A convenient synthesis of some new thiazole and pyrimidine derivatives incorporating a naphthalene moiety

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The reaction of 2-[1-(naphthalen-2-yl)ethylidene]hydrazinecarbothioamide with hydrazonoyl halides afforded new thiazole derivatives, whilst reaction with compounds containing an activated double bond such as ethoxymethylenemalononitrile and benzylidenemalononitrile yielded the respective pyrimidine derivatives. A 4-thiazolidin-4-one was obtained by reaction of the hydrazinecarbothioamide with ethyl bromoacetate. Subsequent condensation of the thiazolidinone with aromatic aldehydes afforded the corresponding arylidene derivatives. Treatment of the hydrazinecarbothioamide with dimethyl acetylenedicarboxylate resulted in the formation of a (methoxycarbonylmethylidene) thiazolinone. Reaction of the hydrazinecarbothioamide with 2-chloro-1,3-dicarbonyl compounds gave the respective thiazole derivatives. The structures of the newly synthesised compounds were confirmed by their elemental analysis and spectral data.

Keywords: thiazoles, thiosemicarbazide, hydrazonoyl halides

Several heterocyclic compounds such as thiazoles and pyrimidines have widespread applications especially in the field of medicine and pharmacology. This has, in turn, attracted the attention of many to develop the chemistry of this class of compounds. Some drugs were found to possess antidiabetic activities, however, most of them can cause problems such as compliance and hypoglycaemia. Thiazolidinone derivatives have been reported to possess antidiabetic activities,[1–3] and were also found to improve compliance and reduce side effects. Furthermore, thiazolidinones have structural similarity with clinically used thiazolidinediones.[4] Also, biological activities of substituted pyrimidines, in general, have received a great deal of interest,[5] and have been tested for their bactericidal and fungicidal activities.[6,7] In view of these observations and in continuation of our previous work on the synthesis of heterocyclic systems for biological evaluations,[8–12] we report here a facile route to various thiazole and pyrimidine derivatives, incorporating a naphthalene moiety.

Results and discussion

Condensation of 2-acetylnaphthalene **1** with thiosemicarbazide in absolute ethanol in the presence of catalytic amount of acetic acid afforded 2-[1-(naphthalen-2-yl)ethylidene]hydrazinecarbothioamide **2** as previously reported.[13] (Scheme 1).

The target compounds, namely 4-substituted-2-(2-(1-(naphthalen-2-yl)ethylidene)hydrazinyl)-5-(aryldiazenyl)thiazole **5a–i**, were synthesised *via* a one-pot reaction of the thiosemicarbazone derivative **2** with hydrazonoyl halides **3** and **4** in 1,4-dioxane in the presence of triethylamine (TEA) (Scheme 1). The structural elucidation of compounds **5a–i** was based on spectral evidence and microanalyses. The mass spectra of these products **5a–i** showed the molecular ion peaks at the expected *m/z* values. Their IR spectra showed the disappearance of the amino group, and revealed, in each case, one band at 1552–1559 cm^{-1} assignable to the N=N group (see Experimental).

The thiazole derivatives **8** and **9** were synthesised in good yields by treatment of thiosemicarbazone derivative **2** with chloroacetone **6** or phenacyl bromide **7** in 1,4-dioxane under reflux following the Hantzsch thiazole synthesis.[14] Upon coupling the thiazole derivatives **8** and **9** with the appropriate diazonium salt in the presence of sodium acetate, the azo derivatives **5a–i** were obtained. All data obtained for the latter compounds were in complete accord with those of the products obtained by direct reaction of compound **2** with hydrazonyl halides. The azo derivatives of similar thiazoles have found extensive applications in the dyeing of synthetic fibres[15,16] and the azo derivatives described in the present work may find similar applications.

Next, we examined the reaction of **2** with compounds containing an activated double bond. Thus, treatment of **2** with ethoxymethylenemalononitrile **10** gave 4-imino-3-(1-(naphthalen-2-yl)ethylideneamino)-2-thioxo-1,2,3,4-tetrahydropyrimidine-5-carbonitrile (**11**) rather than its isomeric structure **12** (Scheme 2). The structure of **11** was confirmed by its spectral data. For example, its ^{1}H NMR spectrum revealed the lack of the signals corresponding to amino and ethoxy groups (hence excluding structure **12**) and instead, exhibited the presence of a signal for the pyrimidine H-6 proton which absorbed at δ 8.29. The pyrimidine structure is in agreement with literature reports.[17–20] The reaction of ethoxymethylenemalononitrile with thiosemicarbazones has not been reported previously, though its reaction with thioureas is known to give pyrimidines.[17–20]

The mechanism of formation of **11** can be explained by a nucleophilic addition of amino group of **2** to the double bond of **10** followed by elimination of ethanol. Thereafter, the cyclisation occurs through addition of NH function to one cyano group to afford the iminopyrimidine derivative **11** as shown in Scheme 3.

In a similar manner, **2** reacted with benzylidenemalononitrile **13** in boiling methanol to give 6-amino-1-[1-(naphthalen-2-yl)-ethylideneamino]-4-phenyl-2-thioxo-1,2-dihydropyrimidine-5-carbonitrile (**14**) (Scheme 2). The mechanism of this reaction resembles that depicted for compound **11**, through a Michael-type addition, except that no elimination occurs. The formation of compound **14** could be accounted for as follows: First, nucleophilic attack of the amino group to the double bond then addition of the NH group to a cyano function, thereafter, imino–amine tautomerisation and finally dehydrogenation through air-oxidation. The structure of **14** was confirmed on the basis of spectroscopic data and elemental analyses.[21–24] For example, the ^{1}H NMR spectrum showed the appearance of D_2O exchangeable amino group signals, and the aromatic region was enriched by additional signals that integrated for five protons (Ph group). Its IR spectrum revealed a band at 2225 cm^{-1} assignable to the CN group.

