 7.74 (d, *J* = 8.6 Hz, 2H), 7.22 (d, *J* = 8.6 Hz, 2H), 2.29 (s, 3H); EIMS (70 eV) *m/z*: 175 (M^+, 53), 132 (11), 105 (100), 91 (18). Anal. Calcd for $C_9H_9N_3O$: C, 61.70; H, 5.18; N, 23.99. Found: C, 61.74; H, 5.19; N, 23.93.

2-(*p*-Chlorophenyl)-2,4-dihydro-1,2,4-triazol-3-one (**7c**): colorless needles; mp > 250 °C; IR (KBr) 3154, 3052, 1695 cm^{-1}; ^1H NMR (DMSO-d_6) δ 12.02 (s, 1H), 8.13 (s, 1H), 7.93 (d, *J* = 9.0 Hz, 2H), 7.49 (d, *J* = 9.0 Hz, 2H); EIMS (70 eV) *m/z*: 197 (M^++2, 16), 195 (M^+, 50), 154 (3), 152 (9), 127 (31), 125 (100), 113 (5), 111 (16), 90 (38). Anal. Calcd for $C_8H_6ClN_3O$: C, 49.12; H, 3.09; Cl, 18.12; N, 21.48. Found: C, 49.12; H, 3.09; Cl, 18.22; N, 21.52.

Synthesis of 8 from Reaction of 1 with 1,4,5,6-Tetrahydropyrimidine

0.6 g (2.90 mmol) **1a** and 0.24 g (2.90 mmol) 1,4,5,6-tetrahydropyrimidine were dissolved in 10 mL isopropyl alcohol and then 1.62 g (8.70 mmol) n-Bu_3N was added. The mixture was stirred at 60 °C for 1 hour and then poured into 100 mL of ice water. The precipitate was recrystalized from EtOAc + isopropyl alcohol to obtain **8a**. According to this procedure, reaction of various forms of **1** with 1,4,5,6- tetrahydropyrimidine was achieved.

4-[3-(2-Phenyl-2,4-dihydro-1,2,4-triazol-3-on-4-yl)-propyl]-2-phenylsemicarbazide (**8a**): colorless needles; mp 224-225 °C; IR (KBr) 3406, 3322, 3214, 3148, 1692, 1659

cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.31 (s, 1H), 7.91-6.99 (m, 11H), 5.18 (s, 2H), 3.69 (t, *J* = 6.3 Hz, 2H), 3.20-3.10 (m, 2H), 1.88-1.82 (m, 2H); EIMS (70 eV) *m/z*: 352 (M^+, 5), 247 (12), 201 (21), 119 (13), 108 (100), 91 (21), 77 (23). Anal. Calcd for $C_{18}H_{20}N_6O_2$: C, 61.36; H, 5.68; N, 23.86. Found: C, 61.40; H, 5.64; N, 23.82.

4-[3-(2-*p*-Methylphenyl-2,4-dihydro-1,2,4-triazol-3-on-4-yl)propyl]-2-*p*-methylphenylsemicarbazide (**8b**): colorless needles; mp > 240 °C; IR (KBr) 3412, 3364, 1683, 1662 cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.27 (s, 1H), 7.62 (d, *J* = 8.4 Hz, 2H), 7.46-7.40 (m, 3H), 7.24 (d, *J* = 8.4 Hz, 2H), 7.05 (d, *J* = 8.4 Hz, 2H), 5.10 (s, 2H), 3.68 (t, *J* = 6.8 Hz, 2H), 3.18-3.10 (m, 2H), 1.90-1.83 (m, 2H); EIMS (70 eV) *m/z*: 380 (M^+, 7), 258 (30), 203 (43), 175 (15), 122 (100), 105 (40), 91 (35). Anal. Calcd for $C_{20}H_{24}N_6O_2$: C, 63.14; H, 6.35; N, 22.09. Found: C, 63.12; H, 6.29; N, 22.14.

