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SYNTHESIS OF NITROGEN-CONTAINING HETEROCYCLES 11.[1] 1,2,4-TRIAZOLE FORMATION THROUGH DISPROPORTIONATION OF POLYAZAPOLYENES

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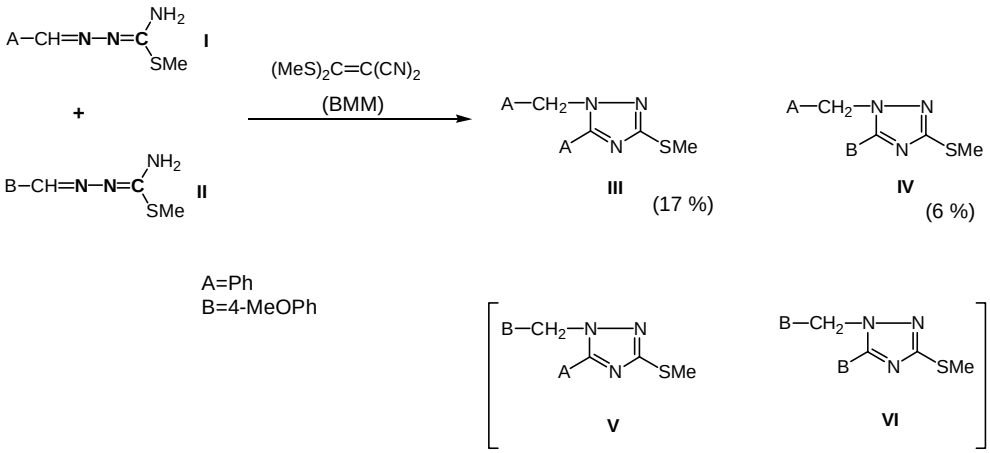
Abstract – Aromatic diaminomethylenehydrazones **1**-**4** were reacted with bis(methylthio)methylenemalononitrile (**BMM**) to give 5-aryl-1-benzyl-3-dimethylamino-1*H*-1,2,4-triazoles (**5**-**8**) via disproportionation in fused condition in moderate to high yields (44-78 %). Little or no effect was observed on disproportionation products in connection with substituents on the benzene ring. When used an equimolar amount of two different diaminomethylenehydrazones **3** and **4**, four types of 5-aryl-1-benzyl-3-dimethylamino-1*H*-1,2,4-triazoles were obtained. In the reaction using two (different) benzaldehyde *S*-methylisothiosemicarbazones **22** and **23,** four types of 5-aryl-1-benzyl-3-methylthio-1*H*-1,2,4-triazoles were formed in 14-26 % yield. The structural assignment of products and reaction mechanism are discussed.

INTRODUCTION

It has already been known that reactions of *N*(4),*N*(4)-dimethylaminomethylenehydrazones[2] or isothiosemicarbazones[3] with ethoxymethylene compounds, such as ethoxymethylenemalononitrile, ethyl ethoxymethylenecyanoacetate and others, give [1,2,4]triazolo[1,5-*c*]pyrimidine derivatives under reflux in an inert solvent, such as acetonitrile, in the presence of triethylamine. Two moles of benzaldehyde isothiosemicarbazone, however underwent a disproportionation type of reaction at elevated temperature (ca. 140^{o}C of bath temperature) in the presence of bis(methylthio)methylenemalononitrile (**BMM**) to produce 1-benzyl-3-methylthio-5-phenyl-1,2,4-triazole, giving increased yield of the triazole when two moles of the isothiosemicarbazone are reacted.[4] In the similar conditions, equimolar two different

benzaldehyde isothiosemicarbazones **I** and **II** were also reacted in the presence of **BMM** to give only two 1-benzyl-3-methylthio-1,2,4-triazoles (**III** and **IV**) in Scheme 1,[4] but the other possible alternative 1-(4-methoxybenzyl)-3-methylthio-1,2,4-triazoles **V** and **VI** were not obtained.



Scheme 1

In the present study, disproportionation reaction of *N*(4),*N*(4)-dimethylaminomethylenehydrazones and isothiosemicarbazones in the presence of **BMM** in which the formation of the triazole types (**V** and **VI**) are also involved were examined.