The 4-thiazolidinone **15** was obtained by reaction of **2** with ethyl bromoacetate in ethanol in the presence of anhydrous potassium carbonate. Reaction of the latter product **15** with aromatic aldehydes afforded the corresponding 5-arylidene

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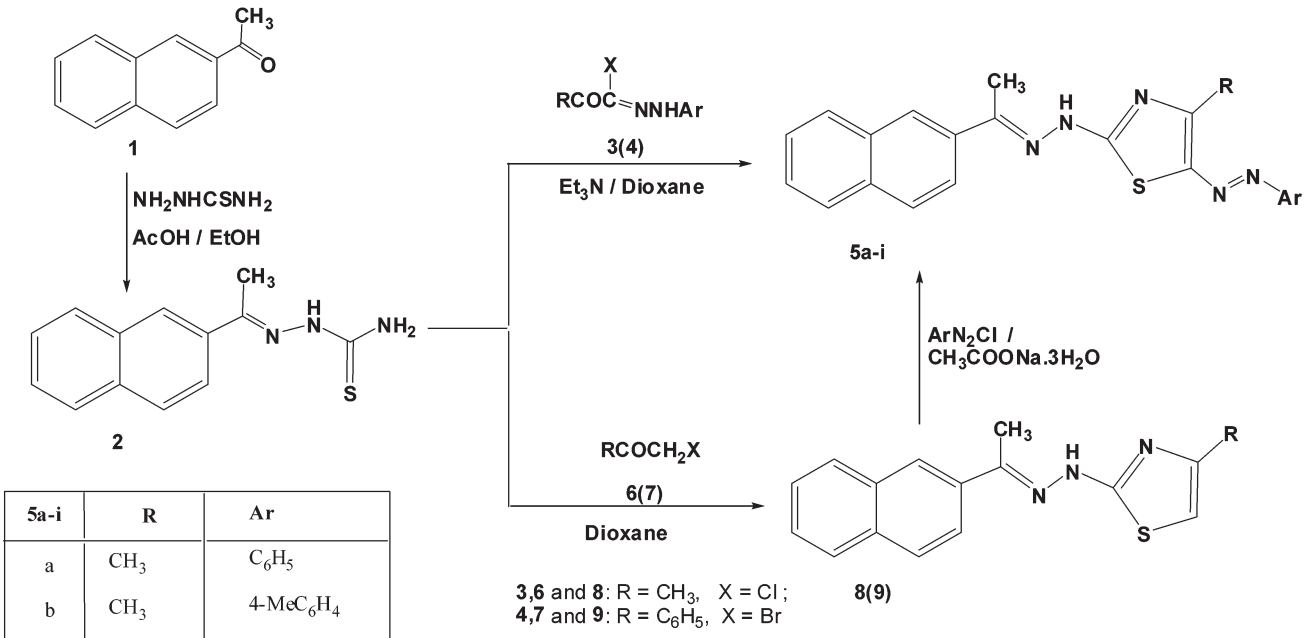
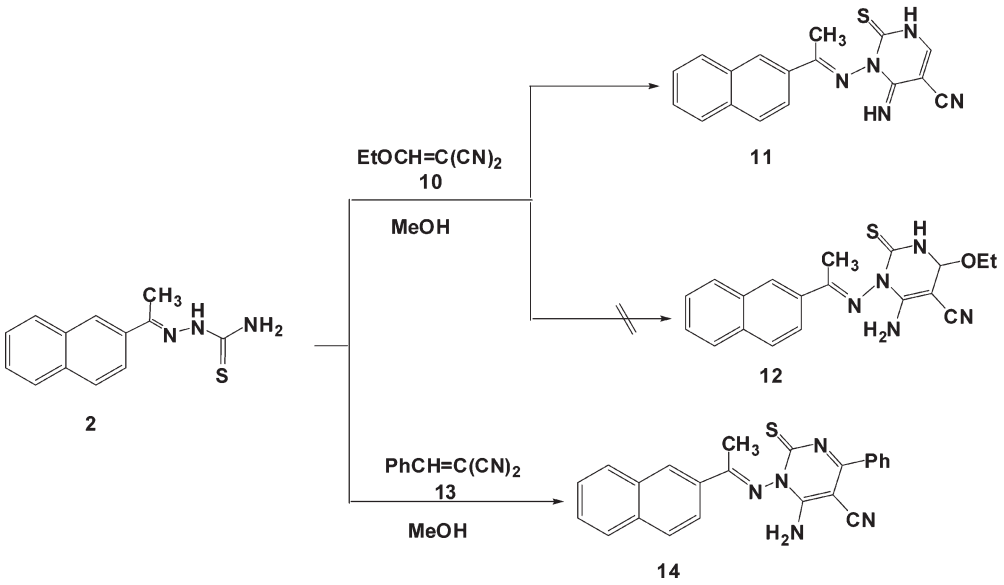


5a-i	R	Ar
a	CH_3	C_6H_5
b	CH_3	4-MeC_6H_4
c	CH_3	4-ClC_6H_4
d	CH_3	4-$NO_2C_6H_4$
e	CH_3	4-BrC_6H_4
f	CH_3	4-$OCH_3C_6H_4$
g	C_6H_5	C_6H_5
h	C_6H_5	4-ClC_6H_4
i	C_6H_5	4-$NO_2C_6H_4$

Scheme 1 Synthesis of 5-arylazothiazole derivatives **5a–i**.

