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New Schiff bases from 2,5-bis-(butylsulfanyl)-2,3-dihydro-4*H*-pyran-2-carbaldehyde

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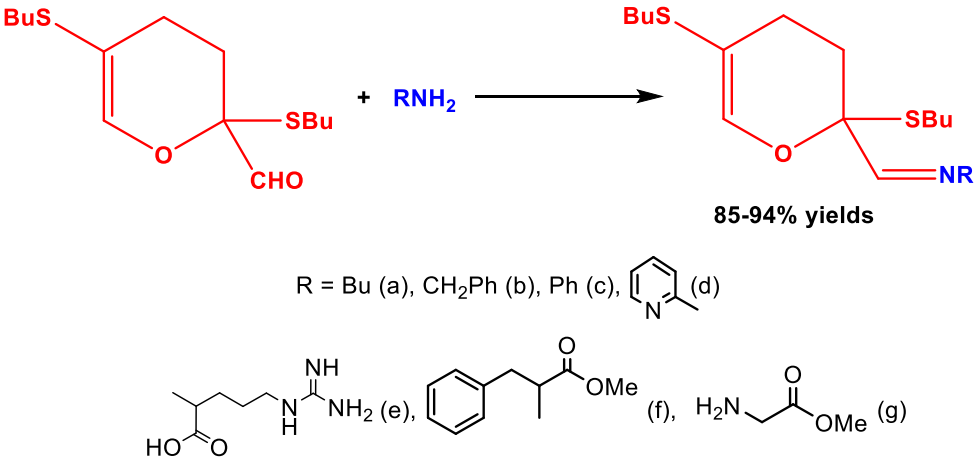
Abstract

Novel densely functionalized Schiff bases have been synthesized by the reaction of 2,5-bis-(butylsulfanyl)-2,3-dihydro-4*H*-pyran-2-carbaldehyde with primary amines and amino acids. Structure of the obtained compounds is confirmed using the data of elemental analysis, IR and NMR techniques, and chromatomass-spectrometry.



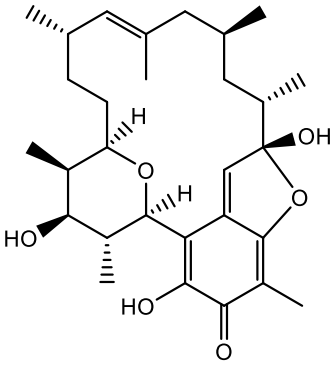
Keywords: Schiff bases, azomethines, 2,5-bis-(butylsulfanyl)-2,3-dihydro-4*H*-pyran-2-carbaldehyde, aldehydes, primary amines, amino acids

Introduction

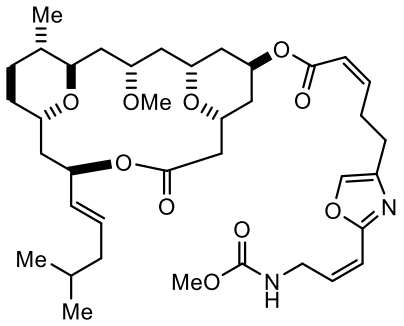
Schiff bases, also known as imines or azomethines, represent an important class of organic compounds, which originate from condensation of primary amines and active carbonyls.[1,2] Schiff bases are among the most widely employed chemical substances that fin application as pigments and dyes, temperature sensors, corrosion inhibitors, catalysts for many reactions, intermediates in organic synthesis and ligands in coordination chemistry.[3-9] Schiff bases also exhibit a wide range of biological activity, including antibacterial, hypotensive, antifungal, antipyretic, anti-tumor, anti-inflammatory and anti-HIV.[10,11]

Of particular interest are derivatives of Schiff bases with amino acids,[12,13] building blocks for the synthesis of proteins and polypeptides[14,15] and various heterocyclic compounds.[16,17] The complexes of amino acid with Schiff bases have gained distinction due to their physiological and pharmacological activity.[18-20] These are very attractive compounds that mimic metal enzymes found in living organisms.[21,22]

