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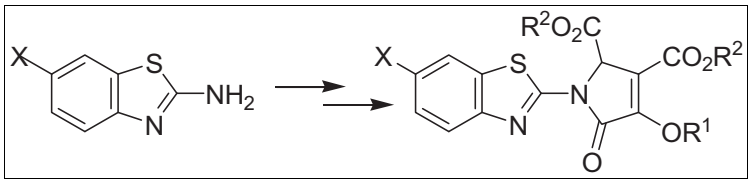

The titled products comprising of two mutually merged bioactive nucleuses, 2-aminobenzo[*d*]thiazole and 2,5-dihydropyrrole rings, were obtained from the reaction between dialkyl acetylenedicarboxylates and alkyl 2-(benzo[*d*]thiazol-2-yl)amino-2-oxoacetates in the presence of triphenylphosphine at RT.

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INTRODUCTION

1*H*-Pyrrol-2(5*H*)-one and 2-aminobenzo[*d*]thiazole are two recurrent nucleuses being found in a variety of bioactive molecules. Pyrrolidinone-containing compounds, for example, have shown to be $\alpha_v\beta_3$ antagonists with high affinity for $\alpha_v\beta_3$ receptors [1], potent CDK2 inhibitor in cellular assays [2], HIV-1 integrase inhibitor [3], HIV protease inhibitor [4], and inhibitor of influenza virus neuraminidase [5]. On the other hand, benzothiazole and 2-aminobenzothiazole motifs constitute the core of many pharmacologically functional compounds including potential antitumor agents [6], neurotransmission blockers [7], $\alpha_4\beta_1$ integrin antagonist [8], and valuable inhibitors of phosphoinositide-3-kinase [9] as well as of human mast cell tryptases [10]. In addition, there are several reports addressing distinct pharmacophoric features created from coupling of benzothiazole and pyrrolidine frameworks. These compounds were reported as peroxisome proliferator-activated receptor agonist [11], the H_3-receptor ligand [12], human cytomegalovirus protease [13], and potent inhibitors of cathepsin K, the main proteolytic enzyme secreted by osteoclasts during resorption of bone [14]. The importance of these compounds can also be evidenced to several patents issued on their applications. Therefore, it is not surprise that several routes have been developed for the synthesis of 1-(2-benzothiazolyl)pyrrolidines including the modified Hugerschoff reaction of thiourea substrates [15–17], condensation of 2-aminobenzothiazoles with cyclic anhydrides, aromatic nucleophilic substitution of 2-benzothiazolyl halides with amines [18], copper catalyzed *N*-benzothiazolylation of amines [19], copper or silver-catalyzed direct oxidative coupling of simple benzothiazoles with amines [20–22], palladium-catalyzed direct oxidative cyclization of *N*-arylthioureas [23], and palladium-catalyzed amination of 2-halobenzothioureas [24]. All of these methods have their own merit; however, some suffer from limits such as requiring harsh conditions or unavailability of the requisite substrates.

As part of our continuing interest in the development of new synthetic methods in heterocyclic chemistry [25], herein, we describe a two-step method planned for the synthesis of some novel 1-(benzo[*d*]thiazol-2-yl)-1*H*-pyrrol-2(5*H*)-ones.

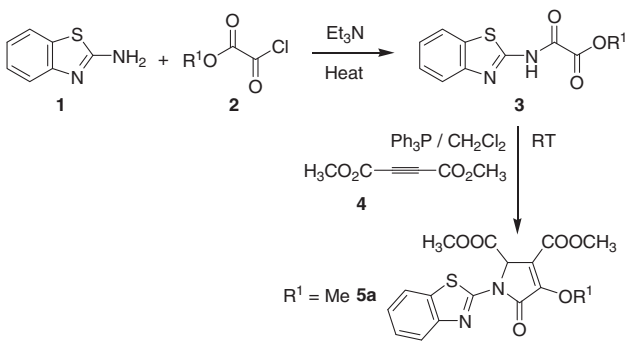
RESULTS AND DISCUSSION

To approach the synthesis of the desired dialkyl 1-(benzo[*d*]thiazol-2-yl)-4-alkoxy-5-oxo-2,5-dihydro-1*H*-pyrrole-2,3-dicarboxylates (**5**), we started from condensation of the commercially available 2-aminobenzo[*d*]thiazoles (**1**) with methyl chlorooxylate (**2a**) to obtain the required intermediate substrate, ethyl 2-(benzo[*d*]thiazol-2-yl) amino-2-oxoacetate (**3**). This reaction was carried out in dichloromethane solution wherein the initial product precipitates once is formed as the hydrochloride salt. The salt was neutralized *in situ*, without separation, by addition of triethylamine and heating until complete dissolution of the salts. Removal of the solvent by evaporation gave a fairly high yield of the required compound **3**. Fortunately, no cyclization-byproduct was formed via a probable intramolecular amidation of **3** under the applied neutralization conditions. Synthesis of the final product was achieved by the subsequent cyclocondensation reaction that is thought to proceed through an

intramolecular Wittig reaction. In this regard, the obtained substrate **3** was treated with almost equimolar quantities of triphenylphosphine and dimethyl acetylenedicarboxylate at around −5°C. This final step of synthesis proceeded smoothly without the aid of any stimulating energy sources or catalysts to give the product **5a** in fairly high yields (Scheme 1).