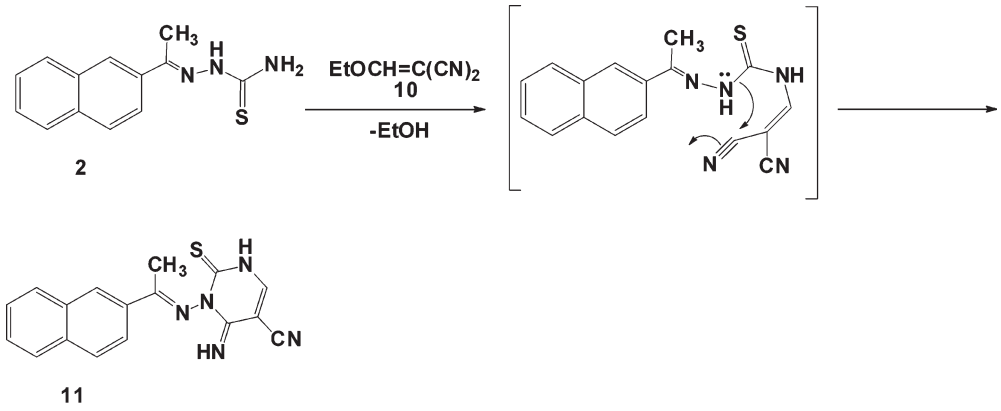


Scheme 2 Reaction of **2** with activated unsaturated compounds **10** and **13**.

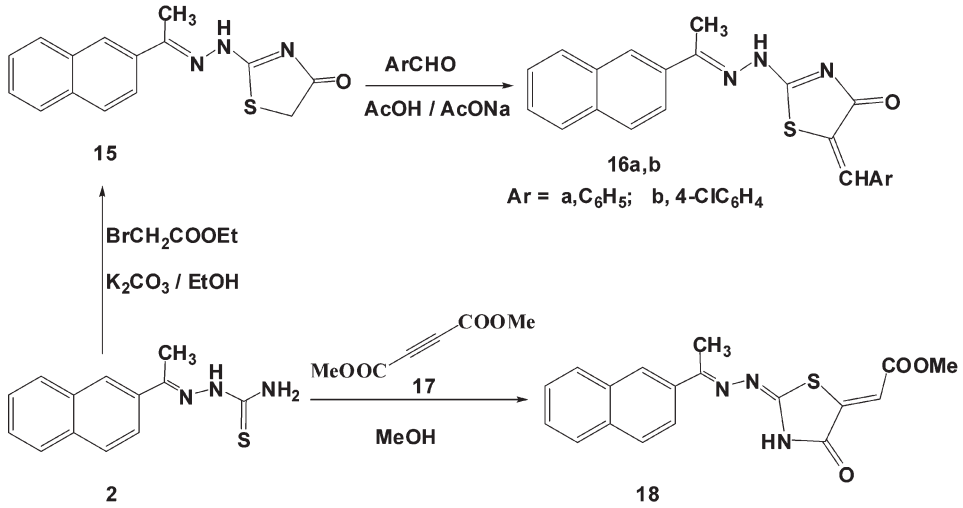
derivatives **16a**,**b** (Scheme 4). The ^{1}H NMR spectral data were also consistent with the assigned structures; thus the thiazolidinone CH_2 protons of **15** appeared at δ 3.88. The arylidene CH protons in **16a**,**b** were observed at 8.3 ppm. These data closely resemble those reported in literature on similar compounds.[25, 26]

In addition, refluxing an equimolecular mixture of **2** and dimethyl acetylenedicarboxylate **17** in methanol yielded compound **18** (Scheme 4), whose structure was established on the basis of analytical and spectral data. Thus, the ^{1}H NMR spectrum showed the presence of a singlet signal at δ 6.68 assigned to the =C*H*COOCH$_3$ proton in the *Z*-configuration,[27–30] and a singlet at δ 3.29 for the ester methyl protons. Its mass spectrum revealed a molecular ion peak at *m/z* 353.

Moreover, treatment of the title compound **2** with 2-chloro-1,3-dicarbonyl compounds, namely, ethyl 2-chloro-3-oxobutanoate **19a** and 2-chloro-3-oxo-*N*-phenylbutanamide **19b** in ethanol in the presence of TEA, gave the corresponding



Scheme 3 Mechanism for the reaction of **2** with ethoxymethylenemalononitrile **10**.



