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A regioselective addition of nucleophiles to monocyclic 1,2-thiazinylium perchlorate: a novel precursor of 6-substituted 1,2-thiazines

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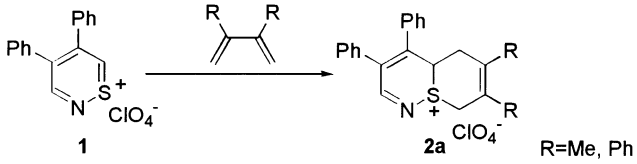
Abstract—The nucleophilic addition reactions of 4,5-diphenyl-1,2-thiazinylium perchlorate **1** regioselectively proceeded to give 6-alkoxy- **3a–c** and 6-alkyl-1,2-thiazines **3e–f**, **4f**, **3i–j** in good to high yields. The Friedel–Crafts type reaction with arenes also afforded 6-aryl adducts **6a–c**.

Recently, we have reported novel hetero Diels–Alder reactions of 1,2-thiazinylium salt as a good dienophile. The inter-element, N=S$^+$ bond of the dibenzo[*c*,*e*]-[1,2]thiazinylium salt has reacted with the 1,3-butadienes to give the cyclic sulfonium salts via the polar [2$^+$+4] cycloaddition reaction,[1] while the reaction site of the monocyclic 4,5-diphenyl-1,2-thiazinylium perchlorate **1** has not been the N=S$^+$ bond of **1**, but the C=S$^+$ bond (Scheme 1).[2] The different reactivity of the cycloaddition reactions between the dibenzo-1,2-thiazinylium salt and the monocyclic derivative could be explained in terms of LUMO coefficients of the thiazinylium salt obtained from the PM3 calculation. The 1,2-thiazinylium salt **1** is a unique heterocyclic compound; however, it has not been characterized except in the polar [2$^+$+4] cycloadditions. Our next interest is the reaction of monocyclic 1,2-thiazinylium salt **1** having several reaction sites with nucleophiles. The regioselective addition of the thiazinylium salt would provide various 1,2-thiazines, which would be easily transformed into the functionalized 1,2-thiazinylium salts as new heterocyclic compounds with the biological interests.[3] We describe herein the regioselective additions of 1,2-thiazinylium salts, providing various 1,2-thiazines, and attempts at preparation of more functionalized 1,2-thiazinylium salts.

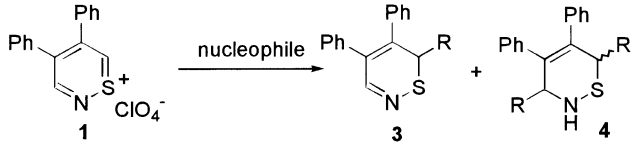


Scheme 1.

1. Results and discussion

We first examined the reaction of **1** with alkoxide nucleophiles. Two equivalents of NaOMe in MeOH gave 6-methoxy-1,2-thiazine **3a** in 94% yield. The structure was determined by the ^{1}H NMR spectral data, showing the methoxy protons at δ 3.44, the 6-methine proton at δ 5.16, the 3-imine proton at δ 8.37, and the ^{13}C NMR spectral data exhibiting the 6-acetal carbon at δ 80.07 (d). The reactions with other alkoxides such as NaOEt and NaO^{i}Pr were also examined and 6-ethoxy- **3b** and

Table 1. Reaction of 1,2-thiazinylium salt **1** with nucleophiles



Entry	Nucleophile (equiv.)	Solvent	Products (R) (% Yield)
1	NaOMe (2)	MeOH	**3a** (OMe) (94)
2	NaOEt (2)	EtOH	**3b** (OEt) (90)
3	NaO^{i}Pr (3)	^{i}PrOH	**3c** (O^{i}Pr) (quant)
4	KO^t Bu(2)	^{t}BuOH	Complex mixture
5	CH_2=CPh(OTMS) (1.2)	MeCN	**3e** (CH_2COPh) (70)
6	CH_2=C(SEt)(OTMS) (1.5)	MeCN	**3f** (CH_2COSEt) (42)
7	CH_2=C(SEt)(OTMS) (5)	MeCN	**4f** (CH_2COSEt) (58)
8	Et_2NH (1.2)	MeCN	Complex mixture
9	NaSPh (1.2)	THF	**3h** (SPh) (77)
10	$NaCH(CO_2Et)_2$ (1.2)	THF	**3i** ($CH(CO_2Et)_2$) (93)
11	$NaCH(COMe)_2$ (1.5)	THF	**3j** ($CH(COMe)_2$ (quant)