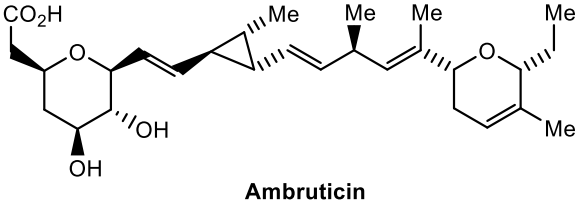
Dihydropyrans are important intermediates for the synthesis of biologically active natural products such as kendomycin, ambruticin, leucascandrolide, neopeltolide, phorboxazoles and diospongins (Fig. 1).[23-35] The 4-methyl substituted dihydropyran unit is present in the macrolide natural products laulimalide and okadaic acid.[36,37] Substituted dihydropyrans are also used as a flavoring or aroma material for food and other products.[38]



(-)-Kendomycin



Leucascandrolide A



Ambruticin

Figure 1. Natural products bearing dihydropyran moiety.

2,5-Dibutylthio-2,3-dihydro-2-formyl-4*H*-pyran is claimed to be a strong and safe antiseptic.[39-41]

Due to the above reasons, we herein report on the synthesis of hitherto unknown Schiff bases from 2,5-dibutylthio-2,3-dihydro-2-formyl-4*H*-pyran **1** and primary amines, as well as amino acids and their esters.

Results and Discussion

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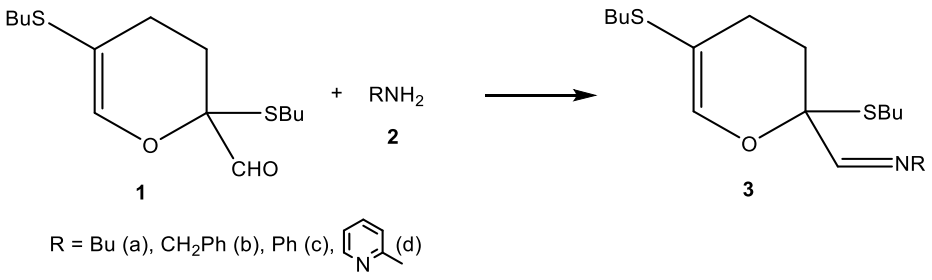
It is found (Scheme 1) that 2,5-dibutylthio-2,3-dihydro-2-formyl-4*H*-pyran **1** reacts with an equimolar amount of butylamine **2a** in the presence of THF at 24 °C for 1 h (Table 1, entry 1) to afford azomethine **3a** in almost quantitative yield (^{1}H NMR), the conversion of aldehyde **1** being complete. Condensation of aldehydes with primary amines is an easily reversible reaction. The reaction mixture contains enough moisture to allow hydrolysis of compound **3**. To prevent this process, drying agents (molecular sieves 4A, $MgSO_4$) are employed. Benzylamine (**2b**) reacts similarly under these conditions (Table 1, entry 2). Filtration of the reaction mixture and evaporation of the solvent in vacuo leads to imines that do not require additional purification.

Schiff bases **3a** and **3b** were obtained as single *E* isomer and showed in the ^{1}H NMR spectra one signal, belonging to the CH=N proton.



Scheme 1. Reaction of 2,5-dibutylthio-2,3-dihydro-2-formyl-4*H*-pyran with primary amines.

Aniline **2c** and 2-aminopyridine **2d** do not interact with pyran **1** under comparable conditions (24 ° C, 2 h) owing to significant decrease of their nitrogen atoms basicity (Table 1, entry 3, 5). A longer reaction time and other solvent also does not give the desired result (Table 1, entry 6, 7). Even upon refluxing in MeOH, the starting substrate **2d** does not react (Table 1, entry 8). In the case of aniline **2c**, changing the solvent made it possible to obtain the desired product in a% yield (Table 1, entry 4).