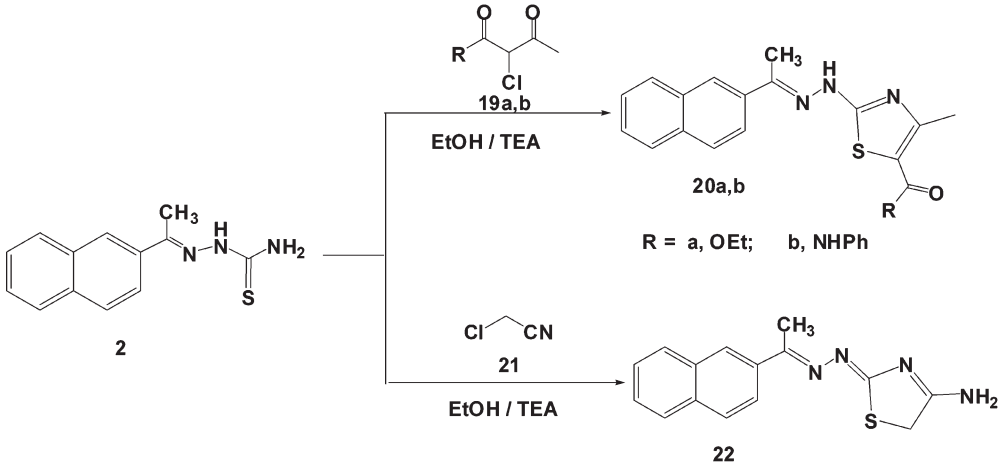
Scheme 4 Synthesis of arylidenethiazolinone derivatives **16a**,**b** and **18**.

thiazole derivatives **20a** and **20b**, respectively (Scheme 5). The structure of these products was elucidated by their microanalysis and spectral data (mass, IR, ^{1}H NMR). The ^{1}H NMR data showed singlet signals at δ 2.52 and 2.49 ppm assignable to the thiazole-CH_3, in addition to the characteristic signals for the COOEt and CONHPh groups in compounds **20a** and **20b**, respectively.

Finally, the reaction of **2** with chloroacetonitrile **21** in boiling ethanol containing a catalytic amount of TEA afforded the aminothiazoline derivative **22** (Scheme 5). The structure of compound **22** was elucidated on the basis of spectroscopic data and microanalysis. For example, the ^{1}H NMR spectrum revealed a singlet signal at δ 3.98 due to the thiazoline–CH_2 protons. The mass spectrum of **22** showed the molecular ion peak at *m/z* 282. (see Experimental section).

Experimental

Melting points were measured on Electrothermal IA 9000 series digital melting point apparatus. The IR spectra were recorded in potassium bromide discs on a Pye Unicam SP 3300 and Shimadzu FT IR 8101 PC IR spectrophotometers. ^{1}H NMR and ^{13}C NMR spectra were recorded in deuterated dimethyl sulfoxide (DMSO-d_6) using a Varian Gemini 300 NMR spectrometer (300 MHz for ^{1}H and 75 MHz for ^{13}C). Mass spectra were recorded on a Shimadzu GCMS-QP1000 EX



Scheme 5 Reaction of **2** with 2-chloro-1,3-dicarbonyl compounds **19a**,**b** and **21**.

mass spectrometer at 70 eV. Elemental analysis was carried out at the Microanalytical Centre of Cairo University, Giza, Egypt. All reactions were followed by TLC (Silica gel, Merck).

2-[1-(Naphthalen-2-yl)ethylidene]hydrazinecarbothioamide **2**[13] and hydrazonoyl halides **3** and **4**[31,32] were prepared as reported in the literature.

Synthesis of 4-substituted-2-[2-(1-(naphthalen-2-yl)ethylidene)hydrazinyl]-5-(aryldiazenyl)thiazole (**5a–i**). *General method A*

A mixture of 2-[1-(naphthalen-2-yl)ethylidene]hydrazinecarbothioamide **2** (0.486 g, 2 mmol) and the appropriate hydrazonoyl halides **3** or **4** (2 mmol) in 1,4-dioxane (30 mL) containing TEA (0.7 mL) was refluxed for 3 h (monitored by TLC), allowed to cool and the solid formed was filtered off, washed with EtOH, dried and recrystallised from DMF to give **5a–i**.

4-Methyl-2-[2-(1-(naphthalen-2-yl)ethylidene)hydrazinyl]-5-(phenyldiazenyl)thiazole (**5a**): Yield 78%; dark red solid; m.p. 216 °C; ^{1}H NMR (DMSO-d_6): δ 2.61 (s, 3H, CH_3), 2.64 (s, 3H, CH_3), 7.33–8.24 (m, 11H, ArH), 8.45 (s, 1H, naphthalene-H1), 10.63 (s, 1H, D_2O exchangeable, NH); ^{13}C NMR (DMSO-d_6): δ 11.8, 21.4, 114.5, 119.8, 124.6, 129.8, 130.5, 134.4, 134.9, 136.7, 138.9, 140.4, 144.6, 146.5, 149.6, 152.4, 164.3, 169.8; IR (KBr): ν_{max} 1553 (N=N), 1591 (C=N), 3445 (NH) cm^{-1}; MS *m/z* (%): 385 (M$^+$, 26), 127 (100). Anal. Calcd for $C_{22}H_{19}N_5S$ (385.48): C, 68.55; H, 4.97; N, 18.17. Found C, 68.45; H, 4.64; N, 18.00%.

4-Methyl-2-[2-(1-(naphthalen-2-yl)ethylidene)hydrazinyl]-5-(p-tolyldiazenyl)thiazole (**5b**): Yield 76%; dark red solid; m.p. 228 °C; ^{1}H NMR (DMSO-d_6): δ 2.21 (s, 3H, CH_3), 2.61 (s, 3H, CH_3), 2.64 (s, 3H, CH_3), 7.30–8.24 (m, 10H, ArH), 8.46 (s, 1H, naphthalene-H1), 10.71 (s, 1H, D_2O exchangeable, NH); IR (KBr): ν_{max} 1553 (N=N), 1617 (C=N), 3478 (NH) cm^{-1}; MS *m/z* (%): 399 (M$^+$, 38), 127 (100). Anal. Calcd for $C_{23}H_{21}N_5S$ (399.51): C, 69.15; H, 5.30; N, 17.53. Found C, 69.32; H, 5.12; N, 17.29%.