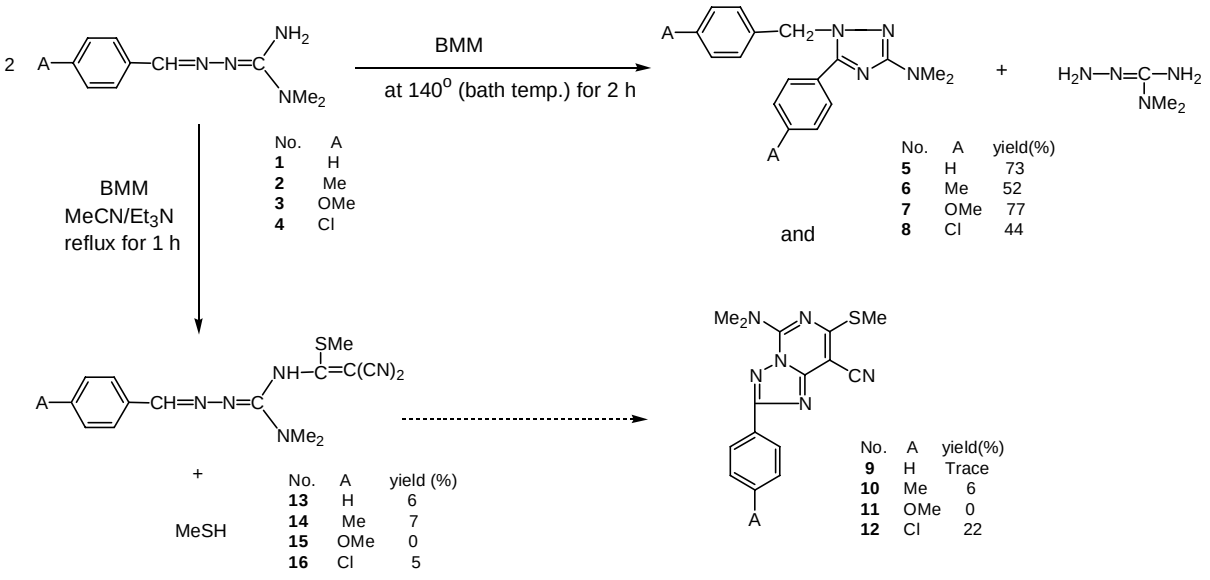
RESULTS AND DISCUSSION

The disproportionation reaction of benzaldehyde diaminomethylenehydrazones **1**-**4** was performed by heating in the presence of **BMM** (molar ratio: hydrazone / BMM=2:1) at 140˚ C (bath temperature) for 2 h (Scheme 2). The reaction products were separated through preparative high-pressure liquid chromatography (HPLC) on silica gel, giving 1-benzyl-1,2,4-triazole derivatives (**5**-**8**) in 44-78 % yield and 1,2,4-triazolo[1,5-*c*]pyrimidines (**9**, **10** and **12**) in a few to 22 % yields, respectively.

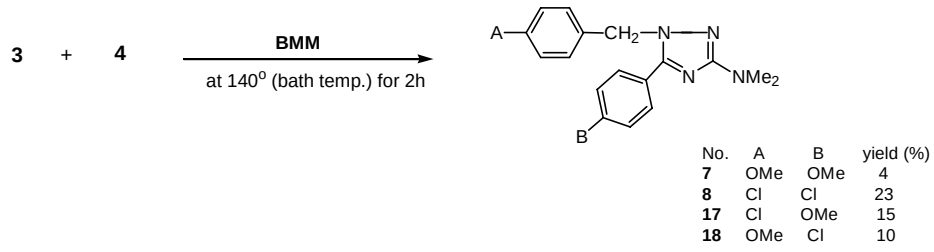
Formation of 1,2,4-triazolo[1,5-*c*]pyrimidines (**9**-**12**) may proceed via condensation product (**13**-**16**) of benzaldehyde diaminomethylenehydrazones **1**-**4**, since this adduct is detected in the reaction of **1**-**4** with **BMM** in the milder condition (see Scheme 2).

Mixture of two typical diaminomethylenehydrazones, one with an electron donating methoxy group and another with an electron withdrawing chlorine atom on the benzene ring, was also reacted in the presence of **BMM** under similar reaction conditions to the disproportionation of diaminomethylenehydrazones (**1**–**4**), resulting the reaction products consisting of **7**, **8**, **17** and **18** (Scheme 3). Chromatographic separation of the products gave four types of triazoles **7** (4 %), **8** (23 %), **17** (15 %) and **18** (10 %),

respectively. These four types of triazoles were produced in the disproportionation conditions, depending upon the electronic properties of the substituents on benzene ring.