Table 1. Condensation of 2,5-dibutylthio-2,3-dihydro-2-formyl-4*H*-pyran (**1**) with primary amines **2a-d**: the reaction conditions[a]

Entry	Amine	Solvent	*T*emp.(°C)	*t*(h)	NMR ^{1}H yield 3 (%)
1	**2a**	THF	24	1	98 (94[b])
2	**2b**	THF	24	1	97 (89[b])
3	**2c**	THF	24	2	-
4	**2c**	MeOH	reflux	6	97 (85[b])
5	**2d**	THF	24	2	-
6	**2d**	THF	24	48	-
7	**2d**	MeOH	24	48	-
8	**2d**	MeOH	reflux	48	-

[a] Pyran **1** (1 mmol), amine **2** (1 mmol), MeOH/THF (1 ml).

[b] Isolated yield.

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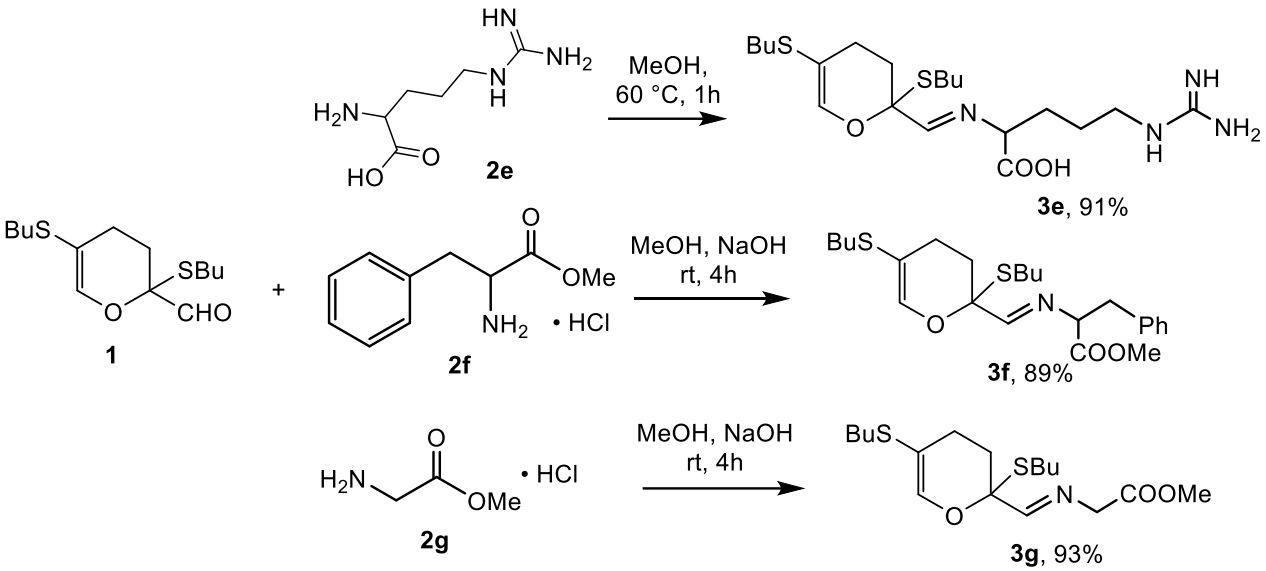
The reaction with arginine **2e** occurs upon boiling in methanol for 1 h to deliver the iminium derivative **3e** in 91% yield (Scheme 2).



Scheme 2. The reaction of 2,5-dibutylthio-2,3-dihydro-2-formyl-4*H*-pyran (**1**) with amino acids and their esters **2e-g**.

Owing to limited solubility in organic solvents and reduced basicity of glycine and phenylalanine, such conditions turn out to be inappropriate. 2,5-Dibutylthio-2,3-dihydro-2-formyl-4*H*-pyran **1** reacted with α-amino acid (phenylalanine and glycine) methyl esters **2f**, **2g** (generated *in situ* from the hydrochlorides by reaction of NaOH) in MeOH at room temperature to give previously unknown Schiff bases **3f**, **3g** in 89-93% yield (Scheme 2).

^{1}H NMR spectrum of Schiff bases **3e,f** shows a mixture of isomers, existing in the form of an *E*-configuration, as indicated by the value of the spin-spin coupling constant ($^1J_{CH}$ = 166-167 Hz) of the carbon fragment HC=N.[42]

Conclusions

In conclusion, we have reported the facile and valuable synthesis of functionalized imine derivatives of original 2,5-bis-(butylsulfanyl)-2,3-dihydro-4*H*-pyran-2-carbaldehyde with primary amines and amino acids. Using this protocol, we were able to assemble a range of functionalized Schiff bases that represent a promising and interesting application in construction of metallocomplexes.