5-[(4-Chlorophenyl)diazenyl]-4-methyl-2-[2-(1-(naphthalen-2-yl)-ethylidene) hydrazinyl]thiazole (**5c**): Yield 81%; dark red solid; m.p. 242 °C; ^{1}H NMR (DMSO-d_6): δ 2.64 (s, 3H, CH_3), 2.66 (s, 3H, CH_3), 7.30–8.28 (m, 10H, ArH), 8.49 (s, 1H, naphthalene-H1), 10.76 (s, 1H, D_2O exchangeable, NH); IR (KBr): ν_{max} 1556 (N=N), 1598 (C=N), 3441 (NH) cm^{-1}; MS *m/z* (%): 419 (M$^+$, 56), 127 (88), 57 (100). Anal. Calcd for $C_{22}H_{18}ClN_5S$ (419.93): C, 62.92; H, 4.32; N, 16.68. Found C, 62.76; H, 4.54; N, 16.34%.

4-Methyl-2-[2-(1-(naphthalen-2-yl)ethylidene)hydrazinyl]-5-[(4-nitrophenyl)diazenyl]thiazole (**5d**): Yield 80%; dark red solid; m.p. 182 °C; ^{1}H NMR (DMSO-d_6): δ 2.63 (s, 3H, CH_3), 2.69 (s, 3H, CH_3), 7.30–8.318 (m, 10H, ArH), 8.49 (s, 1H, naphthalene-H1), 10.79 (s, 1H, D_2O exchangeable, NH); IR (KBr): ν_{max} 1558 (N=N), 1589 (C=N), 3432 (NH) cm^{-1}; MS *m/z* (%): 430 (M$^+$, 15), 127 (100). Anal. Calcd for $C_{22}H_{18}N_6O_2S$ (430.48): C, 61.38; H, 4.21; N, 19.52. Found C, 61.12; H, 4.11; N, 19.24%.

5-[(4-Bromophenyl)diazenyl]-4-methyl-2-[2-(1-(naphthalen-2-yl)-ethylidene)hydrazinyl]thiazole (**5e**): Yield 76%; dark red solid; m.p. 232 °C; ^{1}H NMR (DMSO-d_6): δ 2.63 (s, 3H, CH_3), 2.62 (s, 3H, CH_3), 7.30–8.23 (m, 10H, ArH), 8.46 (s, 1H, naphthalene-H1), 10.72 (s, 1H, D_2O exchangeable, NH); IR (KBr): ν_{max} 1552 (N=N), 1632 (C=N), 3439 (NH) cm^{-1}; MS *m/z* (%): 463 (M$^+$, 15), 154 (100). Anal. Calcd for $C_{22}H_{18}BrN_5S$ (464.38): C, 56.90; H, 3.91; N, 15.08. Found C, 56.66; H, 3.71; N, 14.88%.

5-[(4-Methoxyphenyl)diazenyl]-4-methyl-2-[2-(1-(naphthalen-2-yl)-ethylidene)hydrazinyl]thiazole (**5f**): Yield 74%; dark red solid; m.p. 228 °C; ^{1}H NMR (DMSO-d_6): δ 2.58 (s, 3H, CH_3), 2.63 (s, 3H, CH_3), 3.74 (s, 3H, OCH_3), 6.96–7.60 (m, 10H, ArH), 8.43 (s, 1H, naphthalene-H1), 10.56 (s, 1H, D_2O exchangeable, NH); IR (KBr): ν_{max} 1553 (N=N), 1610 (C=N), 3478 (NH) cm^{-1}; MS *m/z* (%): 399 (M$^+$, 38), 127 (100). Anal. Calcd for $C_{23}H_{21}N_5OS$ (415.51): C, 66.48; H, 5.09; N, 16.85. Found C, 66.31; H, 5.21; N, 16.55%.

2-[2-(1-(Naphthalen-2-yl)ethylidene)hydrazinyl]-4-phenyl-5-(phenyldiazenyl)thiazole (**5g**): Yield 73%; dark brown solid; m.p. 220 °C; ^{1}H NMR (DMSO-d_6): δ 2.68 (s, 3H, CH_3), 7.35–8.31 (m, 16H, ArH), 8.47 (s, 1H, naphthalene-H1), 10.77 (s, 1H, D_2O exchangeable, NH); ^{13}C NMR (DMSO-d_6): δ 20.8, 116.4, 119.4, 122.7, 128.6, 132.7, 133.6, 134.8, 135.3, 136.2, 137.4, 138.9, 140.4, 141.3, 144.6, 146.5, 147.3, 149.6, 151.4, 166.1, 174.8; IR (KBr): ν_{max} 1556 (N=N), 1627 (C=N), 3448 (NH) cm^{-1}; MS *m/z* (%): 477 (M$^+$, 10), 105 (100). Anal. Calcd for $C_{27}H_{21}N_5S$ (447.55): C, 72.46; H, 4.73; N, 15.65 Found C, 72.23; H, 4.54; N, 15.45%.