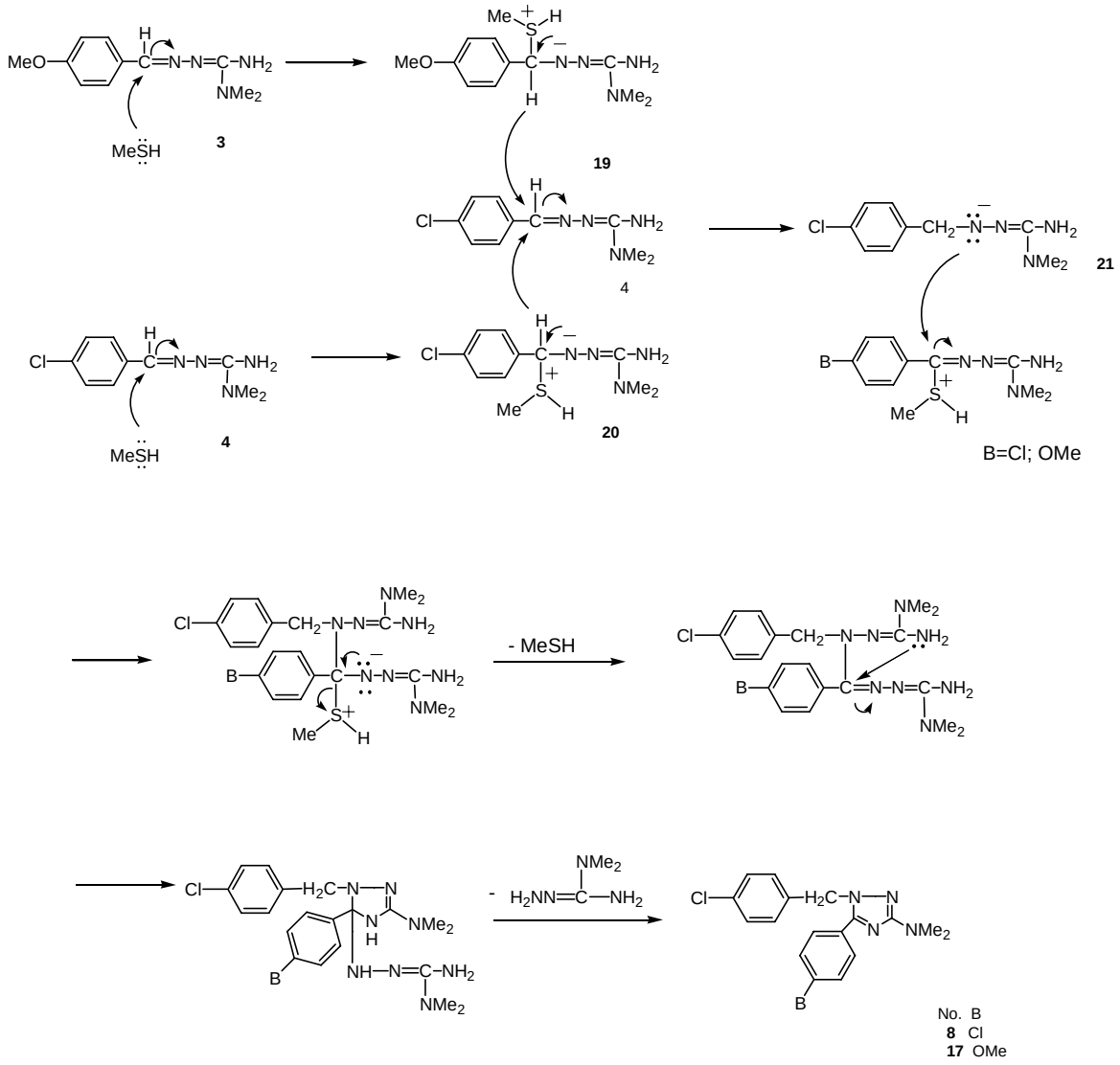
Scheme 2



Scheme 3

Disproportionation of diaminomethylenehydrazones proceeds readily under the fused condition at high temperature. Since **BMM** is a generator of methanethiol,[5] the formation mechanism of 1-benzyl-3-dimethylamino-1,2,4-triazoles is considered to be shown in Scheme 4, as already proposed in the formation of 1-benzyl-3-methylthio-1,2,4-triazoles from benzaldehyde *S*-methylisothiosemicarbazone and alkanethiol.[4] In this paper, it was confirmed that **5** was also the product in the reaction **1** and butanethiol (see, Experimental). The mixed disproportionation reaction starting with **3** and **4** gives mostly **8** and **17**, and less amounts of **7** and **18**. This fact may be considered that the methanethiol binds more feasibly to **4** than does **3**. The first step of this reaction may be attack of methanethiol on the benzylidene carbon atom of **4** with an electron-withdrawing *p*-chlorine atom on the benzene ring, and then

methanethiol attacks **3** with electron-donating *p*-methoxy group. In the next, the hydride anion generated from methanethiol adducts (**19** and **20**) transfers more readily to the benzylidene carbon atom of **4**, where the hydride ion is more readily formed from the adduct **19** than **20** according to electronic nature of the



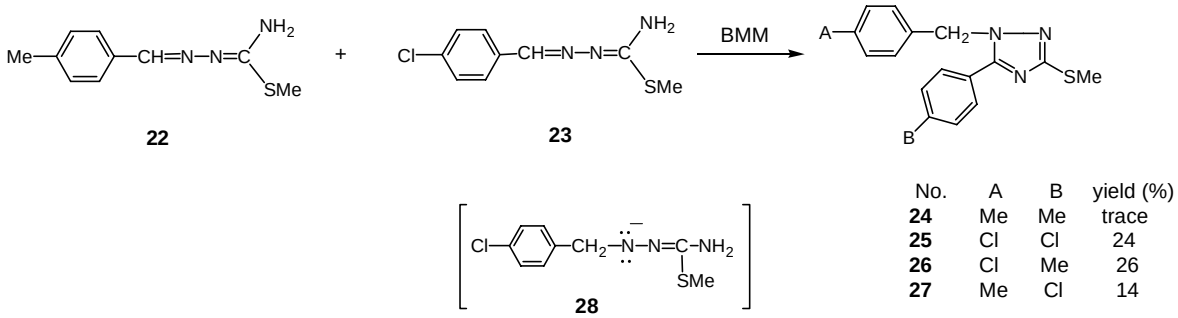
Scheme 4

hydride ion is more readily formed from the adduct **19** than **20** according to electronic nature of substitution. Thus, the intermediate **21** may be formed. Accordingly, the reaction between **3** and **4** affords mostly compound **8** and **17**.

The poorer yields of **7** and **18** may depend upon the difficult or slower attack of the hydride on diaminomethylenehydrazone **3**.