Experimental Section

General. The ^{1}H, ^{13}C and ^{15}N NMR spectra were recorded in $CDCl_3$ solutions at room temperature on Bruker DPX-400 and AV-400 spectrometers (400.13, 100.61 and 40.56 MHz, respectively). ^{1}H, ^{13}C and ^{15}N Chemical

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shifts (δ in ppm) were measured with accuracy of 0.01, 0.02 and 0.1 ppm, respectively, and referred to TMS (^{1}H, ^{13}C) and nitromethane (^{15}N). Chromato-mass spectrometry analysis was performed on a Shimadzu GCMS-QP5050A mass spectrometer (EI ionization, 70 eV). The IR spectra of the compounds were recorded on a Varian 3100 FT-IR spectrometer with the sample in thin film. Elemental analysis was performed on a Thermo Finnigan Flash series 1112 Elemental analyzer.

General synthesis of compounds 3a-c, e. Compounds **3a-c, e**: To the solution of (1 mmol, 0.288 g) of compound (**1**) in MeOH or THF was added 1 mmol of amine (**2a-c**) or amino acid (**2e)** and the mixture was stirred for 1-6 h at room temperature or reflux. The reaction mixture was dried with $MgSO_4$, the precipitate was filtered off and the solvent was removed in vacuo. The desired imine was obtained in the oil or powder.

Reaction of 2,5-dibutylthio-2,3-dihydro-2-formyl-4*H*-pyran with butylamine (3a). Dark brown oil, yield 94%. IR, ν, (cm^{-1}): 2953, 2929, 2865, 1627, 1458, 1145, 1046, 768. ^{1}H NMR ($CDCl_3$) δ: 0.89-0.94 (m, 9H, $3CH_3$ in 2SBu and NBu), 1.32-1.40 (m, 6H, $C\underline{H}_2CH_3$ in 2SBu and NBu), 1.49-1.52 (m, 4H, $2SCH_2C\underline{H}_2$ in 2SBu), 1.57-1.61 (m, 2H, $NCH_2C\underline{H}_2$), 2.09-2.11 (m, 2H, CH_2 at C-4), 2.19 and 2.44 (two m, 2H, CH_2 at C-3), 2.43-2.56 (m, 4H, $2SCH_2$ in 2SBu), 3.42-3.53 (m, 2H, NCH_2), 6.67 (s, 1H, =CH), 7.51 (s, 1H, CH=N). ^{13}C NMR ($CDCl_3$): 13.72 (CH_3 in NBu), 13.82 (CH_3 in SBu at C*), 13.93 (CH_3 in SBu at C=), 20.47 ($\underline{C}H_2CH_3$ in NBu), 21.74 ($\underline{C}H_2CH_3$ in SBu at C*), 22.21 ($\underline{C}H_2CH_3$ in SBu at C=), 23.90 (C-3), 27.52 (SCH_2 at C*), 29.86 (C-4), 31.60 ($SCH_2\underline{C}H_2$ at C*), 31.92 ($SCH_2\underline{C}H_2$ at C=), 32.46 (SCH_2 at C=), 32.92 ($NCH_2\underline{C}H_2$), 60.68 (NCH_2), 84.61 (C*), 107.27 (C-5), 144.10 (=CHO), 160.79 (CH=N). ^{15}N NMR ($CDCl_3$): - 56.4. MS-HRMS m/z, ($J_{отн.}$, %): 343 (1) $[M]^+$, 254 (15) $[M\text{-}SBu]^+$, 213 (3), 199 (3), 185 (4), 171 (3), 164 (4), 149 (6), 129 (9), 115 (7), 98 (8), 85 (67), 83 (100), 69 (65), 43 (63), 41 (77). Found (%:) C, 63.03; H, 9.73; N, 4.12; S, 18.52. Calculated $C_{18}H_{33}NOS_2$ (%): C, 62.92; H, 9.68; N, 4.08; S, 18.66.