4-[3-(2-*p*-Chlorophenyl-2,4-dihydro-1,2,4-triazol-3-on-4-yl)propyl]-2-*p*-chlorophenylsemicarbazide (**8c**): colorless needles; mp > 240 °C; IR (KBr) 3400, 3340, 1698, 1662 cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.34 (s, 1H), 7.92 (d, *J* = 9.0 Hz, 2H), 7.62 (d, *J* = 9.0 Hz, 2H), 7.60 (br, 1H), 7.51 (d, *J* = 9.0 Hz, 2H), 7.30 (d, *J* = 9.0 Hz, 2H), 5.22 (s, 2H), 3.68 (t, *J* = 6.8 Hz, 2H), 3.19-3.10 (m, 2H), 1.88-1.82 (m, 2H); EIMS (70 eV) *m/z*: 422 (M^++2, 2), 420 (M^+, 4), 282 (5), 280 (35), 278 (80), 238 (14), 236 (43), 225 (43), 223 (100), 197 (8), 195 (25), 155 (9), 153 (27), 144 (32), 142 (100), 127 (39), 125 (78), 113 (11), 111 (32), 90 (31). Anal. Calcd for $C_{18}H_{18}Cl_2N_6O_2$: C, 51.32; H, 4.31; Cl, 16.83; N, 19.95. Found: C, 51.34; H, 4.36; Cl, 16.86; N, 19.91.

Synthesis of 9 from Reaction of 1 with 1,3-Thiazole

0.74 g (8.70 mmol) 1,3-thiazole dissolved in 6 mL isopropyl alcohol was stirred with 0.6 g (2.90 mmol) **1a** in an ice bath for 0.5 hour and then the mixture was poured into 100 mL of ice water. The precipitate was recrystalized from THF + isopropyl alcohol to obtain **9a**. According to this procedure, reaction of various forms of **1** with 1,3-thiazole was achieved.

(1-Phenylhydrazino) carboxylic acid (2-(2-phenyl-2,4-dihydro-1,2,4-triazol-3-on-4-yl)vinyl)thiolate (**9a**): colorless needles; mp > 250 °C; IR (KBr) 3340, 3274, 3214, 1725, 1677 cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.14 (s, 1H), 7.92-7.13 (m, 10H), 6.81 (d, *J* = 8.5 Hz, 1H), 6.73 (d, *J* = 8.5 Hz, 1H), 5.86 (s, 2H); EIMS (70 eV) *m/z*: 353 (M^+, 7), 293 (15), 248 (22), 161 (40), 135 (12), 105 (80), 77 (100). Anal. Calcd for $C_{17}H_{15}N_5O_2S$: C, 57.78; H, 4.28; N, 19.82; S, 9.07. Found: C, 57.77; H, 4.30; N, 19.78; S, 9.16.

(1-*p*-Chlorophenylhydrazino) carboxylic acid (2-(2-chlorophenyl-2,4-dihydro-1,2,4-triazol-3-on-4-yl)vinyl)-thiolate (**9b**): colorless needles; mp 224-225 °C; IR (KBr) 3328, 1707, 1674 cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.51 (s, 1H), 7.92 (d, *J* = 9.0 Hz, 2H), 7.66 (d, *J* = 9.0 Hz, 2H), 7.55 (d, *J* = 9.0 Hz, 2H), 7.48 (d, *J* = 9.0 Hz, 2H), 6.80 (d, *J* = 8.4 Hz, 1H), 6.73 (d, *J* = 8.4 Hz, 1H), 5.89 (s, 2H); EIMS (70 eV) *m/z*: 425 (M^++4, 2), 423 (M^++2, 8), 421 (M^+, 11), 365 (4), 363 (25), 361 (37), 282 (3), 280 (8), 256 (5), 254 (36), 252 (72), 197 (4), 195 (9), 171 (6), 169 (17), 155 (16), 153 (48), 143 (30), 141 (100), 113 (20), 111 (60), 90 (20). Anal. Calcd for $C_{17}H_{13}Cl_2N_5O_2S$: C, 48.35; H, 3.10; Cl, 16.79; N, 16.58; S, 7.59. Found: C, 48.36; H, 3.20; Cl, 16.79; N, 16.58; S, 7.49.

Synthesis of 10 from Reaction of 1 with 2-Amino-1,3-thiazole

0.6 g (2.90 mmol) **1a** and 0.87 g (8.70 mmol) 2-amino-1,3-thiazole were stirred in 6 mL isopropyl alcohol at room temperature for 2 hours and then the mixture was poured into 100 mL of ice water. The precipitate was recrystalized from EtOAc + isopropyl alcohol to obtain **10a**. According to this procedure, reaction of various forms of **1** with 2-amino-1,3-thiazole was achieved.