An equimolar mixture of 4-methylbenzaldehyde *S*-methylisothiosemicarbazone (**22**) and 4-chloro-benzaldehyde *S*-methylisothiosemicarbazone (**23**) was analogously subjected to the reaction

conditions in the presence of BMM according to the procedure of the mixed dimerization of benzaldehyde diaminomethylenehydrazones (**3** and **4**), resulting four types of triazoles **24** (trace), **25**[4] (24 %), **26** (26 %) and **27** (14 %), respectively (Scheme 5). This result indicates that the anion intermediate **28**, such as **21** in the mixed dimerization of benzaldehyde diaminomethylenehydrazones (**3** and **4**), may work on formation of the products. In this reaction, 1-(4-methylbenzyl)-3-methylthio-1,2,4-triazoles (**24** and **27**) were positively detected. However, in the same condition, benzaldehyde *S*-methylisothiosemicarbazone and 4-methoxybenzaldehyde *S*-methylisothiosemicarbazone give only two 1-benzyl-3-methylthio-1,2,4-triazoles, but no other possible alternative 1-(4-methoxybenzyl)-3-methylthio-1,2,4-triazoles are obtained.[4] Formation of triazoles **24** and **27** may depend upon the difference of the electron-donating effect between Me and MeO-groups.



No.	A	B	yield (%)
24	Me	Me	trace
25	Cl	Cl	24
26	Cl	Me	26
27	Me	Cl	14

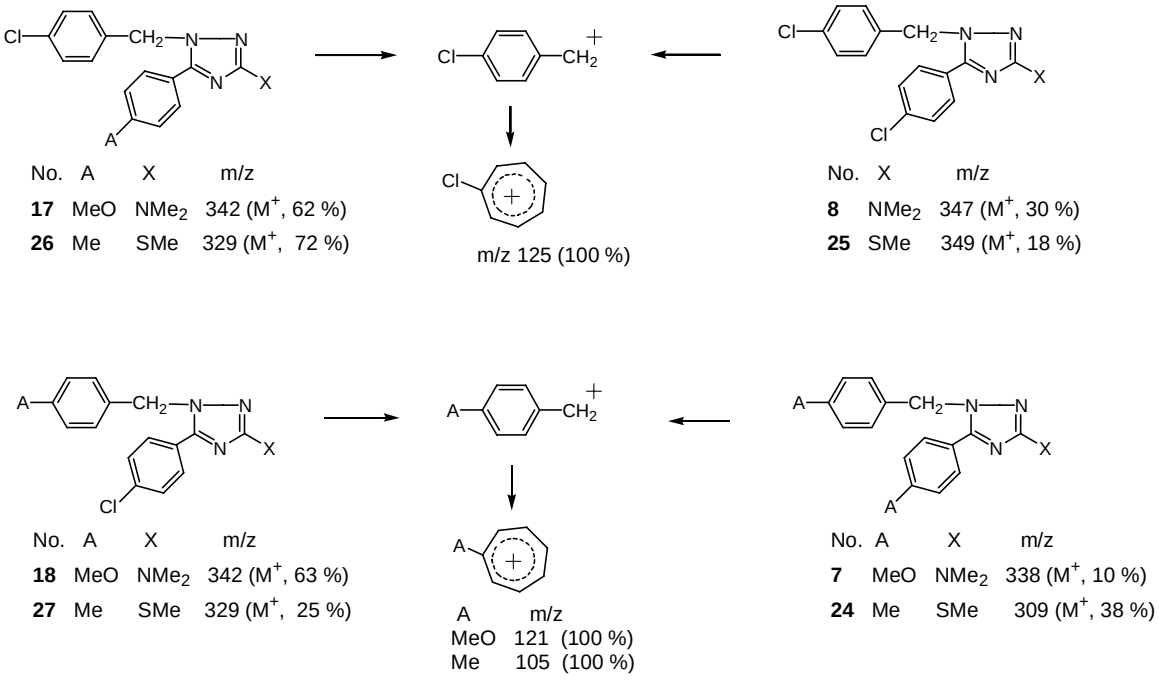
Scheme 5

The structures of *N*-benzyl-1,2,4-triazoles were determined by the ^{13}C and ^{1}H NMR spectra, and mass spectra.

In the 1-benzyl-3-dimethylamino-1,2,4-triazole compounds, the ring carbon signals of C-3 and C-5 of 1,2,4-triazole ring (**5-8, 17** and **18**) appeared at δ 165.7-166.1 as a singlet and δ 153.5-154.4 as a singlet, respectively. The methylene carbon resonance of *N*-benzyl groups appeared at δ 51.4-52.1 as a triplet with coupling constant ($^{1}J_{CH}$=136-140 Hz). In the ^{1}H NMR spectra, dimethylamino on the triazole ring resonated in a single signal of sex-proton intensities at δ 3.03 and the methylene protons of *N*-benzyl groups appeared at δ 5.16-5.25 as a singlet. In the mass spectrum, the 1-benzyl-1,2,4-triazole compounds showed a prominent peak the tropylium ion in the ease of C-N bond cleavage. For example compound **5** (A=H) showed base peak at m/z 91($C_7H_7^+$) due to the tropylium ion and **6** (A=Me) showed base peak at m/z 105(CH_3-$C_7H_6^+$), and thus the compound **8** (X=NMe_2) and **17** (A=MeO, X=NMe_2) showed base peak at m/z 125 due to the tropylium ion (Scheme 6). Similarly, compound **18** (A=MeO, X=NMe_2) and **7** (A=MeO, X=NMe_2) showed by tropylium ion (m/z 121, 100%). All the spectroscopic behavior is well consistent with the proposed structure.