Reaction of 2,5-dibutylthio-2,3-dihydro-2-formyl-4*H*-pyran with benzylamine (3b). Dark brown oil, yield 89%. IR, ν, (cm^{-1}): 2956, 2927, 2866, 1665, 1627, 1455, 1145, 1095, 1046, 738, 698.^{1}H NMR ($CDCl_3$) δ: 0.87 (t, 3H, CH_3 (SBu at C*), *J* = 7.5 Hz), 0.92 (t, 3H, CH_3 (SBu at C=), *J* = 7.3 Hz), 1.31 (q, 2H, $C\underline{H}_2CH_3$ (SBu at C*), *J* = 7.5 Hz), 1.40 (q, 2H, $C\underline{H}_2CH_3$ (SBu at C=), *J* = 7.3 Hz), 1.44-1.49 (m, 2H, $SCH_2C\underline{H}_2$ (SBu at C*)), 1.50-1.56 (m, 2H, $SCH_2C\underline{H}_2$ (SBu at C=)), 2.14-2.17 (m, 2H, CH_2 at C-4), 2.21 and 2.45 (two m, 2H, CH_2 at C-3), 2.49-2.55 (m, 4H, $2SCH_2$), 4.66 and 4.73 (two d, 2H, $C\underline{H}_2Ph$, *J* = 13.5 Hz), 6.66 (s, 1H, =CH), 7.23-7.34 (m, 5H, Ph), 7.65 (s, 1H, CH=N). ^{13}C NMR ($CDCl_3$): 13.81 (CH_3 in SBu at C*), 13.95 (CH_3 in SBu at C=), 21.81 ($\underline{C}H_2CH_3$ in SBu at C*), 22.24 ($\underline{C}H_2CH_3$ in SBu at C=), 23.96 (C-3), 27.60 (SCH_2 in SBu at C*), 29.70 (C-4), 31.65 ($SCH_2\underline{C}H_2$ in SBu at C*), 31.99 ($SCH_2\underline{C}H_2$ in SBu at C=), 32.47 (SCH_2 in SBu at C=), 64.32 (NCH_2), 84.74 (C*), 107.59 (C-5), 127.33 (C_p), 128.21 (C_m), 128.67 (C_o), 138.69 (C_{ipso}), 143.95 (=CHO), 162.13 (CH=N). ^{15}N NMR ($CDCl_3$): - 59.8. MS-HRMS m/z, ($J_{отн.}$, %): 377 (1) $[M]^+$, 348 (5), 288 (58) $[M\text{-}SBu]^+$, 231 (2), 198 (14), 144 (18), 91 (100) $[PhCH_2]^+$, 65 (7), 55 (4), 41 (13). Found (%): C, 66.93; H, 8.13; N, 3.67; S, 16.91. Calculated $C_{21}H_{31}NOS_2$ (%): C, 66.84; H, 8.22; N, 3.71; S, 16.98.