It is worthy to note that no byproduct beside **5a** was resolved from the tarry residue by column chromatography. Encouraged by this successful trial synthesis, we set out to explore the generality of this synthetic route by examining the scope of substrates. As a result, a variety of substrates were employed in this survey leading to synthesis of several new products that lend credit to viability of the present route even with substrate variation. Yields of several products synthesized by this method, as shown in Table 1, reveal no remarkable trend arising from any dependence on the size of alkyl substituents present at the ester groups. Nevertheless, presence of an electron-withdrawing nitro group at 5-position of 2-aminobenzo[*d*]thiazole (**1**) resulted in the lowest yields in this table.

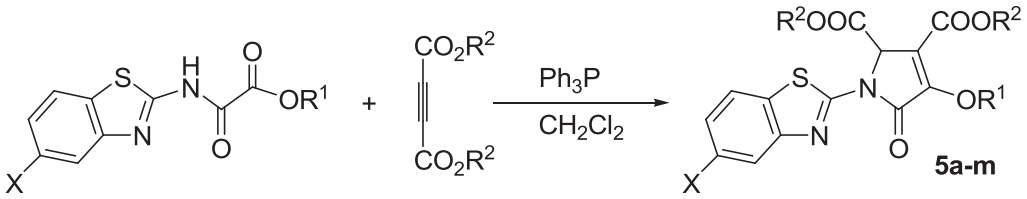
Scheme 1. The sequence of reactions leading to synthesis of the product. **5a**.



However, we have not studied the mechanism of the reactions in details; a plausible pathway for the consecutive events leading to formation of the intermediates and the products is presented in Scheme 2. It is likely that the cascade of reactions is triggered by the Michael-addition of triphenylphosphine on acetylenic ester, resulting in formation of a zwitterionic adduct [26] which by removing the amidic proton of the substrate **3** turns into a more electrophilic phosphonium species and leave the conjugate base of the amide aside **6**. Subsequent conjugate addition of the anionic amide onto phosphonium cation gives the key phosphorane ylide **7** that is prone to follow an intramolecular Wittig reaction to produce the final product. On the basis of this proposal, one may reasonably

Table 1

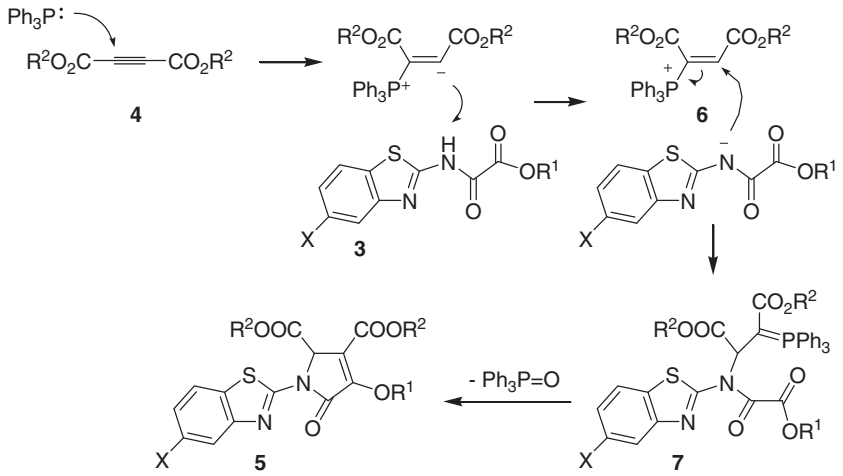
Syntheses of 1-(benzo[*d*]thiazol-2-yl)-4-alkoxy-5-oxo-2,5-dihydro-1*H*-pyrrole-2,3-dicarboxylates (**5**) from reaction of alkyl 2-(benzo[*d*]thiazol-2-yl) amino-2-oxoacetate (**3**) and dialkylacetylene dicarboxylate (**4**).



Yield (%)[a]	R^2	R^1	X	Product
74	Me	Me	H	**5a**
88	Et	Me	H	**5b**
78	*i*-Pr	Me	H	**5c**
84	*t*-Bu	Me	H	**5d**
90	Neopentyl	Me	H	**5e**
98	*i*-Pr	Et	H	**5f**
69	Me	Et	H	**5g**
67	Et	Et	H	**5h**
61	*t*-Bu	Et	H	**5i**
86	Me	Et	Me	**5j**
81	Et	Et	Me	**5k**
57	Me	Et	NO_2	**5l**
53	Et	Et	NO_2	**5m**

[a]Isolated yields.

Scheme 2. A proposed mechanism for the formation of products **5**.



ascribe the success of this synthetic method to the acidity of the amidic proton of the substrate **3** and in turn to the electron-withdrawing effect of benzo[*d*]thiazole ring. However, the electron-withdrawing effect of the benzo [*d*]thiazole ring is not too extensive to make the preparation of amide (**3**) difficult.