Keywords: 1,2-thiazinylium perchlorate; novel precursor; 1,2-thiazines.
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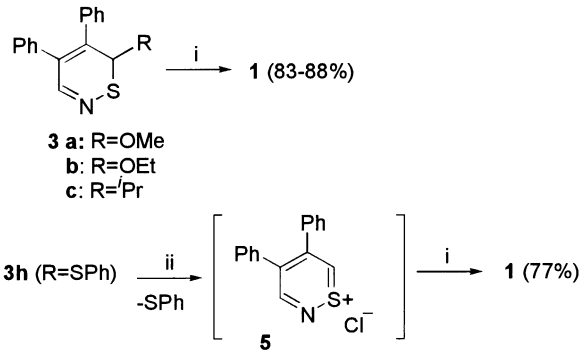


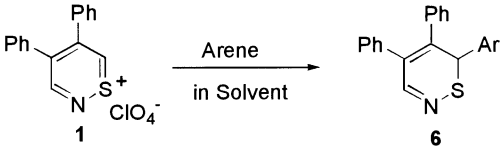
Scheme 2. *Reagent*: i, 70% $HClO_4$; ii, SO_2Cl_2.

6-isopropoxy-1,2-thiazines **3c** were obtained in high yields, respectively, as shown in Table 1 (entries 2 and 3); however, **3c** was found to be labile at room temperature to polymerize. KO^{t}Bu gave a complex mixture (entry 4). Next, we performed the reaction with silyl enol ethers as soft carbon nucleophiles. 1-Phenyl-1-(trimethylsiloxy)ethylene gave alkylated product **3e** in 70% yield (entry 5). Further, *S*-ethyl ketene thioacetal afforded 6-alkyl-1,2-thiazine **3f**. Interestingly, the reaction with a large excess of the acetal gave 3,6-dialkyl-1,2-thiazine **4f** in good yield (entries 6 and 7). However, a large excess of 1-phenyl-1-(trimethylsiloxy)-ethylene gave no dialkylated 1,2-thiazine. These results might be explained in terms of higher nucleophilicity of *S*-ethyl ketene thioacetal. Other nucleophiles also reacted on the 6-position of the 1,2-thiazinylium salt to give 6-(phenylsulfanyl)-1,2-thiazine **3h**, diethyl (1,2-thiazin-6-yl)malonate **3i** and (1,2-thiazin-6-yl)pentane-2,4-dione **3j** (entries 9–11).

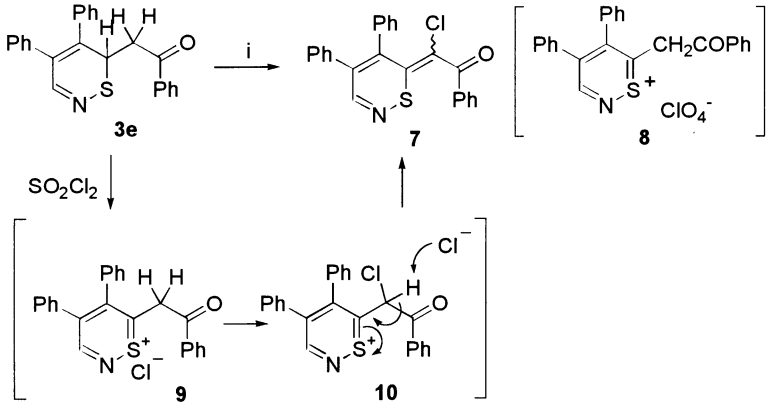
We investigated the reaction of the products with acid (Scheme 2). Treatment of 6-methoxy-1,2-thiazine **3a** with $HClO_4$ provided the thiazinylium salt **1** in 88% yield. Similarly, other 6-alkoxy-1,2-thiazines **3b** and **3c** also provided the salt **1** in good yields on treatment with the acid. The addition of SO_2Cl_2 to an ethereal solution of **3h** provided a yellow suspension, which was successively treated with 70% $HClO_4$ to give the salt **1** via the replacement of the counter anion of an in situ formed 1,2-thiazinylium chloride **5** from chloride to perchlorate.