Reaction of 2,5-dibutylthio-2,3-dihydro-2-formyl-4*H*-pyran with aniline (3c). Dark brown oil, yield 85%. IR, ν, (cm^{-1}): 2957, 2928, 2868, 1730, 1627, 1490, 1144, 1088, 1044, 758, 694. ^{1}H NMR ($CDCl_3$) δ: 0.88-0.93 (m, 6H, $2CH_3$ in SBu), 1.36-1.43 (m, 4H, $C\underline{H}_2CH_3$), 1.51-1.57 (m, 4H, $SCH_2C\underline{H}_2$), 2.23-2.26 (m, 2H, CH_2 at C-4), 2.27 and 2.49 (two m, 2H, CH_2 at C-3), 2.52 (m, 2H, SCH_2 in SBu at C*), 2.63 (m, 2H, SCH_2 in SBu at C=), 6.71 (s, 1H, =CH), 7.09 (d, 2H, *o*-H, *J* = 7.6 Hz), 7.22 (t, 1H, *p*-H, *J* = 7.4 Hz), 7.36 (dd, 2H, *m*-H, *J* = 7.6, *J* = 7.4 Hz), 7.70 (s, 1H, CH=N). ^{13}C NMR ($CDCl_3$): 13.74 (CH_3 in SBu at C*), 13.83 (CH_3 in SBu at C=), 21.78 ($\underline{C}H_2CH_3$ in SBu at C*), 22.23 ($\underline{C}H_2CH_3$ in SBu at C=), 23.91 (C-3), 27.64 (SCH_2 at C*), 29.59 (C-4), 31.66 ($SCH_2\underline{C}H_2$ at C*), 31.97 ($SCH_2\underline{C}H_2$ at C=), 32.48 (SCH_2 at C=), 84.92 (C*), 107.73 (C-5), 120.94 (C_m); 126.38 (C_p); 129.30 (C_o); 143.91 (Ci), 150.87 (=CHO), 160.7 (CH=N). ^{15}N NMR ($CDCl_3$): -61.2. Found (%): C, 66.02; H, 7.85; N, 3.81; S, 17.51. Calculated $C_{20}H_{29}NOS_2$ (%): C, 66.11; H, 7.99; N, 3.86; S, 17.63.

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Reaction of 2,5-dibutylthio-2,3-dihydro-2-formyl-4*H*-pyran with arginine (3e). Gray powder, yield 91%. Compound **3e** is a mixture of isomers in 2:1 ratio. IR, ν, (cm^{-1}): 3314, 3264, 2957, 1660, 1627, 1587, 1377, 1145, 1043, 829, 746, 604. ^{1}H NMR (CD_3OD): **major-3e:** δ 0.95 (m, 6H, $2CH_3$ in 2SBu), 1.40-1.47 (m, 4H, $2C\underline{H}_2CH_3$ in 2SBu), 1.51-1.60 (m, 4H, $2SCH_2C\underline{H}_2$ in 2SBu), 1.65 (m, 2H, $C\underline{H}_2CH_2NH$), 1.93 (m, 2H, CH*), 2.19 (m, 2H, CH_2 at C-4), 2.24 and 2.48 (two m, 2H, CH_2 at C-3), 2.66 (m, 4H, $2SCH_2$ in 2SBu), 3.22 (m, 2H, $C\underline{H}_2NH$), 3.79 (m, 1H, $C\underline{H}$*COOH), 4.89 (s, 5H, NH, NH_2, OH), 6.65 (s, 1H, =CH), 7.64 (s, 1H, CH=N); **minor-3e:** δ 0.92 (m, 6H, $2CH_3$ in 2SBu), 1.36-1.40 (m, 4H, $2C\underline{H}_2CH_3$ in 2SBu), 1.48-1.53 (m, 4H, $2SCH_2C\underline{H}_2$ in 2SBu), 1.61 (m, 2H, $C\underline{H}_2CH_2NH$), 1.87 (m, 2H, CH*), 2.11 (m, 2H, CH_2 at C-4), 2.25 and 2.46 (two m, 2H, CH_2 at C-3), 2.61 (m, 4H, $2SCH_2$ in 2SBu), 3.20 (m, 2H, $C\underline{H}_2NH$), 3.80 (m, 1H, $C\underline{H}$*COOH), 4.89 (br. s, 5H, NH, NH_2, OH), 6.64 (s, 1H, =CH), 7.66 (s, 1H, CH=N).^{13}C NMR (CD_3OD): **major-3e:** 14.07 ($2CH_3$ in 2SBu), 22.55 ($2C\underline{H}_2CH_3$ in 2SBu), 24.80 (C-3), 27.06 ($2C\underline{H}_2CH_2CH_3$ in 2SBu), 28.39 (C-4), 30.73 ($SC\underline{H}_2$ in SBu at C*), 32.20 ($SC\underline{H}_2$ in SBu at C=), 32.69 ($C\underline{H}_2CH_2NH$), 32.90 ($C\underline{H}_2CH_2CH_2NH$), 42.22 ($C\underline{H}_2NH$), 76.02 (CH*), 85.81 (C-2), 107.58 (C-5), 144.69 (=CHO), 159.30 (C=NH), 163.06 (CH=N, $^1J_{CH}$ = 167.0 Hz), 180.50 (COOH); **minor-3e:** 14.11 (CH_3 in SBu), 23.02 ($C\underline{H}_2CH_3$ in SBu), 24.80 (C-3), 27.06 ($2C\underline{H}_2CH_2CH_3$ in 2SBu), 28.39 (C-4), 30.73 ($SC\underline{H}_2$ in SBu at C*), 32.20 ($SC\underline{H}_2$ in SBu at C=), 32.69 ($C\underline{H}_2CH_2NH$), 33.00 ($C\underline{H}_2CH_2CH_2NH$), 42.22 ($C\underline{H}_2NH$), 76.02 (CH*), 85.8 (C-2), 107.58 (C-5), 144.68 (=CHO), 159.26 (C=NH), 163.07 (CH=N, $^1J_{CH}$ = 166.0 Hz), 180.50 (COOH).^{15}N NMR ($CDCl_3$): **major-3e**: -58.3 (CH=N). Found (%): C, 54.17; H, 8.21; N, 12.52, S, 14.32. Calculated $C_{20}H_{36}N_4O_3S_2$ (%): C, 54.05; H, 8.12; N, 12.61, S, 14.41.