Structures of all the products are well consistent with their IR, ^{1}H-NMR, ^{13}C-NMR, and mass spectral data as well as elemental microanalyses. The mass spectrum of **5a**, for example, displayed the molecular ion peak at $m/z = 375$, which is consistent with the 1:1 adduct of dimethyl acetylenedicarboxylate and the substrate **3** associated with loss of a water molecule. The IR spectrum of this compound exhibited well defined absorptions in harmony with its characteristic vibrations. Of notable are three absorption bands arising from the nonconjugated ester group at 1740 cm^{-1}, the conjugated ester group at 1690 cm^{-1}, and the γ-lactam carbonyl at 1725 cm^{-1}. There are two strong and characteristic bands centered at 1440 and 1350 cm^{-1} in IR spectra of all the products, attributable to the typical vibrations of pyrrol-2(5*H*)-one ring. The ^{1}H-NMR spectrum of this product displayed three sharp lines readily recognized as arising from three methoxy groups. There was observed also a fairly sharp singlet for the allylic proton of the pyrrol-2(5*H*)-one ring along with four characteristic signals of appropriate chemical shifts and coupling constants for the four aromatic protons. The ^{13}C{^{1}H}NMR spectrum of **5a** showed 17 distinct resonances in agreement with the proposed structure. Partial assignments of these resonances are suggested in the Experimental section.

CONCLUSION

In conclusion, a two-step route was devised to merge the two biologically important nucleuses, 2-aminobenzo [*d*]thiazole and 1*H*-pyrrol-2(5*H*)-one, into an elaborated heterocyclic framework, providing the synthesis of novel dialkyl 1-(benzo[*d*]thiazol-2-yl)-4-alkoxy-5-oxo-2,5-dihydro-1*H*-pyrrole-2,3-dicarboxylates. The efficiency of these syntheses might be attributed to the moderate electron-withdrawing effect of benzo[*d*]thiazole ring making its 2-amido-substituent acidic enough to proceed the intramolecular Wittig reaction, whereas do not prevent the precursor's 2-amino group from being sufficiently nucleophilic to undergo acylation with alkyl chlorooxylates.

EXPERIMENTAL

General. All of the solvents and reagents were purchased from Fluka (Buchs, Switzerland) or Merck (Darmstadt, Germany) chemical companies. Progress of the reactions were monitored by chromatography using silica gel-coated aluminum sheets using 1:1 mixture of petroleum ether and ethyl acetate as eluents. Melting points were measured on an Electrothermal apparatus and are uncorrected. IR spectra were obtained in KBr disks on a Shimadzu IR-470 spectrometer (Kyoto, Japan). ^{1}H-NMR and ^{13}C-NMR spectra were measured with Bruker (Karlsruhe, Germany) DRX AVANCE spectrometers. Chemical shifts of ^{1}H-NMR and ^{13}C-NMR spectra were expressed in parts per million downfield from TMS. Mass spectra were recorded on a (Kyoto, Japan) QP1100EX mass spectrometer operating at an ionization potential of 70 eV. Elemental analyses for C, H, and N were performed using a Foss Heraus (Hanau, Germany) CHN-O-rapid analyzer.

Typical preparation of ethyl 2-(benzo[*d*]thiazol-2-yl)amino-2-oxoacetate (3a). To a 25-mL round-bottomed flask containing a magnetic stirring bar and a solution of 0.136 g ethyl chlorooxylate (1 mmol) in 5 mL dichloromethane was added dropwise and under stirring a solution of 0.150 g (1 mmol) 2-aminobenzothiazole in 10 mL dichloromethane over 10 min. The white solids appeared immediately after addition was dissolved by heating the mixture up to 40°C and addition of triethylamine until achieving a clear solution. At this instance, a yellow solution is obtained, which was stirred for 6 h. To workup the reaction, the solvent was evaporated under vaccuo, and the remaining solid was recrystallized from ethanol (95.5%).

Typical synthesis of compound 5a. To a stirred solution of ethyl 2-(benzo[*d*]thiazol-2-yl)amino-2-oxoacetate (**3a**) 0.250 g (1 mmol) and triphenylphosphine 0.314 g (1.2 mmol) in 10 mL dichloromethane at −12°C was added dropwise a solution of dimethyl acetylenedicarboxylate 0.170 g (1.2 mmol) in 2 mL dichloromethane over 10 min. The reaction mixture was stirred further overnight, and the product was separated by column chromatography on silica gel (230–400 mesh) support using petroleum ether and ethyl acetate (1:1) as eluents. The separated product was recrystallized from ethanol (95.5%) to give 0.26 g (69%) of the product dimethyl 1-(benzo[*d*]thiazol-2-yl)-4-methoxy-5-oxo-2,5-dihydro-1*H*-pyrrole-2,3-dicarboxylate (**5a**), mp 103–105°C.