(1-*p*-Methylphenylhydrazino) carboxylic acid (2-(2-*p*-methylphenyl-4-amino-2,4-dihydro-1,2,4-triazol-3-on-4-yl)-vinyl)thiolate (**10a**): colorless needles; mp > 250 °C; IR (KBr) 3466, 3364, 3304, 3208, 1710, 1671, 1644 cm^{-1}; ^1H NMR (DMSO-d_6) δ 7.71 (d, *J* = 8.5 Hz, 2H), 7.46 (d, *J* = 8.5 Hz, 2H), 7.21-7.17 (m, 4H), 7.01 (d, *J* = 7.8 Hz, 1H), 6.38 (d, *J* = 7.8 Hz, 1H), 6.24 (s, 2H), 5.71 (s, 2H), 2.28 (s, 6H); EIMS (70 eV) *m/z*: 396 (M^+, 41), 247 (26), 190 (38), 147 (18), 121 (34), 91 (100), 77 (34). Anal. Calcd for $C_{19}H_{20}N_6O_2S$: C, 57.56; H, 5.08; N, 21.20; S, 8.09. Found: C, 57.58; H, 5.04; N, 21.21; S, 8.05.

(1-*p*-Chlorophenylhydrazino) carboxylic acid (2-(2-*p*-chlorophenyl-4-amino-2,4-dihydro-1,2,4-triazol-3-on-4-yl)-vinyl)thiolate (**10b**): colorless needles; mp > 250 °C; IR (KBr) 3466, 3346, 3208, 1713, 1647 cm^{-1}; ^1H NMR (DMSO-d_6) δ 7.86 (d, *J* = 9.0 Hz, 2H), 7.64 (d, *J* = 9.0 Hz, 2H), 7.46 (d, *J* = 9.0 Hz, 2H), 7.45 (d, *J* = 9.0 Hz, 2H), 7.01 (d, *J* = 5.8 Hz, 1H), 6.41 (d, *J* = 5.8 Hz, 1H), 6.38 (s, 2H), 5.81 (s, 2H); EIMS (70 eV) *m/z*: 440 (M^++4, 1), 438 (M^++2, 5), 436 (M^+, 9), 269 (9), 267 (20), 212 (4), 210 (14), 155 (7), 153 (23), 143 (14), 141 (55), 127 (13), 125 (38), 113 (32), 111 (100), 90 (33), 77 (84). Anal. Calcd for $C_{17}H_{14}Cl_2N_6O_2S$: C, 46.70; H, 3.23; Cl, 16.21; N, 19.22; S, 7.33. Found: C, 46.69; H, 3.22; Cl, 16.21; N, 19.22; S, 7.30.

Synthesis of 11 from Reaction of 1 with 2-Amino-1,3,4-thiadiazole

0.6 g (2.71 mmol) **1b** and 0.82 g (8.10 mmol) 2-amino-1,3,4-thiadiazole were stirred in 6 mL isopropyl alcohol at 60