We also performed the Friedel–Crafts type reaction of the 1,2-thiazinylium salt **1** with arenes (Table 2). On treatment with 1,2,3-trimethoxybenzene (2 equiv.) in $ClCH_2CH_2Cl$ at 83°C, the salt **1** underwent nucleophilic addition reaction at 6 position to give 6-(2,3,4-trimethoxyphenyl)-1,2-thiazine **6a** in 31% yield. The reaction site of the 1,2,3-trimethoxybenzene was found to be the 4-position by the ^{1}H NMR spectral data of **6a**, which show the two aromatic protons of the 2,3,4-trimethoxyphenyl group at δ 6.61 (d, J=9 Hz) and 6.99 (d, J=9 Hz) as an AB quartet. 1,2-Dimethoxybenzene also reacted with **1** to give 6-(3,4-dimethoxyphenyl)-1,2-thiazine **6b** in 39% yield, while anisole and benzene did not react, and the salt **1** was recovered

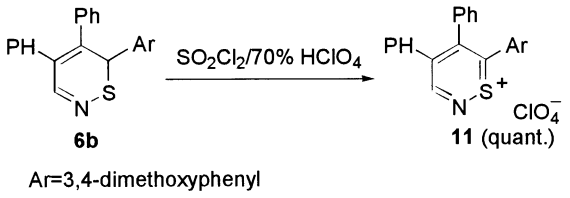
Table 2. Reactions of 1,2-thiazinylium salt **1** with arenas



Entry	Arene (equiv.)	Solvent	Product (Ar) (% Yield)
1	1,2,3-Trimethoxybenzene (1.2)	$ClCH_2CH_2Cl$	**6a** (2,3,4-trimethyoxyphenyl) (31)
2	1,2-Dimethoxybenzene (2)	$ClCH_2CH_2Cl$	**6b** (3,4-dimethoxyphenyl) (39)
3	Anisole (5)	$ClCH_2CH_2Cl$	Recovery
4	Benzene	Neat	Recovery
5	Thioanisole (5)	$ClCH_2CH_2Cl$	Complex mixture
6	Thiophene (2)	$ClCH_2CH_2Cl$	Complex mixture
7	Furan (2)	CH_3CN	**6c** (2-furyl) (46)



Scheme 3. *Reagent*: i, SO_2Cl_2/70% $HClO_4$.



Scheme 4.

unchanged, and thioanisole and thiophene gave complex mixtures. The regioselective reaction with furan gave 6-(2-furyl)-1,2-thiazine **6c** in 46% yield (entry 5).

We next investigated the transformation of the 6-alkylated **3** or 6-arylated 1,2-thiazines **6** to the corresponding 6-substituted 1,2-thiazinylium salts. The treatment of **3e** with SO_2Cl_2/70% $HClO_4$, under the conditions similar to those for the synthesis of **1**, afforded the 6-(1-chloro-1-phenacylidene)-1,2-thiazine **7** in 58% yield as an *E*,*Z* mixture, and not **8** (Scheme 3). The plausible mechanism for the formation of **7** is shown in Scheme 3. The reaction with SO_2Cl_2 would afford the 1,2-thiazinylium chloride **9**, which easily undergoes chlorination of the α-position to the carbonyl group to form **10**. The acidic hydrogen of the chloride **10** would be abstracted by chloride ion to give the phenacylidene derivative **7**. The treatment of 6-ary-1,2-thiazine **6b** with SO_2Cl_2/70% $HClO_4$, however, quantitatively afforded the 4,5,6-triaryl-1,2-thiazinylium perchlorate **11** as stable white needles (Scheme 4).

2. Experimental

Mps were determined on a Yanagimoto micro-melting point apparatus and are uncorrected. Elemental analyses were performed at the Microanalytical Laboratory of Gifu Pharmaceutical University. ^{1}H (400 MHz) and ^{13}C (100 MHz) NMR spectra were determined with a Varian Inova 400 (400 MHz) spectrometer at the Center of Instrumentation of Gifu University. Chemical shifts are expressed in parts per million (ppm) with respect to tetramethylsilane as the internal standard. Splitting patterns are designated as follows: s, singlet; d, doublet; t, triplet; q, quartet. IR spectra were recorded on a JASCO IR A-100 infrared spectrometer. EI Mass spectra (MS) were obtained using a JMS-SX102A spectrometer with a direct-insertion probe at an ionization voltage of 70 eV. Preparation of 4,5-diphenyl-1,2-thiazinylium perchlorate **1** was performed according to our previous report.[2]