Dimethyl 1-(1,3-benzo[d]thiazol-2-yl)-4-methoxy-5-oxo-2,5-dihydro-1H-pyrrol-2,3-dicarboxylate (5a). White solid, yield (0.27 g) 74%. mp 179.5–182°C; IR (potassium bromide): 3050, 2950 (C—H str.) 1690, 1725, and 1740 (C═O), 1630, 1520, 1350, 1440 (3-pyrrolin-2-one ring) cm^{-1}. ^{1}H-NMR (300.13 MHz, deuterated chloroform): δ_H 7.81 (2H, d, J = 8.1 Hz, 4′-H and 7′-H), 7.43 (1H, m), 7.30 (1H, m), 5.61 (1H, s, 2-H), 4.39 (3H, s, OCH_3), 3.85 (3H, s, OCH_3), 3.80 (3H, s, OCH_3). ^{13}C-NMR (75.48 MHz, deuterated chloroform): δ_C 167.67, 162.85, 161.61 (3 C═O), 154.70, 153.07, 148.35 (C-2′, C-4, C-3′a), 132.11, 126.37, 124.51, 121.93, 121.42, 113.78 (C-3), 60.36, 60.07 (C-2 and OCH_3), 53.40, 52.36 (2 OCH_3). MS (EI) *m/z* (%): 362 (M^+, 5), 364 (8), 303 (97), 275 (65), 229 (50), 134 (16). *Anal*. Calcd for $C_{16}H_{14}N_2O_6S$: C, 53.03; H, 3.89; N, 7.73. Found: C, 53.18; H, 4.02; N, 7.69.

Diethyl 1-(1,3-benzo[d]thiazol-2-yl)-4-methoxy-5-oxo-2,5-dihydro-1H-pyrrol-2,3-dicarboxylate (5b). White crystals, yield (0.34 g) 88%. mp 119–121°C; IR (potassium bromide): 3050, 2950 (C—H str.), 1740, 1722, 1690 (C═O), 1640, 1520, 1440, 1375 (3-pyrrolin-2-one ring) cm^{-1}. ^{1}H-NMR (300.13 MHz, deuterated chloroform): δ_H 7.85 (1H, d, J = 8.4 Hz), 7.83 (1H, d, J = 8.7 Hz), 7.40 (1H, t, J = 7.3 Hz), 7.29 (1H, t, J = 7.8 Hz), 5.59 (1H, s, 2-H), 4.36 (3H, S, OCH_3), 4.17–4.32 (4H, m, 2 OCH_2), 1.34 (3H, t, J = 7.1 Hz CH_3), 1.25 (3H, t, J = 7.1 Hz CH_3). ^{13}C-NMR (75.48 MHz, deuterated chloroform): δ_C 167.14, 162.94, 161.02 (C═O), 154.79, 153.08, 148.32 (C-2′, C-3′a, C-4), 132.14, 126.34, 124.42, 121.74, 121.43, 114.04 (C-3), 62.41, 61.45, 60.45, 60.34 (2OCH_2, C-2 and OCH_2) 14.09, 14.03 (2CH_3). MS (EI) *m/z* (%): 390 (M^+, 2), 317 (3), 279 (4), 167 (30), 149 (100), 112 (17), 70 (54), 57 (52), 43 (95), 40 (65). *Anal*. Calcd for $C_{18}H_{18}N_2O_6S$: C, 55.38; H, 4.65; N, 7.18. Found: C, 55.49; H, 4.73; N, 7.11.

Diisopropyl 1-(1,3-benzo[d]thiazol-2-yl)-4-methoxy-5-oxo-2,5-dihydro-1H-pyrrol-2,3-dicarboxylate (5c). White solid, yield (0.33 g) 78%. mp 139–141°C; IR (potassium bromide): 3040, 2950 (C—H str.), 1738, 1723, and 1688 (C═O), 1630, 1520, 1430, 1370 (3-pyrrolin-2-one ring) cm^{-1}. ^{1}H-NMR (300.13 MHz, deuterated chloroform): δ_H 7.80 (2H, t, J = 8.5 Hz, 4′-H and 7′-H), 7.42 (1H, t, J = 8.5 Hz), 7.30 (1H, m), 5.58 (1H, s, 2-H), 5.04–5.27 (2H, 2 sep., J = 6.2 Hz, 2 $OCH(CH_3)_2$), 4.37 (3H, s, OCH_3), 1.30–1.35 (9H, m, 2 $CH(CH_3)_2$), 1.21 (3H, d, J = 6.3 Hz, $CH(CH_3)_2$). ^{13}C-NMR (75.48 MHz, deuterated chloroform): δ_C 166.58, 163.12, 160.64 (3 C═O), 154.87, 152.95, 148.31 (C-2′, C-4, C-3′a), 132.18, 126.36, 124.40, 121.64, 121.47, 114.55 (C-3), 70.47, 69.47 (2 OCH), 60.62 (OCH_3), 60.48 (C-2), 21.82, 21.77 (2 CH_3 of $OCH(CH_3)_2$), 21.55, 21.58 (2 CH_3 of $OCH(CH_3)_2$); MS (EI) *m/z* (%): 418 (M^+, 8), 359 (3), 332 (15), 289 (24), 273 (16), 229 (14), 202 (30), 174 (17), 161 (22), 134 (13), 43 (100). *Anal*. Calcd for $C_{20}H_{22}N_2O_6S$: C, 57.40; H, 5.30; N, 6.69. Found: C, 57.33; H, 5.32; N, 6.74.