Table 4. Crystal Data for **3c**, **5a**, **4c**

Compound	**3c**	**5a**	**4c**
Formula	$C_{16}H_{10}ClN_3O$	$C_{18}H_{16}N_6O_2$	$C_{11}H_9ClN_4O$
Fw	295.73	348.36	248.67
diffractometer used	Nonius CAD4	Rigaku AFC6S	Rigaku AFC6S
cryst system	Monoclinic	Triclinic	Monoclinic
space group	$P2_1/n$	P1 (#2)	$P2_1/c$ (#14)
a, Å	6.1067(21)	8.6475(9)	12.464(2)
b, Å	16.143(3)	10.041(1)	11.363(3)
c, Å	13.8118(20)	11.115(1)	7.759(3)
α, deg	-	93.91(1)	-
β, deg	102.294(17)	110.46(1)	101.33(2)
γ, deg	-	109.45(1)	-
V, $Å^3$	1330.4(5)	833.9(2)	1077.5(5)
Z	4	2	4
D_{calcd}, g cm^{-3}	1.476	1.387	1.533
λ(Kα), Å	0.70930 (Mo)	1.54178 (Cu)	1.54178 (Cu)
F (000)	607.88	364.00	512.00
no. 2θ range, deg	24,12.44-25.42	25, 78.8-79.9	25, 78.1-80.1
$2\theta_{max}$, deg	49.8	120.2	120.4
scan type	θ-2θ	ω-2θ	ω–2θ
μ(Kα)	0.28mm^{-1} (Mo)	7.86cm^{-1} (Cu)	30.56cm^{-1} (Cu)
cryst size, mm	0.09 × 0.12 × 0.52	0.20 × 0.20 × 0.58	0.41 × 0.41 × 0.55
transm factor	0.891-0.935	0.9184-0.9980	0.7516-0.9980
temp, K	298	296	296
no. of measd reflns	2565	2655	1836
no. of unique reflns	2334	2463	1684
no. of obsd reflns (N_o)	1482 (> 2.5σ)	2166 (> 3σ)	1241 (>3 σ)
R^a, R_w^a	0.040, 0.045	0.042, 0.051	0.061, 0.045
GOF[a]	1.67	5.72	6.20
weighting scheme	unit weights	$[\sigma^2(F_o)]^{-1}$	$[\sigma^2(F_o)]^{-1}$
$(\Delta_Q)_{max}$, $e^-Å^{-3}$	0.150	0.17	0.23
$(\Delta_Q)_{min}$, $e^-Å^{-3}$	-0.170	-0.28	-0.31

°C for 2 hours and then the mix ture was poured into 150 mL of ice wa ter. The pre cip i tate was recrystalized from THF + isopropyl al co hol to ob tain **11a**. Ac cord ing to this pro ce dure, re ac tion of var i ous forms of **1** with 2-amino-1,3,4-thiadiazole

Table 5. Bond Distances/Å of 2-(*p*-Chlorophenyl)-2*H*-[1,2,4]triazolo[4,3-*b*]isoquinolin-3-one **3c**

C(1)-C(2)	1.367(5)	C(8)-N(2)	1.371(4)
C(1)-C(6)	1.388(5)	C(8)-N(3)	1.299(4)
C(1)-Cl	1.739(3)	C(9)-C(10)	1.407(4)
C(2)-C(3)	1.376(5)	C(9)-C(16)	1.389(5)
C(3)-C(4)	1.394(5)	C(10)-C(11)	1.453(5)
C(4)-C(5)	1.380(5)	C(10)-C(13)	1.409(5)
C(4)-N(1)	1.413(4)	C(11)-C(12)	1.332(6)
C(5)-C(6)	1.376(5)	C(12)-N(2)	1.392(4)
C(7)-N(1)	1.372(4)	C(13)-C(14)	1.369(7)
C(7)-N(2)	1.390(4)	C(14)-C(15)	1.384(6)
C(7)-O(7)	1.217(4)	C(15)-C(16)	1.382(5)
C(8)-C(9)	1.449(4)	N(1)-N(3)	1.398(3)

Table 6. Bond Angles/deg of 2-(*p*-Chlorophenyl)-2*H*-[1,2,4]triazolo[4,3-*b*]isoquinolin-3-one **3c**

C(2)-C(1)-C(6)	121.0(3)	C(10)-C(9)-C(16)	120.9(3)
C(2)-C(1)-Cl	119.2(3)	C(9)-C(10)-C(11)	120.6(3)
C(6)-C(1)-Cl	119.9(3)	C(9)-C(10)-C(13)	117.8(3)
C(1)-C(2)-C(3)	120.0(3)	C(11)-C(10)-C(13)	121.6(3)
C(2)-C(3)-C(4)	119.9(3)	C(10)-C(11)-C(12)	120.6(3)
C(3)-C(4)-C(5)	119.3(3)	C(11)-C(12)-N(2)	119.0(4)
C(3)-C(4)-N(1)	120.4(3)	C(10)-C(13)-C(14)	120.6(4)
C(5)-C(4)-N(1)	120.3(3)	C(13)-C(14)-C(15)	121.0(4)
C(4)-C(5)-C(6)	120.9(3)	C(14)-C(15)-C(16)	119.9(4)
C(1)-C(6)-C(5)	118.9(3)	C(9)-C(16)-C(15)	119.9(3)
N(1)-C(7)-N(2)	102.5(3)	C(4)-N(1)-C(7)	127.5(3)
N(1)-C(7)-O(7)	130.6(3)	C(4)-N(1)-N(3)	119.6(2)
N(2)-C(7)-O(7)	126.9(3)	C(7)-N(1)-N(3)	112.9(2)
C(9)-C(8)-N(2)	118.7(3)	C(7)-N(2)-C(8)	108.6(2)
C(9)-C(8)-N(3)	129.2(3)	C(7)-N(2)-C(12)	127.3(3)
N(2)-C(8)-N(3)	112.1(3)	C(8)-N(2)-C(12)	124.0(3)
C(8)-C(9)-C(10)	117.0(3)	C(8)-N(3)-N(1)	103.9(2)
C(8)-C(9)-C(16)	122.1(3)		