General synthesis of compounds 3f, g. Compounds **3f, g**: To the solution of (1 mmol, 0.288 g) of compound (**1**) in MeOH was added 1 mmol of amino acid methyl ester hydrochloride (**2f, g**) and NaOH (1 mmol) and the mixture was stirred for 4 h at room temperature. The reaction mixture was dried with $MgSO_4$, the precipitate was filtered off and the solvent was removed in vacuum. The desired imine was obtained in the oil.

Reaction of 2,5-dibutylthio-2,3-dihydro-2-formyl-4H-pyran with L-phenylalanine methyl ester hydrochloride (3f). Dark brown oil, yield 89%. Compound **3f** is a mixture of isomers in ratio 1.3:1. ^{1}H NMR (DMSO): major-3f: δ 0.84 (m, 6H, $2CH_3$ in 2SBu), 1.25-1.32 (m, 4H, $C\underline{H}_2CH_3$ in 2SBu), 1.37-1.48 (m, 4H, $C\underline{H}_2CH_2CH_3$ in 2SBu), 2.01-2.17 (m, 2H, CH_2 at C-4), 2.19-2.22 (m, 2H, CH_2 at C-3), 2.31 (m, 4H, $2SCH_2$), 2.93 (m, 2H, $C\underline{H}_2Ph$), 3.61 (s, 3H, OMe), 4.25 (two d, 2H, *C$\underline{H}$, *J* = 13.5 Hz), 6.60 (s, 1H, =CH), 7.13-7.18 (m, 5H, Ph), 7.41 (s, 1H, CH=N); minor-3f: δ 0.80 (t, 6H, $2CH_3$ in 2SBu), 1.20-1.24 (m, 4H, $C\underline{H}_2CH_3$), 1.32-1.37 (m, 4H, $C\underline{H}_2CH_2CH_3$ in 2SBu), 1.84-1.91 (m, 2H, CH_2 at C-4), 2.22-2.25 (m, 2H, CH_2 at C-3), 2.47 (m, 4H, $2SCH_2$), 3.19 (m, 2H, $C\underline{H}_2Ph$), 3.62 (s, 3H, OMe), 4.31 (two d, 2H, *C$\underline{H}$, *J* = 13.5 Hz), 6.55 (s, 1H, =CH), 7.22-7.26 (m, 5H, Ph), 7.53 (s, 1H, CH=N). ^{13}C NMR (DMSO): major-3f: δ 13.36 ($2CH_3$ in 2SBu), 21.35 ($2C\underline{H}_2CH_3$ in 2SBu), 23.02 (C-3), 26.51 ($2C\underline{H}_2CH_2CH_3$ in 2SBu), 28.85 (C-4), 30.91 ($SC\underline{H}_2$ in SBu at C*), 31.17 ($SC\underline{H}_2$ in SBu at C=), 38.51 ($C\underline{H}_2Ph$), 51.85 (OCH_3), 71.87 (*CH), 84.15 (C-2), 106.70 (C-5), 126.35 (C_p), 128.14 (C_o), 129.28 (C_m), 137.15 (C_i), 143.25 (CH=), 164.08 (CH=N, $^1J_{CH}$ = 165.8 Hz), 171.02 ($C\underline{O}OMe$); minor-3f: δ 13.49 ($2CH_3$ in 2SBu), 21.42 ($2C\underline{H}_2CH_3$ in 2SBu), 23.07 (C-3), 26.61 ($2C\underline{H}_2CH_2CH_3$ in 2SBu), 28.86 (C-4), 31.16 ($SC\underline{H}_2$ in SBu at C*), 31.23 ($SC\underline{H}_2$ in SBu at C=), 38.51 ($C\underline{H}_2Ph$), 48.54 (OCH_3), 72.01 (*CH), 84.44 (C-2), 106.75 (C-5), 126.35 (C_p), 128.47 (C_o), 129.40 (C_m), 137.15 (C_i), 143.11 (CH=), 164.64 (CH=N, $^1J_{CH}$ = 165.8 Hz), 170.93 ($C\underline{O}OMe$). ^{15}N NMR (DMSO): major-3f: -61.2; minor-3f: -60.6. MS-HRMS m/z, ($J_{отн.}$, %): 449 (3) $[M]^+$, 360 (100) $[M\text{-}SBu]^+$, 270 (36), 158 (15), 91 (53), 77 (5). Found (%): C, 64.21; H, 7.87; N, 3.01, S, 14.17. Calculated $C_{24}H_{35}NO_3S_2$ (%): C, 64.14; H, 7.79; N, 3.12, S, 14.25.