2.1. Reactions of 4,5-diphenyl-1,2-thiazinylium perchlorate 1 with nucleophiles

2.1.1. With NaOMe. A solution of NaOMe (8.58 mmol) in MeOH (8.6 ml) was added dropwise to a stirred suspension of 1,2-thiazinylium perchlorate **1** (150 mg, 0.43 mmol) in dry MeOH (1.5 ml) and the mixture was stirred for 30 min at room temperature. The solvent was removed under reduced pressure. The residue was poured into water (50 ml) and the organic layer was separated and the aqueous layer was extracted with ether. The combined organic layer was dried over $MgSO_4$. The solvent was removed under reduced pressure. The residue was purified by preparative TLC on silica gel eluting with hexane–ethyl acetate (10:1) to give 6-methoxy-4,5-diphenyl-6*H*-1,2-thiazine **3a** (114 mg, 94%) as brown powders, mp 110–113°C (dec.), IR (KBr, cm^{-1}): 1450 (N=CH), 1066 (ether). ^{1}H NMR ($CDCl_3$) δ: 3.44 (3H, s, Me), 5.16 (1H, s, 6-H), 7.13–7.25 (10H, m, ArH), 8.37 (1H, s, 3-H). ^{13}C NMR ($CDCl_3$) δ: 53.01 (q), 80.07 (d), 127.86 (d), 128.33 (d), 128.42 (d×2), 128.58 (d×2), 128.96 (s), 129.76 (d×2), 130.31 (d×2), 131.49 (s), 138.58 (s), 138.85 (s), 155.97 (d). MS *m*/*z*: 281 (M^+). Anal. calcd for $C_{17}H_{15}NOS$: C, 72.57; H, 5.37; N, 4.98. Found: C, 72.63; H, 5.45; N, 4.98.

2.1.2. With NaOEt. A solution of NaOEt (1 mmol) in EtOH (1 ml) was added dropwise to a stirred suspension of 1,2-thiazinylium perchlorate **1** (175 mg, 0.5 mmol) in EtOH (2 ml). The work-up as above gave 6-ethoxy-4,5-diphenyl-6*H*-1,2-thiazine **3b** (148 mg, 90%) as an oil, IR (film, cm^{-1}): 1440 (N=CH), 1040 (ether). ^{1}H NMR ($CDCl_3$) δ: 1.28 (3H, t, *J*=7 Hz, Me), 3.47–3.55 (1H, m, C*H*H), 3.87–3.95 (1H, m, CH*H*), 5.22 (1H, s, 6-H), 7.11–7.27 (10H, m, ArH), 8.36 (1H, s, 3-H). ^{13}C NMR ($CDCl_3$) δ: 15.21 (q), 61.32 (t), 78.40 (d), 127.75 (d), 128.21 (d), 128.35 (d×2), 128.48 (d×2), 129.09 (s), 129.68 (d×2), 130.32 (d×2), 131.32 (s), 138.60 (s), 139.03 (s), 155.87 (d). High resolution mass spectrum, *m*/*z*, 295.1037 (calcd for $C_{18}H_{17}NOS$, 295.1031).

2.1.3. With NaO^{i}Pr. A solution of NaO^{i}Pr (1.5 mmol) in ^{i}PrOH (1 ml) was added dropwise to a stirred suspension of **1** (175 mg, 0.50 mmol) in ^{i}PrOH (2 ml) at 0°C. The work-up as above afforded 6-isopropyloxy-4,5-diphenyl-6*H*-1,2-thiazine **3c** (155 mg, quant.) as an oil, IR (film, cm^{-1}): 1120 (ether). ^{1}H NMR ($CDCl_3$) δ: 1.23 (3H, d, *J*=6 Hz, Me), 1.27 (3H, d, *J*=6 Hz, Me), 4.09–4.22 (1H, m, C*H*(Me)$_2$), 5.26 (1H, d, *J*=1 Hz, 6-H), 7.12–7.27 (10H, m, ArH), 8.40 (1H, s, 3-H). This compound was labile at room temperature to give a polymer.