Di-tert-butyl 1-(1,3-benzo[d]thiazol-2-yl)-4-methoxy-5-oxo-2,5-dihydro-1H-pyrrole-2,3-dicarboxylate (5d). White solid, yield (0.37 g) 84%. mp 144–147°C; IR (potassium bromide): 3050, 2950 (C—H str.), 1740, 1725, and 1690 (C═O), 1640, 1520, 1425, 1355 (3-pyrrolin-2-one ring) cm^{-1}. ^{1}H-NMR (300.13 MHz, deuterated chloroform): δ_H 7.80 (2H, t, J = 7.4 Hz, 4′-H and 7′-H), 7.42 (1H, t, J = 7.4 Hz), 7.31 (1H, m), 5.47 (1H, s, 2-H), 4.34 (OMe), 1.56 (9H, s, $C(CH_3)_3$), 1.40 (9H, s, $C(CH_3)_3$). ^{13}C-NMR (75.48 MHz, deuterated chloroform): δ_C 165.53, 163.31, 160.35 (3 C═O), 154.95, 152.26, 148.35 (C-2′, C-4, C-3′a), 132.18, 126.34, 124.33, 121.57, 121.46, 116.14 (C-3), 83.24 and 82.98 (2 $OC(CH_3)_3$), 61.54 (OCH_3), 60.15 (C-2), 28.11, 27.74 (2 $C(CH_3)_3$); MS (EI) *m/z* (%): 446 (M^+, 1), 346 (2), 290 (14), 202 (10), 167 (16), 149 (62),56 (100). *Anal*. Calcd for $C_{22}H_{26}N_2O_6S$: C, 59.18; H, 5.87; N, 6.27. Found: C, 59.16; H, 5.91; N, 6.22.

Bis-2,2-dimethylpropyl 1-(1,3-benzo[d]thiazol-2-yl)-4-methoxy-5-oxo-2,5-dihydro-1H-pyrrole-2,3-dicarboxylate (5e). White solid, yield (0.43 g) 90%. mp 161–164°C; IR (potassium bromide): 3050, 2950 (C—H str.), 1737, 1725, and 1692 (C═O), 1640, 1520, 1430, 1355 (3-pyrrolin-2-one ring) cm^{-1}. ^{1}H-NMR (300.13 MHz, deuterated chloroform): δ_H 7.89 (2H, t, J = 8.8 Hz, 4′-H and 7′-H), 7.43 (1H, t, J = 7.3 Hz), 7.31 (1H, m), 5.70 (1H, s, 2-H), 4.40 (OMe), 3.76–4.02 (4H, m, 2 OCH_2), 4.78 (2H, q, J = 7.0 Hz, OCH_2CH_3), 1.44 (3H, t, J = 7.0 Hz, OCH_2CH_3), 1.02 (9H, s, $C(CH_3)_3$), 0.90 (9H, s, $C(CH_3)_3$). ^{13}C-NMR (75.48 MHz, deuterated chloroform): δ_C 166.89, 163.14, 161.46 (3 C═O), 154.72, 153.03, 148.38 (C-2′, C-4, C-3′a), 132.16, 126.36, 124.44, 121.85, 121.42, 114.97 (C-3), 75.56 and 74.84 (2 OCH_2), 60.30 (OCH_3), 60.16 (C-2), 31.65, 31.54 (2 $C(CH_3)_3$), 26.48, 26.30 (2 C $(CH_3)_3$). MS (EI) *m/z* (%): 474 (M^+, 1), 360 (3), 279 (5), 167 (24), 149 (100), 112 (13). *Anal*. Calcd for $C_{24}H_{30}N_2O_6S$: C, 60.74; H, 6.37; N, 5.90. Found: C, 60.70; H, 6.44; N, 5.91.