In the 1-benzyl-3-methylthio-1,2,4-triazloe compounds, the direct support for *N*-benzyl structure of the

3-methylthio-1,2,4-triazoles was obtained from the ^{13}CNMR spectra of these compounds that exhibited a triplet (δ 52.1-52.7, $^{1}J_{CH}$=141-142 Hz). The C-3 and C-5 ring carbon signals for products **24** (A=Me, X=SMe), **26** (A=Me, X=SMe) and **27** (A=Me, X=SMe) were at δ 160.9-161.2 as a quartet with coupling constant ($^{3}J_{CH}$=3.7 Hz) and resonated at δ 155.2-156.5 at a singlet, respectively. In the mass spectra, compound **25** and **26** showed base peak at m/z 125 due to the tropylium ion (Scheme 6). Similarly, between **24** and **27** showed a prominent peak at m/z 105 due to the tropylium ion.



Scheme 6

Assignment of the triazolopyrimidine structure **9** (A=H) was based on the spectral data. The triazolopyrimidine structure was best characterized by the appearance in the IR spectrum (in KBr pellet) of the CN stretching band at 2205 cm^{-1}. The resonance of the *ortho*-protons of the 2-phenyl group in **9** was greatly deshielded (δ 8.22) relative to that of the *meta*- and *para*-protons (δ 7.46). The 6-methylthio proton resonance appeared at δ 2.60 as a singlet and 4-dimethylamino proton resonances at δ 3.69 as a singlet. Furthermore, the ^{13}C NMR spectra of the compound **9** exhibited the 6-methylthio carbon signal as quartet at δ 13.7 ($^{1}J_{CH}$=140 Hz) and the 9-CN carbon signal resonated at δ 113.8 as a singlet.

The structure of initially products (**13-16**) showed a strong two CN stretching band at near 2140 and 2200cm^{-1} in the IR spectra. The proton on the N(3) nitrogen and benzoyl carbon that well characterized the structure of the vinylaminomethylenhydrazones resonated at near δ 7.71-8.04 and δ 8.33-8.38 in the ^{1}H NMR spectra. The ^{13}C NMR spectra of **13** showed the methylthio carbon resonance at δ 13.6 as quartet ($^{1}J_{CH}$=142 Hz) and dimethylamino carbon resonance at δ 38.3 as a quartet ($^{1}J_{CH}$= 140 Hz).

EXPERIMENTAL

Melting points were determined in open capillary tubes and uncorrected. ^{1}H and ^{13}C NMR spectra were obtained with a JNM EX-400 (400 MHz) or JNM FX-90Q (90 MHz) spectrometer. The chemical shift values were recorded in parts per million (ppm) on the δ scale with tetramethylsilane as the internal reference. The mass spectra (75 eV) were obtained on a JMS-D100 mass spectrometer. Preparative high-performance liquid chromatography (HPLC) was carried out in a Kusano Kagaku KHLC-201 instrument with a 300 X 22 mm glass column packed with silica gel. Microanalyses were performed with a Perkin-Elmer 240D elemental analyzer at the Microanalytical Laboratory of Kitasato University.

All the *N*(3)-amino-*N*(4),*N*(4)-dimethylaminomethylenehydrazones (**1**-**4**) and isothiosemicarbazones (**22, 23** and **29**) employed in this study were known compounds and prepared according to the literature method.[3, 4]

Disproportionation Reaction of N(4),N(4)-Dimethyldiaminomethylenehydrazone (1) in the Presence of BMM.

A mixture of **1** (0.38 g, 2 mmoles) and **BMM** (0.2 g, 1.2 mmoles) was heated at 140 ^{o}C (bath temperature) for 2 h with occasional agitation and then cooled to rt. The sticky amorphous mass was partitioned between 10 % aqueous hydrochloric acid and $CHCl_3$. The organic phase was washed with water, dried over anhydrous sodium sulfate and evaporated under reduced pressure to give brown oil. The oil was subjected to preparative HPLC on silica gel with $CHCl_3$ as an eluent to give two major fractions. The higher Rf fraction gave spectroscopically **5** (0.11 g, 73 %) and lower Rf one gave **9** (trace).

1-Benzyl-3-dimehylamino-5-phenyl-1*H*-1,2,4-triazole (**5**).

This compounds was obtained as colorless needles, mp 93-95 ^{o}C; ^{1}H NMR($CDCl_3$): δ 3.04 (6H, s, NMe_2), 5.25 (2H, s, CH_2), 7.18 (2H, d, *J*=6.8 Hz, Ph), 7.30 (3H, m, Ph), 7.40 (3H, m, Ph), 7.53 (2H, d, *J*=7.8 Hz, Ph); ^{13}C NMR ($CDCl_3$): δ 38.7 (q), 52.1 (t), 126.6 (d), 127.6 (d), 128.3 (d), 128.7 (d), 129.8 (d), 135.2 (s), 136.7 (s), 154.6 (s), 166.0 (s); MS: m/z (relative intensity) 278 (M^+, 87), 91 (M^+-187, 100).