2.1.4. With 1-phenyl-1-(trimethylsilyloxy)ethylene. A THF solution of Bu_4NF (1.00 M, 4–5 drops) was added dropwise to a stirred mixture of **1** (1.00 g, 2.86 mmol) and 1-phenyl-1-trimethylsilyloxyethylene (660 mg, 3.43 mmol) in dry MeCN (3 ml) and the reaction mixture was stirred for 0.5 h. The reaction mixture was poured into a sat. $NaHCO_3$ solution and extracted with ethyl acetate. The extract was washed with water, dried over $MgSO_4$, and evaporated. The residue was purified by column chromatography on silica gel eluting with hexane–ethyl acetate (10:1) to afford 6-phenacyl-4,5-diphenyl-6*H*-1,2-thiazine **3e** (744 mg, 70%) as yellow prisms, mp 142–145°C (dec.) (from hexane–CH_2Cl_2), IR (KBr, cm^{-1}): 1670 (CO). ^{1}H NMR ($CDCl_3$) δ: 3.12 (1H, dd, *J*=18 and 3 Hz, C*H*H), 3.81 (1H, dd, *J*=18 and 10 Hz, CH*H*), 4.46 (1H, dd, *J*=10 and 3 Hz, 6-H), 7.11–7.25 (10H, m, ArH), 7.43–7.47 (2H, m, ArH), 7.54–7.58 (1H, m, ArH), 7.93–7.96 (2H, m, ArH), 8.28 (1H, s, 3-H). ^{13}C NMR ($CDCl_3$) δ: 37.74 (d), 40.81 (t), 127.67 (d), 128.34 (d×2), 128.45 (d), 128.49 (d×2), 128.68 (d×2), 128.84 (d×2), 129.79 (d×2), 129.92 (d×2), 131.09 (s), 131.65 (s), 133.68 (d), 136.96 (s), 138.41 (s), 138.45 (s), 156.68 (d), 196.73 (s). MS *m*/*z*: 369 (M^+). Anal. calcd for $C_{24}H_{19}NOS$: C, 78.02; H, 5.18; N, 3.79. Found: C, 77.75; H, 5.38; N, 3.74.

2.1.5. With 1-ethylthio-1-(trimethylsilyloxy)ethylene. Under an Ar atmosphere, a solution of 1-ethylthio-1-(trimethylsilyloxy)ethylene (76.0 mg, 0.43 mmol) in dry CH_2Cl_2 (0.5 ml) was added dropwise to a stirred solution of **1** (100 mg, 0.29 mmol) in dry CH_2Cl_2 (1 ml) and the mixture was stirred for 0.5 h. The reaction mixture was poured into a sat. $NaHCO_3$ solution and the organic layer was separated. The water layer was extracted with ethyl acetate. The combined organic layer was washed with water, dried over $MgSO_4$, and evaporated in vacuo. The residual oil was subjected to preparative TLC on silica gel with hexane–ethyl acetate (3:1) to give 6-(ethylthio)carbonylmethyl-4,5-diphenyl-6*H*-1,2-thiazine **3f** (42.0 mg, 42%) as an oil, IR (film, cm^{-1}): 1670 (CO). ^1H NMR ($CDCl_3$) δ: 1.27 (3H, t, J=8 Hz, Me), 2.86–2.96 (3H, m, C*H*HCO+ SCH_2), 3.10 (1H, dd, J=16 and 10 Hz, CH*H*CO), 4.19 (1H, dd, J=10 and 4 Hz, 6-H), 7.09–7.13 (2H, m, ArH), 7.16–7.19 (6H, m, ArH), 7.20–7.26 (2H, m, ArH), 8.25 (1H, s, 3-H). ^{13}C NMR ($CDCl_3$) δ: 14.81 (q), 23.96 (t), 38.96 (d), 45.94 (t), 127.75 (d), 128.49 (d×3), 128.72 (d×2), 129.90 (d×2), 129.98 (d×2), 131.00 (s×2), 138.28 (s), 138.38 (s), 156.80 (d), 196.48 (s). High resolution mass spectrum, *m/z*, 353.0912 (calcd for $C_{20}H_{19}NOS_2$, 353.0908).