Diisopropyl 1-(1,3-benzo[d]thiazol-2-yl)-4-ethoxy-5-oxo-2,5-dihydro-1H-pyrrole-2,3-dicarboxylate (5f). White solid, yield (0.35 g) 97.5%. mp 114–116°C; IR (potassium bromide): 3050, 2950 (C—H str.), 1738, 1722, and 1687 (C═O), 1630, 1520, 1430, 1360 (3-pyrrolin-2-one ring) cm^{-1}. ^{1}H-NMR (300.13 MHz, deuterated chloroform): δ_H 7.79 (2H, t, J = 8.4 Hz, 4′-H and 7′-H), 7.30 (1H, m), 7.42 (1H, m), 7.30 (1H, m), 5.59 (1H, s, 2-H), 5.10–5.18 (2H, 2 sep., J = 6.3 Hz, $OCH(CH_3)_2$), 4.78 (2H, q, J = 7.0 Hz, OCH_2CH_3), 1.44 (3H, t, J = 7.0 Hz, OCH_2CH_3), 1.30–1.34 (9H, m, $CH(CH_3)_2$), 1.21 (3H, d, J = 6.3 Hz, $CH(CH_3)_2$). ^{13}C-NMR (75.48 MHz, deuterated chloroform): δ_C 166.68, 163.32, 160.75 (3 C═O), 154.93, 152.62, 148.32 (C-2′, C-4, C-3′a), 132.17, 126.34, 124.37, 121.63, 121.45, 113.78 (C-3), 70.41 (OCH_2CH_3), 69.32, 69.03 (2 OCH ester), 60.64 (C-2), 21.79, 21.83 (2 CH_3 of $OCH(CH_3)_2$), 21.53, 21.57 (2 CH_3 of $OCH(CH_3)_2$), 15.58 (OCH_2CH_3). MS (EI) *m/z* (%): 432 (M^+, 1.37), 272 (14), 230 (48), 167 (38), 149 (38). *Anal*. Calcd for $C_{21}H_{24}N_2O_6S$: C, 58.32; H, 5.59; N, 6.48. Found: C, 58.29; H, 5.67; N, 6.44.

Dimethyl 1-(benzo[d]thiazol-2-yl)-4-ethoxy-5-oxo-2,5-dihydro-1H-pyrrole-2,3-dicarboxylate (5g). White crystals, yield (0.26 g) 69%. mp 103–105°C; IR (potassium bromide): 3050, 2950 (C—H str.) 1689, 1724, and 1736 (C═O), 1630, 1520, 1350, 1440 (3-pyrrolin-2-one ring) cm^{-1}. ^{1}H-NMR (500.13 MHz,

deuterated chloroform): δ_H 7.84 (2H, d, J = 8.2 Hz, 4′-H and 7′-H), 7.45 (1H, t, J = 7.6 Hz), 7.34 (1H, t, J = 7.9 Hz), 5.66 (1H, s, 2-H), 4.83 (2H, q, J = 7.0 Hz, OCH_2), 3.88 (3H, s, OCH_3), 3.82 (3H, s, OCH_3), 1.48 (3H, t, J = 7.0 Hz, CH_3). ^{13}C-NMR (125.77 MHz, deuterated chloroform): δ_C 168.17, 163.45, and 162.15 (3 C═O), 155.22, 153.29, 148.82 (C-2′, C-4, C-3′a), 132.57, 126.77, 124.90, 122.35, 121.83, 114.61 (C-3), 69.51, 60.57 (C-2 and OCH_2), 53.79, 52.69 (2 OCH_3), 16.08 (CH_3). MS (EI) *m/z* (%): 375 (M^+, 5), 279 (22.1), 167 (64), 149 (100), 57 (46), 29 (10). *Anal*. Calcd for $C_{17}H_{16}N_2O_6S$: C, 54.25; H, 4.28; N, 7.44. Found: C, 54.19; H, 4.39; N, 7.40.

Diethyl 1-(benzo[d]thiazol-2-yl)-4-ethoxy-5-oxo-2,5-dihydro-1H-pyrrole-2,3-dicarboxylate (5h). White crystals, yield (0.27 g) 67%. mp 90–93°C. IR (potassium bromide): 3050, 2980 (C—H str.), 1740, 1722 (C═O), 1636, 1518, 1442 (3-pyrrolin-2-one ring), 1375 cm^{-1}. ^{1}H-NMR (500.13 MHz, deuterated chloroform): δ_H 7.85 (1H, d, J = 8.4 Hz), 7.83 (1H, d, J = 8.7 Hz), 7.46 (1H, t, J = 7.9 Hz), 7.35 (1H, t, J = 7.6 Hz), 5.66 (1H, s, 2-H), 4.83 (2H, q, J = 7.0 Hz, 4-OCH_2), 4.37–4.32 (3H, m, OCH_2), 4.27–4.24 (1H, m, OCH_2), 1.48 (3H, t, J = 7.0 Hz CH_3), 1.39 (3H, t, J = 7.1 Hz CH_3), 1.31 (3H, t, J = 7.1 Hz, CH_3). ^{13}C-NMR (125.77 MHz, deuterated chloroform): δ_C 167.63, 163.61, 161.60 (C═O), 155.32, 153.26, 148.82 (C-2′, C-3′a, C-4), 132.63, 126.76, 124.84, 122.20, 121.68, 114.96 (C-3), 69.55, 62.83, 61.79, 60.85 (C-2 and 3OCH_2) 16.03, 14.51, 14.46 (3CH_3). MS (EI) *m/z* (%): 404 (M^+, 6), 257 (54), 125 (50), 84 (47), 57 (100), 43 (71), 29 (11). *Anal*. Calcd for $C_{19}H_{20}N_2O_6S$: C, 56.42; H, 4.98; N, 6.93. Found: C, 56.47; H, 5.07; N, 7.78.