8-Cyano-5-dimethylamino-7-methylthio-2-phenyl[1,2,4]triazolo [1,5-*c*]pyrimidine (**9**).

This compound was obtained as colorless crystalline powder, mp 223-225 ^{o}C; ^{1}H NMR (DMSO-d_6): δ 2.60 (3H, s, SMe), 3.69 (6H, s, NMe_2), 7.46 (2H, m, Ph), 8.22 (3H, s, Ph); IR (KBr): 2205 (CN) cm^{-1}.

Disproportionation Reaction of 2.

In a similar manner as described for disproportionation reaction of **1**, treatment of **2** (0.4 g, 2 mmol) with **BMM** (0.2 g, 1.2 mmol) afforded **6** (0.16 g) and **10** (0.02 g) in 52 and 6 % yield, respectively.

1-(4-Methybenzyl)-3-dimehylamino-5-(4-methyphenyl)-1*H*-1,2,4-triazole (**6**).

This compounds was obtained as colorless needles, mp 74-79 ^{o}C; ^{1}H NMR ($CDCl_3$): δ 2.32 (s, 3H, Me), 2.27 (s, 3H, Me), 3.03 (6H, s, NMe_2), 5.19 (2H, s, CH_2), 7.07 (2H, d, *J*=8.1 Hz, Ph), 7.12 (2H, d, *J*=8.1 Hz, Ph), 7.20 (2H, d, *J*=7.8, Ph), 7.43 (2H, d, *J*=7.8 Hz, Ph); ^{13}C NMR ($CDCl_3$): δ 21.1 (s), 21.4 (q), 38.7 (q), 52.8 (t), 125.4 (s), 126.5 (d), 128.4 (d), 129.2 (d),133.6 (s), 139.7 (s), 154.4 (s), 165.7 (s); MS: m/z (relative intensity) 306 (M^+, 48), 105 (M^+-201, 100).

8-Cyano-5-dimethylamino-7-methylthio-2-(4-methylphenyl)[1,2,4]triazolo[1,5-*c*]pyrimidine (**10**).

This compound was obtained as colorless crystalline powder, mp 257-259 ^{o}C; ^{1}H NMR (DMSO-d_6): δ 2.60 (3H, s, SMe), 3.69 (6H, s, NMe_2), 7.45 (2H, d, *J*=8.1Hz, Ph), 8.09 (2H, d, *J*=8.1Hz, Ph); IR (KBr): 2200 (CN) cm^{-1}.

Disproportionation Reaction of 3.

In a similar manner as described for disproportionation reaction of **1**, treatment of **3** (0.44 g, 2 mmol) with **BMM** (0.2 g, 1.2 mmol) afforded **7**, yield 0.26 g (77 %).

1-(4-Methoxybenzyl)-3-dimethylamino-5-(4-methoxyphenyl)-1*H*-1,2,4-triazole (**7**).

This compound was obtained as pale yellow oil; ^{1}H NMR($CDCl_3$): δ 3.04 (6H, s, NMe_2), 3.79 (3H, s, OMe), 3.83 (3H, s, OMe), 5.16 (2H, s, CH_2), 6.95 (2H, d, *J*=8.5 Hz, Ph), 6.85 (2H, d, *J*=8.5 Hz, Ph), 7.12 (2H, d, *J*=8.5 Hz, Ph), 7.47 (2H, d, *J*=8.5 Hz, Ph); ^{13}C NMR($CDCl_3$): δ 38.8 (q), 51.6 (t), 55.3 (q), 55.4 (q), 114.1 (d), 120.9 (s), 128.1 (d), 128.9 (s), 130.1 (s), 154.1 (s), 159.1 (s),160.8 (s),165.9 (s); MS: m/z (relative intensity): 338 (M^+, 10), 121 (M^+-217, 100).

Disproportionation Reaction of 4.

In a similar manner as described for disproportionation reaction of **1**, treatment of **4** (0.45 g, 2 mmol) with **BMM** (0.2 g, 1.2 mmol) afforded **8** (0.15 g) and **12** (0.075 g) in 44 and 22 % yield, respectively.

1-(4-Chlorobenzyl)-3-dimethylamino-5-(4-chlorophenyl)-1*H*-1,2,4-triazple (**8**).

This compound was obtained as colorless needles, mp 71-73 ^{o}C; ^{1}H NMR($CDCl_3$): δ 3.04 (6H, s, NMe_2), 5.18 (2H, s, CH_2), 7.11 (2H, d, *J*=8.3 Hz, Ph), 7.31 (2H, d, *J*=8.3 Hz, Ph), 7.39 (2H, d, *J*=8.3 Hz, Ph), 7.45 (2H, d, *J*=8.3 Hz, Ph); ^{13}C NMR($CDCl_3$): δ 38.6 (q), 51.6 (t), 114.1 (d), 126.7 (s), 128.1 (d), 129.1 (d), 129.9 (d), 133.7 (s), 134.9 (s), 136.2 (s), 153.3 (s), 166.1 (s); MS: m/z (relative intensity): 347 (M^+, 30), 125 (M^+-222, 100).

8-Cyano-5-dimethylamino-7-methylthio-2-(4-chlorophenyl)[1,2,4]triazolo[1,5-*c*]pyrimidine (**12**).