Table 7. Bond Lengths/Å of 2-(*p*-Chlorophenyl)-2,8a-dihydro-1*H*-[1,2,4]triazolo[4,3-*b*]pyridazin-3-one **4c**

Cl(1)-C(9)	1.748(4)	N(1)-C(1)	1.360(5)
N(1)-N(2)	1.438(5)	N(2)-C(2)	1.442(5)
N(1)-C(6)	1.424(5)	N(3)-N(4)	1.358(4)
N(3)-C(1)	1.357(5)	N(3)-C(2)	1.454(6)
N(4)-C(5)	1.283(6)	C(2)-C(3)	1.477(6)
C(6)-C(7)	1.389(6)	C(3)-C(4)	1.318(6)
C(7)-C(8)	1.396(6)	C(4)-C(5)	1.435(8)
C(8)-C(9)	1.367(6)	C(6)-C(11)	1.377(6)
C(9)-C(10)	1.358(7)	C(10)-C(11)	1.389(6)
O(1)-C(1)	1.226(5)		

Table 8. Bond Angles/deg of 2-(*p*-Chlorophenyl)-2,8a-dihydro-1*H*-[1,2,4]triazolo[4,3-*b*]pyridazin-3-one **4c**

N(2)-N(1)-C(1)	117.3(3)	N(2)-N(1)-C(6)	118.8(4))
C(1)-N(1)-C(6)	129.4(4)	N(1)-N(2)-C(2)	102.4(3)
N(4)-N(3)-C(1)	123.9(4)	N(4)-N(3)-C(2)	124.4(4)
C(1)-N(3)-C(2)	110.8(4)	N(3)-N(4)-C(5)	112.5(4)
O(1)-C(1)-N(1)	127.8(4)	O(1)-C(1)-N(3)	127.0(4)
N(1)-C(1)-N(3)	105.1(4)	N(2)-C(2)-N(3)	102.2(4)
N(2)-C(2)-C(3)	117.2(4)	C(2)-C(3)-C(4)	117.0(5)
N(3)-C(2)-C(3)	108.6(4)	N(4)-C(5)-C(4)	125.3(5)
C(3)-C(4)-C(5)	120.1(5)	N(1)-C(6)-C(11)	119.7(5)
N(1)-C(6)-C(7)	120.4(4)	C(6)-C(7)-C(8)	118.9(5)
C(7)-C(6)-C(11)	119.8(4)	Cl(11)-C(9)-C(8)	118.7(4)
C(7)-C(8)-C(9)	119.7(5)	C(8)-C(9)-C(10)	122.0(4)
Cl(1)-C(9)-C(10)	119.3(4)	C(6)-C(11)-C(10)	120.8(5)
C(9)-C(10)-C(11)	118.7(5)		

was achieved.

Synthesis of 11 from Reaction of 1 with 3-Amino-1,2,4-triazole

0.6 g (2.90 mmol) **1a** and 0.69 g (8.10 mmol) 3-amino-1,2,4-triazole were stirred in 6 mL isopropyl alcohol at 60 °C for 2 hours and then the mixture was poured into 150 mL of ice water. The precipitate was recrystalized from THF + isopropyl alcohol to obtain **11a**. According to this procedure, reaction of various forms of **1** with 3-amino-1,2,4-triazole was achieved.