Di-tert-butyl 1-(benzo[d]thiazol-2-yl)-4-ethoxy-5-oxo-2,5-dihydro-1H-pyrrole-2,3-dicarboxylate (5i). White powder, yield (0.28 g) 61%. mp 120–122°C; IR (potassium bromide): 3072, 2990 (C—H str.), 1739, 1717, 1700 (C═O), 1630, 1520, 1440, 1363 (3-pyrrolin-2-one ring), 1260 cm^{-1}. ^{1}H-NMR (500.13 MHz, deuterated chloroform): δ_H 7.84 (2H, t, J = 7.4 Hz, 4′-H and 7′-H), 7.46 (1H, t, J = 7.5 Hz), 7.34 (1H, t, J = 7.8 Hz), 5.52 (1H, s, 2-H), 4.81–4.76 (2H, m, —OCH_2), 1.60 (9H, s, $C(CH_3)_3$), 1.48 (3H, t, J = 7.0 Hz, OCH_2CH_3), 1.44 (9H, s, $C(CH_3)_3$). ^{13}C-NMR (125.77 MHz, deuterated chloroform): δ_C 166.06, 164.01, and 160.84 (3 C═O), 155.47, 152.30, 148.85 (C-2′, C-3′a, C-4), 132.66, 126.73, 124.71, 122.01, 121.86, 117.23 (C-3), 83.57, 83.18 (2 $OC(CH_3)_3$), 69.08, 62.04 (C-2 and OCH_2), 28.56, 28.18 (2 $C(CH_3)_3$), 16.01 (OCH_2CH_3); MS (EI) *m/z* (%): 460 (M^+, 14.1), 360 (47), 304 (95), 257 (18), 161 (34), 57 (100). *Anal*. Calcd for $C_{23}H_{28}N_2O_6S$: C, 59.98; H, 6.13; N, 6.08. Found: C, 60.06; H, 6.18; N, 6.01.

Dimethyl 1-(6-methylbenzo[d]thiazol-2-yl)-4-ethoxy-5-oxo-2,5-dihydro-1H-pyrrole-2,3-dicarboxylate (5j). White powder, yield (0.336 g) 86%. mp 150–152°C; IR (potassium bromide): 3060, 2950 (C—H str.), 1737, 1711 (C═O), 1633, 1521, 1438, 1360 (3-pyrrolin-2-one ring), 1233, 1200 cm^{-1}. ^{1}H-NMR (400 MHz, deuterated chloroform): δ_H 7.72 (1H, d, J = 8.0 Hz, 4′-H), 7.64 (1H, d, J = 2.0 Hz, 7′-H), 7.27 (1H, *dd*, J = 8.0 and 2.0 Hz, 5′-H), 5.65 (1H, s, H-2), 4.85 (2H, q, J = 7.0 Hz, 4-OCH_2—CH_3), 3.88 (3H, s, CO_2CH_3), 3.82 (3H, s, CO_2CH_3), 2.49 (3H, s, 6′-CH_3), 1.48 (3H, t, J = 7.0 Hz, 4-OCH_2CH_3). ^{13}C-NMR (100 MHz, deuterated chloroform): δ_C 167.80, 162.96, 161.78, 154.00, 153.00 (3 C═O, C-2′ and C-4), 146.37 (C-3′a), 134.63, 132.29 (C-6′ and C-7′a), 127.86, 121.50, 121.17 (C-4′, C-5′, and C-7′), 114.01 (C-3), 69.08 (C-2), 60.13 (4-OCH_2), 53.39, 52.29 (2 CO_2CH_3), 21.51 (6′-CH_3), 15.70 (OCH_2CH_3); MS (EI) *m/z* (%): 390 (M^+, 100), 375 (M^+ —CH_3, 12), 323 (20), 333 (25), 289 (22), 271 (42), 243 (40), 175 (47). *Anal*. Calcd for $C_{18}H_{18}N_2O_6S$: C, 55.38; H, 4.65; N, 7.18. Found: C, 55.27; H, 4.62; N, 7.19.