Reaction of 2,5-dibutylthio-2,3-dihydro-2-formyl-4*H*-pyran with glycine methyl ester hydrochloride (3g). Dark brown oil, yield 93%. IR, ν, (cm^{-1}): 2971, 2926, 2831, 1667, 1455, 1131, 1095, 1046, 681. ^{1}H NMR (DMSO) δ: 0.82-0.87 (m, 6H, CH_3 in SBu), 1.29-1.37 (m, 4H, $C\underline{H}_2CH_3$), 1.42-1.47 (m, 4H, $SCH_2C\underline{H}_2$), 2.04-2.14 (m, 2H, CH_2 at C-4), 2.18 and 2.27 (two m, 2H, CH_2 at C-3), 2.57 (m, 4H, $2SCH_2$), 3.64 (s, 3H, OMe), 4.26 and 4.32 (d, 2H, $C\underline{H}_2COOMe$, J^2_{HH} = 16 Hz), 6.63 (s, 1H, =CH), 7.71 (s, 1H, CH=N). ^{13}C NMR (DMSO): 13.35 (CH_3 in SBu at C*), 13.47 (CH_3 in SBu at

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C=), 20.85 ($\underline{C}H_2CH_3$ in SBu at C*), 21.36 ($\underline{C}H_2CH_3$ in SBu at C=), 23.14 (C-3), 26.73 (SCH_2 at C*), 28.75 (C-4), 30.86 ($SCH_2\underline{C}H_2$ at C*), 31.10 ($SCH_2\underline{C}H_2$ at C=), 31.27 (SCH_2 at C=), 51.60 (OMe), 59.48 (NCH_2), 84.43 (C*), 106.83 (C-5), 143.18 (=CHO), 165.3 (CH=N), 169.80 (C=O). ^{15}N NMR (DMSO): -69.8. MS-HRMS m/z, ($J_{отн.}$, %): 359 (2) $[M]^+$, 330 (1 3), 270 (100) $[M\text{-}SBu]^+$, 180 (32), 127 (23), 73 (13), 41 (54). Found (%): C, 56.77; H, 8.11; N, 3.99, S, 17.91. Calculated $C_{17}H_{29}NO_3S_2$ (%): C, 56.82; H, 8.08; N, 3.90, S, 17.83.

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Supplementary Material

Supplementary material is available on the publisher's website along with the published article.

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