5-[(4-Chlorophenyl)diazenyl]-2-[2-(1-(naphthalen-2-yl)ethylidene)-hydrazinyl]-4-phenylthiazole (**5h**): Yield 74%; dark brown solid; m.p. 194 °C; ^{1}H NMR (DMSO-d_6): δ 2.68 (s, 3H, CH_3), 7.35–8.31 (m, 15H, ArH), 8.47 (s, 1H, naphthalene-H1), 10.77 (s, 1H, D_2O exchangeable, NH);IR (KBr): ν_{max} 1553 (N=N), 1634 (C=N), 3424 (NH) cm^{-1}; MS *m/z* (%): 481 (M$^+$, 75), 70(100). Anal. Calcd for $C_{27}H_{20}ClN_5S$ (482.00): C, 67.28; H, 4.18; N, 14.53. Found C, 67.11; H, 4.28; N, 14.32%.

2-[2-(1-(Naphthalen-2-yl)ethylidene)hydrazinyl]-5-[(4-nitrophenyl)-diazenyl]-4-phenylthiazole (**5i**): Yield 72%; dark brown solid; m.p. 182 °C; ^{1}H NMR (DMSO-d_6): δ 2.68 (s, 3H, CH_3), 7.35–8.31 (m, 15H, ArH), 8.47 (s, 1H, naphthalene-H1), 10.77 (s, 1H, D_2O exchangeable, NH); IR (KBr): ν_{max} 1559 (N=N), 1602 (C=N), 3444 (NH) cm^{-1}; MS *m/z* (%): 492 (M$^+$, 5), 127(100). Anal. Calcd for $C_{27}H_{20}N_6O_2S$ (492.55): C, 65.84; H, 4.09; N, 17.06. Found C, 65.84; H, 4.09; N, 17.06%.

Synthesisof4-substituted-2-[(2-(1-(naphthalen-2-yl)ethylidene)hydrazinyl]thiazoles (**8** and **9**). *General method B*

A mixture of **2** (0.243 g, 1 mmol) and chloroacetone **6** or phenacyl bromide **7** (1 mmol) in absolute EtOH (30 mL) was refluxed for 1 h (monitored by TLC). The product started to separate out during the course of reaction. The crystalline solid was filtered, washed with water, dried and recrystallised from DMF-EtOH to give the corresponding compounds **8** and **9** respectively.

4-Methyl-2-[(2-(1-(naphthalen-2-yl)ethylidene)hydrazinyl]thiazole (**8**): Yield 72%; yellow solid; m.p. 208 °C; ^{1}H NMR (DMSO-d_6): δ 2.56 (s, 3H, CH_3), 2.66 (s, 3H, CH_3), 6.72 (s, 1H, 5-H), 7.15–8.23 (m, 6H, ArH), 8.44 (s, 1H, naphthalene-H1), 10.70 (s, 1H, D_2O exchangeable, NH); ^{13}C NMR (DMSO-d_6): δ 14.6, 21.4, 110.4, 117.4, 124.6, 128.6, 132.7, 136.2, 138.9, 140.3, 148.9, 151.6, 165.3, 171.5; IR (KBr): ν_{max} 1632 (C=N), 3442 (NH) cm^{-1}; MS *m/z* (%): 281 (M$^+$, 76), 57 (100). Anal. Calcd for $C_{16}H_{15}N_3S$ (281.38): C, 68.30; H, 5.37; N, 14.93. Found C, 68.14; H, 5.19; N, 14.68%.

2-[2-(1-(Naphthalen-2-yl)ethylidene)hydrazinyl]-4-phenylthiazole (**9**): m.p. 288 °C; lit.[33] 286 °C.

Coupling of (**8** *and* **9**) *with arenediazonium chlorides*: To a solution of **8** or **9** (1 mmol) in EtOH (20 mL) was added sodium acetate trihydrate (0.138 g, 1 mmol), and the mixture was cooled to 0–5 °C in an ice bath. To the resulting cold solution was added, portionwise, a cold solution of an arenediazonium chloride [prepared by diazotising the appropriate aniline derivative] (1 mmol) dissolved in hydrochloric acid (6 M, 1 mL) with a solution of sodium nitrite (0.07 g, 1 mmol) in water (2 mL)]. After complete addition of the diazonium salt, the reaction mixture was stirred for a further 30 min in an ice bath. The solid that separated was filtered off, washed with water and finally recrystallised from EtOH to give a product that proved to be identical in all respects (m.p., mixed m.p. and IR spectra) with compounds **5a–i** obtained from method A.

Reaction of **2** *with activated unsaturated compounds* **10** *and* **13**

4-Imino-3-[1-(naphthalen-2-yl)ethylideneamino]-2-thioxo-1,2,3,4-tetrahydropyrimidine-5-carbonitrile (**11**): A mixture of **2** (0.243 g, 1 mmol) and ethoxymethylenemalononitrile **10** (0.122g, 1 mmol) in MeOH (20 mL) was refluxed for 1 h (monitored by TLC). The reaction mixture was cooled and the resulting precipitate was filtered off and recrystallised from DMF/EtOH to give **11**. Yield 70%; yellow solid; m.p. 226 °C; ^{1}H NMR (DMSO-d_6): δ 2.42 (s, 3H, CH_3), 7.50–8.02 (m, 6H, ArH), 8.29 (s, 1H, Pyrimidine-H6), 8.30 (s, 1H, naphthalene-H1), 8.33 (s, 1H, D_2O exchangeable, NH), 10.25 (s, 1H, D_2O exchangeable, NH); ^{13}C NMR (DMSO-d_6): δ 22.1, 104.2, 117.6, 119.8, 123.6, 126.6, 130.4, 132.7, 138.9, 141.3, 148.9, 152.6, 162.3, 168.7, 184.3; IR (KBr): ν_{max} 1592 (C=N), 2220 (CN), 3234 (NH), 3400 (NH) cm^{-1};MS *m/z* (%): 319 (M$^+$, 7), 127 (100). Anal. Calcd for $C_{17}H_{13}N_5S$ (319.38): C, 63.93; H, 4.10; N, 21.93. Found C, 63.82; H, 4.00; N, 21.71%.