Diethyl 1-(6-methylbenzo[d]thiazol-2-yl)-4-ethoxy-5-oxo-2,5-dihydro-1H-pyrrole-2,3-dicarboxylate (5k). Pale yellow powder, yield (0.339 g) 81%. mp 100–102°C; IR (potassium bromide): 3054, 29 (C—H str.), 1743, 1722, 1694 (C═O), 1627 (C═C str.), 1519, 1440, 1364 (3-pyrrolin-2-one ring), 1190 cm^{-1}. ^{1}H-NMR (400 MHz, deuterated chloroform): δ_H 7.70 (1H, d, J = 8.4 Hz, 4′-H), 7.63 (1H, s, 7′-H), 7.26 (1H, dd, J = 8.4 and 1.2 Hz, 5′-H), 5.63 (1H, s, 2-H), 4.82 (2H, q, J = 7.2 Hz, 3-OCH_2CH_3), 4.35–4.24 (4H, m, 2 $CO_2CH_2CH_3$), 1.47 (3H, t, J = 7.2 Hz, CH_3), 1.37 (3H, t, J = 7.2 Hz, CH_3), 1.29 (3H, t, J = 7.2 Hz, CH_3). ^{13}C-NMR (100 MHz, deuterated chloroform): δ_C 167.26, 163.10, 161.21, 154.10, 152.95 (3 C═O, C-2′ and C-4), 146.35 (C-3′a), 134.54, 132.34 (C-6′ and C-7′a), 127.84, 121.33, 121.20 (C-4′, C-5′ and C-7′), 114.36 (C-3), 69.10 (C-2), 62.40, 61.36, 60.41 (3 O—CH_2), 21.50 (6′-CH_3), 15.63, 14.10, 14.04 (3 OCH_2CH_3); 418 (M^+, 100), 345 (19), 289 (59), 271 (68), 243 (48), 175 (64). *Anal*. Calcd for $C_{20}H_{22}N_2O_6S$: C, 57.40; H, 5.30; N, 6.69. Found: C, 57.38; H, 5.35; N, 6.63.

Dimethyl 1-(6-nitrobenzo[d]thiazol-2-yl)-4-ethoxy-5-oxo-2,5-dihydro-1H-pyrrole-2,3-dicarboxylate (5l). Creamy powder, yield (0.240 g) 57%. mp 172–174°C; IR (potassium bromide): 3089, 2948 (C—H str.), 1736, 1717 (C═O), 1638 (C═C str.), 1520, 1505, 1442, 1337 (NO_2), 1217 cm^{-1}. ^{1}H-NMR (400 MHz, deuterated chloroform): δ_H 8.78 (1H, d, J = 2.4 Hz, 7′-H), 8.35 (1H, dd, J = 8.8 and 2.0 Hz, 5′-H), 7.90 (1H, d, J = 8.8 Hz, 4′-H), 5.67 (1H, s, 2-H), 4.83 (2H, q, J = 7.2 Hz, 3-OCH_2CH_3), 3.90 (3H, s, OCH_3), 3.85 (3H, s, OCH_3), 1.49 (3H, t, J = 7.2 Hz, 3-OCH_2CH_3). ^{13}C-NMR (100 MHz, deuterated chloroform): δ_C 167.36, 163.45, 161.58, 159.05, 152.80, 152.32 (3 C═O, C-4, C-2′, C-6′), 144.37, 132.57 (C-3′a and C-7′a), 122.16, 121.94, 118.19 (C-4′, C-5′, and C-7′), 114.86 (C-3), 69.35 (C-2), 60.20 (3-OCH_2), 53.61, 52.49 (2 OCH_3), 15.65 (OCH_2CH_3); 421 (M^+, 100), 405 (40), 362 (31), 320 (38), 302 (61), 274 (85), 205 (54). *Anal*. Calcd for $C_{17}H_{15}N_3O_8S$: C, 48.46; H, 3.59; N, 9.97. Found: C, 48.37; H, 3.56; N, 10.12.

Diethyl 1-(6-nitrobenzo[d]thiazol-2-yl)-4-ethoxy-5-oxo-2,5-dihydro-1H-pyrrole-2,3-dicarboxylate (5m). Creamy powder, yield (0.238 g) 53%. mp 170–172°C; IR (potassium bromide): 3100, 2997 (C—H str.), 1739, 1718 (C═O), 1632 (C═C str.), 1507, 1440, 1338 (NO_2), 1200 cm^{-1}. ^{1}H-NMR (400 MHz, deuterated chloroform): δ_H 8.79 (1H, d, J = 2.2 Hz, 7′-H), 8.35 (1H, dd, J = 8.8 and 2.2 Hz, 5′-H), 7.88 (1H, d, J = 9.2 Hz, 4′-H), 5.66 (1H, s, 2-H), 4.81 (2H, q, J = 6.8 Hz, 3-OCH_2CH_3), 4.38–4.25 (4H, m, 2 $CO_2CH_2CH_3$), 1.49 (3H, t, J = 6.8 Hz, CH_3), 1.39 (3H, t, J = 6.8 Hz, CH_3), 1.32 (3H, t, J = 6.8 Hz, CH_3). ^{13}C-NMR (100 MHz, deuterated chloroform): δ_C 166.81, 163.60, 161.02, 159.16, 152.80, 152.24 (3 C═O, C-4, C-2′, C-6′), 144.34, 132.61 (C-3′a and C-7′a), 122.18, 121.75, 118.23 (C-4′, C-5′, and C-7′), 115.22 (C-3), 69.38 (C-2), 62.70, 61.64, 60.49 (3 OCH_2), 15.58 (CH_3), 14.09 (CH_3), 14.06 (CH_3); 449 (M^+, 36), 377 (43), 348 (34), 320 (68), 302 (73), 274 (100), 206 (69). *Anal*. Calcd for $C_{19}H_{19}N_3O_8S$: C, 50.78; H, 4.26; N, 9.35. Found: C, 50.80; H, 4.34; N, 9.23.

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