This compound was obtained as colorless needles, mp 273-274 ^{o}C; ^{1}H NMR (DMSO-d_6): δ 2.63 (3H, s, SMe), 3.71 (6H, s, NMe_2), 7.44 (2H, d, *J*=8.6Hz, Ph), 8.17 (2H, d, *J*=8.6Hz, Ph); IR (KBr): 2200 (CN) cm^{-1}.

Cross Reaction between N(4),N(4)-Dimethyldiaminomethylenehydrazones 3 and 4 in the Presence of BMM.

A mixture of **3** (0.22 g, 1 mmol), **4** (0.22 g, 1 mmol) and **BMM** (0.2 g, 1 mmol) was heated at 140 ˚C for 2 h and then cooled to ambient temperature. The sticky amorphous mass was partitioned between 10 % aqueous hydrochloric acid and $CHCl_3$. The organic phase was washed with water, dried over anhydrous sodium sulfate and evaporated under pressure to give brown oil. The oil was subjected to preparative HPLC on silica gel ($CHCl_3$) to give the products **8** (80 mg), **18** (20 mg), **17** (50 mg) and **7** (13 mg) in 23, 10, 15 and 4 % yield, respectively.

1-(4-Methoxybenzyl)-3-dimethylamino-5-(4-chlorophenyl)-1*H*-1,2,4-triazole (**18**).

This compound was obtained as pale yellow oil; ^{1}H NMR($CDCl_3$): δ 3.04 (6H, s, NMe_2), 3.79 (3H, s, OMe), 5.16 (2H, s, CH_2), 6.86 (2H, d, *J*=8.5 Hz, Ph), 7.10 (2H, d, *J*=8.5 Hz, Ph), 7.40 (2H, d, *J*=8.83 Hz, Ph), 7.48 (2H, d, *J*=8.3 Hz, Ph); ^{13}C NMR ($CDCl_3$): δ 38.6 (q), 51.7 (t), 55.2 (q), 114.0 (d), 126.8 (s), 127.9 (d), 128.3 (s), 128.8 (d), 129.8 (d), 135.8 (s), 153.0 (s), 159.0 (s), 165.7 (d); MS: m/z (relative intensity): 342 (M^+, 63), 121 (M^+-221, 100).

1-(4-Chlorobenzyl)-3-dimethylamino-5-(4-methoxyphenyl)-1*H*-1,2,4-triazole (**17**).

This compound was obtained as pale yellow oil; ^{1}H NMR($CDCl_3$): δ 3.03 (6H, s, NMe2), 3.82 (3H, s, OMe), 5.19 (2H, s, CH_2), 6.92 (2H, d, *J*=8.3 Hz, Ph), 7.13 (2H, d, *J*=8.8 Hz, Ph), 7.30 (2H, d, *J*=8.3 Hz, Ph), 7.44 (2H, d, *J*=8.8 Hz, Ph); ^{13}C NMR($CDCl_3$): δ 38.7 (q), 51.4 (t), 55.4 (q), 114.2 (d), 120.6 (s), 128.1 (d), 128.9 (d), 130.0 (d), 133.5 (s), 135.3 (s),154.6 (s), 160.9 (s), 166.0 (s); MS: m/z (relative intensity): 342 (M^+, 62), 125 (M^+-217, 100).

Cross Reaction between Isothiosemicarbazones 22 and 23 in the Presence of BMM.

A mixture of **22** (0.21 g, 1 mmol), **23** (0.23 g, 1 mmol) and **BMM** (0.2 g, 1 mmol) was heated at 140 ˚C for 2 h and then cooled to ambient temperature. The sticky amorphous mass was partitioned between 10 % aqueous hydrochloric acid and $CHCl_3$. The organic phase was washed with water, dried over anhydrous sodium sulfate and evaporated under pressure to give brown oil. The oil was subjected to preparative HPLC on silica gel ($CHCl_3$) give products **24** (trace), **25** (24 %), **26** (26 %) and **27** (14 %).

1-(4-Methylbenzyl)-3-methylthio-5-(4-methylphenyl)-1*H*-1,2,4-triazole (**24**)

This compound was obtained as colorless needles, mp 101-102 ^{o}C; ^{1}H NMR($CDCl_3$): δ 2.33 (3H, s, Me), 2.38 (3H, s, Me), 2.62 (3H, s, SMe), 5.20 (2H, s, CH_2), 7.06 (2H, d, *J*=7.8 Hz, Ph), 7.13 (2H, d, *J*=7.8 Hz, Ph), 7.23 (2H, d, *J*=8.3 Hz, Ph), 7.45 (2H, d, *J*=8.3 Hz, Ph); MS: m/z (relative intensity): 309 (M^+, 38), 105 (M^+-204, 100). *Anal*. Calcd for $C_{18}H_{19}N_3S$: C, 69.90; H, 6.15; N, 13.59. Found: C, 69.78; H, 6.38; N, 13.75.

1-(4-Chlorolbenzyl)-3-methylthio-5-(4-chlorophenyl)-1*H*-1,2,4-triazole (**25**)

This compound was obtained as colorless needles, mp 139-140 ^{o}C (lit.,[4] mp 139-139.5 ^{o}C).