6-Amino-1-[1-(naphthalen-2-yl)ethylideneamino]-4-phenyl-2-thioxo-1,2-dihydropyrimidine-5-carbonitrile (**14**): A mixture of **2** (0.243 g, 1 mmol) and benzylidenemalononitrile **13** (0.154g, 1 mmol) in MeOH (20 mL) was refluxed for 1 h (monitored by TLC). The reaction mixture was cooled and the resulting precipitate was filtered off and recrystallised from DMF/EtOH to give **14**. Yield 74%; yellow solid; m.p. 189 °C; ^{1}H NMR (DMSO-d_6): δ 2.48 (s, 3H, CH_3), 6.73 (s, 2H, D_2O exchangeable, NH_2), 7.53–8.12 (m, 11H, ArH), 8.41 (s, 1H, naphthalene-H1); IR (KBr): ν_{max} 1589 (C=N), 2225 (CN), 3227, 3585 (NH_2) cm^{-1}; MS *m/z* (%): 395 (M$^+$, 2), 127(100). Anal. Calcd for $C_{23}H_{17}N_5S$ (395.48): C, 69.85; H, 4.33; N, 17.71. Found C, 69.50; H, 4.82; N, 17.62%.

*Synthesis of 5-arylidene-2-[2-(1-(naphthalen-2-yl)ethylidene)hydrazinyl]thiazol-4(5*H*)-ones* (**16a–d**)

I. *2-[2-(1-(Naphthalen-2-yl)ethylidene)hydrazinyl]thiazol-4(5*H*)-one* (**15**): A mixture of **2** (0.243 g, 1 mmol) and ethyl bromoacetate

(0.167g, 1 mmol) in EtOH (20 mL) containing anhydrous potassium carbonate (0.276 g, 2 mmol) was refluxed for 1 h (monitored by TLC). The reaction mixture was cooled and poured into cold water; the resulting precipitate was filtered off, washed with water, and recrystallised from DMF to give **15**. Yield 78%; yellow solid; m.p. 224 °C; ^{1}H NMR (DMSO-d_6): δ 2.50 (s, 3H, CH_3), 3.88 (s, 2H, CH_2),7.53–8.13 (m, 6H, ArH), 8.30 (s, 1H, naphthalene-H1) 11.96 (s, 1H, D_2O exchangeable, NH); IR (KBr): ν_{max} 1612 (C=N), 1704 (CO), 3443 (NH) cm^{-1}; MS *m/z* (%): 283 (M$^+$, 96), 154(100). Anal. Calcd for $C_{15}H_{13}N_3OS$ (283.08): C, 63.58; H, 4.62; N, 14.83. Found C, 63.43; H, 4.54; N, 14.47%.

II. *Reaction of* (**15**) *with aromatic aldehydes; general procedure*
To a solution of 5-thiazolidinone **15** (0.283 g, 1 mmol) and benzaldehyde or 4-chlorobenzaldehyde (1 mmol) in glacial acetic acid (20 mL), anhydrous sodium acetate (0.33 g, 4 mmol) was refluxed for 6 h (monitored by TLC). The reaction mixture was left to cool and the formed solid was filtered off, washed with water, dried and recrystallised from DMF to give **16a**,**b**.

*5-Benzylidene-2-[2-(1-(naphthalen-2-yl)ethylidene)hydrazinyl]-thiazol-4(5*H*)-one* (**16a**): Yield 72%; yellow solid; m.p. 254 °C; ^{1}H NMR (DMSO-d_6): δ 2.52 (s, 3H, CH_3), 7.33–8.11 (m, 11H, ArH), 8.26 (s, 1H, =CH), 8.44 (s, 1H, naphthalene-H1), 12.12 (s, 1H, D_2O exchangeable, NH); IR (KBr): ν_{max} 1610 (C=N), 1669 (CO), 3423 (NH) cm^{-1}; MS *m/z* (%): 371(M$^+$, 26), 77(100). Anal.Calcd for $C_{22}H_{17}N_3OS$ (371.45): C, 71.14; H, 4.61; N, 11.31. Found C, 71.10; H, 4.44; N, 11.01%.

*5-(4-Chlorobenzylidene)-2-[2-(1-(naphthalen-2-yl)ethylidene)hydrazinyl]thiazol-4(5*H*)-one* (**16b**): Yield 72%; yellow solid; m.p. 302 °C; ^{1}H NMR (DMSO-d_6): δ 2.53 (s, 3H, CH_3), 7.43–8.26 (m, 10H, ArH), 8.30 (s, 1H, =CH), 8.46 (s, 1H, naphthalene-H1), 12.12 (s, 1H, D_2O exchangeable, NH); IR (KBr): ν_{max} 1608 (C=N), 1662 (CO), 3427 (NH) cm^{-1}; MS *m/z* (%): 405(M$^+$, 18), 75(100). Anal. Calcd for $C_{22}H_{16}ClN_3OS$ (405.90): C, 65.10; H, 3.97; N, 10.35. Found C, 65.18; H, 3.72; N, 10.11%.