5-Amino-bis(2-phenyl-2,4-dihydro-1,2,4-triazol-3-on-4-yl) (**11a**): colorless needles; mp > 250 °C; IR (KBr) 3340, 3184, 1716 cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.76(s, 1H), 7.90-7.14 (m, 10H), 7.02 (s, 2H); EIMS (70 eV) *m/z*: 335 (M^+, 40), 175 (20), 119 (11), 105 (23), 91 (21), 77 (100). Anal. Calcd for $C_{16}H_{13}N_7O22$: C, 57.31; H, 3.88; N, 29.25. Found: C, 57.36; H, 3.86; N, 29.31.

5-Amino-bis(2-*p*-methylphenyl-2,4-dihydro-1,2,4-triazol-3-on-4-yl) (**11b**): colorless needles; mp > 250 °C; IR (KBr) 3352, 3184, 1716 cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.76 (s, 1H), 7.75 (d, *J* = 8.4 Hz, 2H), 7.68 (d, *J* = 8.4 Hz, 2H), 7.32 (d, *J* = 8.4 Hz, 2H), 7.24 (d, *J* = 8.4 Hz, 2H), 6.97 (s, 2H), 2.33 (s, 3H), 2.29 (s, 3H); EIMS (70 eV) *m/z*: 363 (M^+, 20), 189 (12), 175 (12), 119 (31), 91 (100). Anal. Calcd for $C_{18}H_{17}N_7O_2$: C, 59.60; H, 4.72; N, 26.98. Found: C, 59.41; H, 4.76; N, 26.89.

5-Amino-bis(2-*p*-chlorophenyl-2,4-dihydro-1,2,4-triazol-3-on-4-yl) (**11c**): colorless needles; mp > 250 °C; IR

Table 9. Bond Lengths/Å of 2,7-Diphenyl-2,3,3a,5a,6,7-hexahydro-2,3,6,7,8a,8b-hexaaza-as-indacene-1,8-dione **5a**

O(1)-C(1)	1.213(3)	N(2)-C(3)	1.469(3)
N(1)-N(2)	1.443(3)	N(3)-N(6)	1.404(3)
N(1)-C(7)	1.413(3)	N(3)-C(3)	1.471(3)
N(3)-C(1)	1.406(3)	N(4)-C(2)	1.353(3)
N(4)-N(5)	1.446(3)	N(5)-C(6)	1.464(3)
N(4)-C(13)	1.413(3)	N(6)-C(2)	1.398(3)
N(6)-C(6)	1.471(3)	C(3)-C(4)	1.492(4)
C(7)-C(8)	1.380(4)	C(4)-C(5)	1.321(4)
C(8)-C(9)	1.386(4)	C(5)-C(6)	1.492(4)
C(9)-C(10)	1.367(4)	C(7)-C(12)	1.383(4)
C(10)-C(11)	1.371(4)	C(13)-C(14)	1.392(4)
C(11)-C(12)	1.385(4)	C(14)-C(15)	1.382(4)
C(13)-C(18)	1.382(4)	C(15)-C(16)	1.374(5)
O(2)-C(2)	1.213(3)	C(16)-C(17)	1.377(5)
N(1)-C(1)	1.353(3)	C(17)-C(18)	1.384(4)

Table 10. Bond Angles/deg of 2,7-Diphenyl-2,3,3a,5a,6,7-hexahydro-2,3,6,7,8a,8b-hexaaza-as-indacene-1,8-dione **5a**