1-(4-Chlorobenzyl)-3-mehylthio-5-(4-metnylphenyl)-1*H*-1,2,4-triazole (**26**)

This compound was obtained as colorless needles, mp 114.4-116 ^{o}C; ^{1}H NMR($CDCl_3$): δ 2.40 (3H, s, Me), 2.63 (3H, s, SMe), 5.30 (2H, s, CH_2), 7.11 (2H, d, *J*=7.8 Hz, Ph), 7.25 (2H, d, *J*=7.8 Hz, Ph), 7.31 (2H, d, *J*=8.3 Hz, Ph), 7.42 (2H, d, *J*=8.3 Hz, Ph); MS: m/z (relative intensity): 329 (M^+, 70), 125 (M^+-204, 100). *Anal.* Calcd for $C_{17}H_{16}ClN_3S$: C, 61.89; H, 4.85; N, 12.74. Found: C, 62.08; H, 4.94; N, 12.74.

1-(4-Methylbenzyl)-3-methylthio-5-(4-chlorophenyl)-1*H*-1,2,4-triazole (**27**)

This compound was obtained as colorless needles, mp 106.5-108 ^{o}C; ^{1}H NMR($CDCl_3$): δ 2.34 (3H, s, Me), 2.63 (3H, s, SMe), 5.30 (2H, s, CH_2), 7.05(2H, d, *J*=7.8 Hz, Ph), 7.15 (2H, d, *J*=7.8 Hz, Ph), 7.41 (2H, d, *J*=8.3 Hz, Ph), 7.50 (2H, d, *J*=8.3 Hz, Ph); MS: m/z (relative intensity): 329 (M^+, 25), 105 (M^+-224, 100). *Anal.* Calcd for $C_{17}H_{16}ClN_3S$: C 61.55; H, 4.84; N, 12.75. Found: C, 61.89; H, 4.85; N, 12.74.

General Procedure for the Reaction of N(3)-amino-N(4),N(4)-dimethylaminomethylenehydrazones (1-4) with BMM.

A mixture of *N*-(3)-amino-*N*(4),N(4)-Dimethylaminomethylenehydrazone (1 mmole), **BMM** (1 mmol), triethylamine (0.2 mL) in MeCN (2 mL) was heated under reflux for 1 h and then allowed to cool to rt. The separate crystals were collected and washed will MeCN to give the corresponding **13**, **14** and **16**.

Benzaldehyde *N*(3)-[(2,2-dicyano-1-methylthio)vinyl]amino-*N*(4),*N*(4)-dimethylaminomethylenehydrazone **13**.

This compound was obtained as colorless crystalline powder (6 %), mp 232-233 ^{o}C ; ^{1}H NMR (DMSO-d_6): δ 2.58 (3H, s, SMe), 3.09 (6H, s, NMe_2), 7.48 (2H, m, Ph), 7.90 (3H, m, Ph), 7.99 (1H, s, NH), 8.34 (1H, s, CH=); IR (KBr): 2185, 2139 (CN) and 1668 (C=C) cm^{-1}.

4-Methylbenzaldehyde *N*(3)-[(2,2-dicyano-1-methylthio)vinyl]amino-*N*(4),*N*(4)-dimethylaminomethyl-enehydrazone **14**.

This compound was obtained as colorless crystalline powder (7 %); mp 197-198 ^{o}C; ^{1}H NMR (DMSO-d_6): δ 2.36 (3H, s, Me), 2.53 (3H, s, SMe), 3.21 (6H, s, NMe_2), 7.19 (2H, d, *J*=7.6 Hz, Ph), 7.65 (2H, d, *J*=7.6 Hz, Ph), 7.71 (1H, s, NH), 8.38(1H, s, CH=). ^{13}C NMR (DMSO-d_6): δ 12.7 (q), 21.5 (q), 36.8 (q), 75.5, 116.0, 116.8, 127.3 (d), 129.3 (d), 131.0, 140.0, 143.2 (d), 159.1, 159.2; IR(KBr): 2200, 2185 (CN) cm^{-1}.

4-Chlorobenzaldehyde *N*(3)-[(2,2-dicyano-1-methylthio)vinyl]amino-*N*(4),*N*(4)-dimethylaminomethyl-enehydrazone **16**.

This compound was obtained as colorless crystalline powder (5 %), mp 226-227 ^{o}C; ^{1}H NMR (DMSO-d_6): δ 2.59 (3H, s, SMe), 3.09 (6H, s, NMe_2), (2H, d, *J*=8.3 Hz, Ph), (2H, d, *J*=8.3 Hz, Ph),

8.04(1H, s, NH), 8.33(1H, s, CH=); IR (KBr): 2204, 2153 (CN) and 1672 (C=C) cm^{-1}.

Disproportionation Reaction of N(4),N(4)-Dimethyldiaminomethylenehydrazone (1) in the Presence of Butanethiol.

A mixture of **1** (0.38 g, 2 mmol) and butanethiol (0.18 g, 2 mmol) was heated at 140 ^{o} C for 8 h and then cooled at rt. The resulting amorphous material was subjected to chromatographic separation on silica gel (Wakogel C-300) with $CHCl_3$ to give two fractions. The higher Rf fraction gave **5** (15 mg, 5.4 %) and lower Rf one gave starting material (17 mg, 44 %).

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