(Z)-Methyl 2-[2-(1-(naphthalen-2-yl)ethylidene)hydrazono)-4-oxothiazolidin-5-ylidene]acetate (**18**): An equimolecular mixture of **2** (0.243 g, 1 mmol) and dimethyl acetylenedicarboxylate **17** (0.142 g, 1 mmol) in MeOH (20 mL) was refluxed for 2 h (monitored by TLC). The formed solid was collected by filtration and recrystallised from DMF to give compound **18**. Yield 80%; canary yellow solid; m.p. 278 °C; ^{1}H NMR (DMSO-d_6): δ 2.57 (s, 3H, CH_3), 3.29 (s, 3H, CH_3), 6.68 (s, 1H, =CHCOOCH$_3$), 7.55–8.03 (m, 6H, ArH), 8.38 (s, 1H, naphthalene-H1), 10.43 (s, 1H, D_2O exchangeable, NH); ^{13}C NMR (DMSO-d_6): δ 17.8, 48.3, 104.2, 117.6, 120.8, 124.6, 128.6, 130.4, 132.7, 136.8, 141.3, 148.9, 162.4, 167.3, 174.7, 192.4; IR (KBr): ν_{max} 1615 (C=N), 1675, 1703 (2C=O), 3466 (NH) cm^{-1}; MS *m/z* (%): 353 (M$^+$, 92), 154 (100). Anal. Calcd for $C_{18}H_{15}N_3O_3$ S (353.39): C, 61.18; H, 4.28; N, 11.89. Found C, 61.25; H, 4.29; N, 11.57%.

Reaction of (**2**) *with 2-chloro-1,3-dicarbonyl compounds* (**19a**,**b** *and* **21**); *general procedure*
To a solution of **2** (0.243 g, 1 mmol) in EtOH was added TEA (0.7 mL) and the mixture was stirred for 10 min at room temperature. To the resulting clear solution was added the appropriate 2-chloro-1,3-dicarbonyl compound **19a**,**b** and **21** (1 mmol) dropwise whilst the reaction mixture was stirred. After complete addition, the reaction mixture was refluxed for 2 h (monitored by TLC). The solid that precipitated was filtered off, washed with H_2O, dried and finally crystallised from 1,4-dioxane to give the respective products i.e. **20a**,**b** and **22**.

Ethyl 4-methyl-2-[2-(1-(naphthalen-2-yl)ethylidene)hydrazinyl]thiazole-5-carboxylate (**20a**): Yield 71%; yellow solid; m.p. 176 °C; ^{1}H NMR (DMSO-d_6): δ 1.27 (t, 3H, CH_3), 2.52 (s, 3H, CH_3), 2.60 (s, 3H, CH_3), 4.11 (q, 2H, CH_2), 7.55–8.01 (m, 6H, ArH), 8.39 (s, 1H, naphthalene-H1), 10.40 (s, 1H, D_2O exchangeable, NH); IR (KBr): ν_{max} 1540 (C=N), 1660 (C=O), 3417 (NH) cm^{-1}. MS *m/z* (%): 353 (M$^+$, 33), 127 (100). Anal. Calcd for $C_{19}H_{19}N_3O_2S$ (353.44): C, 64.57; H, 5.42; N, 11.89. Found C, 64.24; H, 5.30; N, 11.77%.

*4-Methyl-2-[2-(1-(naphthalen-2-yl)ethylidene)hydrazinyl]-*N*-phenylthiazole-5-carboxamide* (**20b**): Yield 74%; yellow solid; m.p. 160 °C; ^{1}H NMR (DMSO-d_6): δ 2.49 (s, 3H, CH_3), 2.59 (s, 3H, CH_3), 7.09–8.13 (m, 11H, ArH), 8.23 (s, 1H, naphthalene-H1), 9.65 (s, 1H, D_2O exchangeable, NH), 11.33 (s, 1H, D_2O exchangeable, NH); IR (KBr): ν_{max} 1535 (C=N), 1629 (C=O), 3445 (NH) cm^{-1}; MS *m/z* (%): 400 (M$^+$, 27), 127 (100). Anal. Calcd for $C_{23}H_{20}N_4OS$ (400.50): C, 68.98; H, 5.03; N, 13.99. Found C, 68.77; H, 5.00; N, 13.76%.

4-Amino-2-[(1-(naphthalen-2-yl)ethylidene)hydrazono]-2,5-dihydrothiazole (**22**): Yield 76%; yellow solid; m.p. 185 °C; ^{1}H NMR (DMSO-d_6): δ 2.49 (s, 3H, CH_3), 3.98 (s, 2H, CH_2), 7.53–8.27 (m, 9H, ArH and NH_2; IR (KBr): ν_{max} 1611 (C=N), 3270, 3451 (NH_2) cm^{-1}; MS *m/z* (%): 282 (M$^+$, 72), 127 (100). Anal. Calcd for $C_{15}H_{14}N_4S$ (282.36): C, 63.80; H, 5.00; N, 19.84. Found C, 63.65; H, 5.23; N, 19.68%.

Conclusions

A series of novel 5-(aryldiazenyl)thiazole derivatives, 5-arylidene-4-thiazolone derivatives, 6-amino-4-phenyl-2-thioxo-1,2-dihydropyrimidine-5-carbonitrile derivatives and 4-imino-2-thioxo-1,2,3,4-tetrahydropyrimidine-5-carbonitrile derivatives have been synthesised readily and in a good yield from 2-(1-(naphthalen-2-yl)ethylidene) hydrazinecarbothioamide, an easily available starting material, and characterised *via* IR, NMR, MS and elemental analyses.

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