N(2)-N(1)-C(1)	111.8(2)	N(1)-N(2)-C(3)	102.6(2)
C(1)-N(1)-C(7)	128.3(2)	N(6)-N(3)-C(3)	116.9(2)
N(6)-N(3)-C(1)	112.9(2)	N(5)-N(4)-C(2)	111.9(2)
C(1)-N(3)-C(3)	107.0(2)	C(2)-N(4)-C(13)	129.3(2)
N(5)-N(4)-C(13)	118.2(2)	N(3)-N(6)-C(2)	115.4(2)
N(4)-N(5)-C(6)	102.4(2)	C(2)-N(6)-C(6)	107.5(2)
N(3)-N(6)-C(6)	116.3(2)	O(1)-C(1)-N(3)	125.1(2)
O(1)-C(1)-N(1)	128.0(3)	O(2)-C(2)-N(4)	128.1(2)
N(1)-C(1)-N(3)	106.9(2)	N(4)-C(2)-N(6)	106.7(2)
O(2)-C(2)-N(6)	125.1(2)	N(2)-C(3)-C(4)	113.4(2)
N(2)-C(3)-N(3)	102.8(2)	N(3)-C(3)-C(4)	111.8(2)
C(3)-C(4)-C(5)	123.2(3)	C(4)-C(5)-C(6)	122.8(3)
N(5)-C(6)-N(6)	102.8(2)	N(5)-C(6)-C(5)	113.1(2)
N(1)-C(7)-C(8)	120.8(2)	N(6)-C(6)-C(5)	111.5(2)
C(8)-C(7)-C(12)	120.2(2)	N(1)-C(7)-C(12)	119.0(2)
C(8)-C(9)-C(10)	121.1(3)	C(7)-C(8)-C(9)	119.1(3)
C(10)-C(11)-C(12)	120.7(3)	C(9)-C(10)-C(11)	119.4(3)
N(4)-C(13)-C(14)	120.4(2)	C(7)-C(12)-C(11)	119.4(3)
C(14)-C(13)-C(18)	120.4(3)	N(4)-C(13)-C(18)	119.2(3)
C(14)-C(15)-C(16)	120.9(3)	C(13)-C(14)-C(15)	119.2(3)
N(2)-N(1)-C(7)	119.7(2)	C(15)-C(16)-C(17)	119.4(3)
C(16)-C(17)-C(18)	121.1(3)	C(13)-C(18)-C(17)	119.1(3)

(KBr) 3352, 3184, 1719, 1668 cm^{-1}; ^1H NMR (DMSO-d_6) δ 8.79 (s, 1H), 7.91 (d, *J* = 9.0 Hz, 2H), 7.82 (d, *J* = 9.0 Hz, 2H), 7.60 (d, *J* = 9.0 Hz, 2H), 7.51 (d, *J* = 9.0 Hz, 2H), 7.09 (s, 2H); EIMS (70 eV) *m/z*: 394 (M^++4, 12), 392 (M^++2, 72), 390 (M^+, 98), 211 (10), 209 (31), 155 (2), 153 (7), 127 (8), 125 (25), 113 (34), 111 (100). Anal. Calcd for $C_{16}H_{11}Cl_2N_7O_2$: C, 47.54; H, 2.74; Cl, 17.54; N, 24.26. Found: C, 47.58; H, 2.71; Cl, 17.52; N, 24.29.

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Key Words

α-Chloroformylarylhydrazine hydrochloride; Pyridines; 2-Aryl-2*H*-[1,2,4]triazolo[4,3-a]pyridin-3-ones; Cycloaddition; N-heterocyclic compounds; Isoquinoline; Pyridazine; 1,3,5-Triazine; 1,4,5,6-Tetrahydropyrimidine; 1,3-Thiazole; 2-Amino-1,3-thiazole; 2-Amino-1,3,4-thiadiazole; 3-Amino-1,2,4-triazole.

REFERENCES

1. Kuo, C. N.; Wu, M. H.; Chen, S. P.; Li, T. P.; Hwang, C. Y.; Yeh, M. Y. *J. Chin. Chem. Soc.* **1994**, *41*, 849.
2. Chiu, C. Y.; Kuo, C. N.; Kuo, W. F.; Yeh, M. Y. *J. Chin. Chem. Soc.* **2001**, *48*, 1135.
3. Nguyen, T. H.; Milcent, R.; Barbier, G. *J. Heterocycl. Chem.* **1985**, *22*, 1383.
4. Rae, A. D.; Ramsay, C. G.; Steel, P. J. *Aust. J. Chem.* **1988**, *41*, 419.
5. Mitsuru, K. S.; Hitoshi, K. T.; Katsumasa, O. K.; Tatsul, T. H. M. *German Patent* **1981**, *3*, 024, 316; *Chem. Abstr.* **1981**, *95*, 43128b.
6. Carruba, M. O.; Parenti, M.; Ricciardi, S.; Picotti, G. B.; Mantegazza, P. *Pharmacol. Res. Commun.* **1979**, *11*, 169.
7. Lyga, John W. *Synth. Commun.* **1986**, *16(2)*, 163.
8. Kametani, T.; Sota, K.; Shio, M. *J. Heterocycl. Chem.* **1970**, *7*, 821.