The reaction of **1** (175 mg, 0.50 mmol) with 1-ethylthio-1-(trimethylsilyloxy)ethylene (441 mg, 2.50 mmol) in CH_2Cl_2 (1.5 ml) gave 3,6-bis[(ethylthio)carbonylmethyl]-4,5-diphenyl-3,6-dihydro-2*H*-1,2-thiazine **4f** (132 mg, 58%) as brown powders, mp 105–108°C (dec.), IR (KBr, cm^{-1}): 3300 (NH), 1670 (CO). ^1H NMR ($CDCl_3$) δ: 1.19 (3H, t, J=7 Hz, Me), 1.21 (3H, t, J=7 Hz, Me), 2.29 (1H, dd, J=16 and 2 Hz, 3-CHC*H*H), 2.69 (1H, dd, J=16 and 3 Hz, 6-CH–C*H*H), 2.76–2.90 (4H, m, 2×S-CH_2Me), 2.95 (1H, dd, J=16 and 10 Hz, 6-CHCH*H*), 3.34 (2H, br. s and dd, J=16 and 10 Hz, NH and 3-CHCH*H*), 3.76 (1H, dd, J=10 and 3 Hz, 6-H), 4.50 (1H, dd, J=10 and 2 Hz, 3-H), 6.93–6.96 (4H, m, ArH), 7.03–7.11 (6H, m, ArH). ^{13}C NMR ($CDCl_3$) δ: 14.79 (q), 14.87 (q), 23.57 (t), 23.73 (t), 39.25 (d), 45.58 (t), 47.42 (t), 54.86 (d), 127.10 (d×2), 128.23 (d×2), 128.28 (d×2), 129.72 (d×2), 129.84 (d×2), 136.96 (s), 140.05 (s), 140.36 (s), 140.95(s), 197.58 (s), 198.15 (s). MS *m/z*: 457 (M^+). Anal. calcd for $C_{24}H_{27}NO_2S_3$: C, 62.99; H, 5.95; N, 3.06. Found: C, 62.82; H, 5.91; N, 3.01.

2.1.6. With sodium benzenethiolate. NaH (26.0 mg, 0.64 mmol) was added to a solution of benzenethiol (57.0 mg, 0.52 mmol) in dry THF (2 ml) and the mixture was stirred for 0.5 h. This mixture was ice-cooled and added dropwise to a stirred suspension of **1** (150 mg, 0.43 mmol) in dry THF (2 ml) at 0°C. After stirring for 0.5 h, the reaction mixture was poured into water and extracted with ether. The extract was washed with water, and dried over $MgSO_4$. The solvent was evaporated under reduced pressure to leave an oil, which was purified by preparative TLC on silica gel with hexane–ether (10:1) to afford 4,5-diphenyl-6-phenylsulfanyl-6*H*-1,2-thiazine **3h** (118 mg, 77%) as pale yellow prisms, mp 109–111°C (dec.) (from hexane–CH_2Cl_2). IR (KBr, cm^{-1}): 700 (CSC). ^1H NMR ($CDCl_3$) δ: 4.95 (1H, s, SCH), 7.07–7.10 (2H, m, ArH), 7.15–7.26 (6H, m, ArH), 7.28–7.52 (5H, m, ArH), 7.64–7.72 (2H, m, ArH), 8.16 (1H, s, 3-H). ^{13}C NMR ($CDCl_3$) δ: 55.20 (d), 127.56 (s), 127.83 (d), 128.45 (d×2), 128.57 (d×3), 129.16 (d×2), 129.23 (d), 129.73 (d×2), 130.07 (d×2), 132.13 (s×2), 135.40 (d×2), 138.15 (s), 138.25 (s), 156.62 (d). MS *m/z*: 359 (M^+). Anal. calcd for $C_{22}H_{17}NS_2 \cdot 1/6H_2O$: C, 72.89; H, 4.82; N, 3.86. Found: C, 72.98; H, 4.83; N, 3.85. High resolution mass spectrum, *m/z*, 359.0793 (calcd for $C_{20}H_{19}NOS_2$, 359.0803).

2.1.7. With sodium salt of diethyl malonate. NaCH-$(CO_2Et)_2$ [prepared from diethyl malonate (120 mg, 0.75 mmol) and NaH (30.0 mg, 0.75 mmol) in dry THF (2 ml)] was added dropwise to a stirred suspension of **1** (175 mg, 0.50 mmol) in dry THF (2 ml) and the mixture was stirred for 0.5 h. The work-up as above afforded diethyl 4,5-diphenyl-6*H*-1,2-thiazin-6-ylmalonate **3i** (190 mg, 93%) as a brown oil, IR (film, cm^{-1}): 1730 (CO), 1450 (N=CH). ^1H NMR ($CDCl_3$) δ: 1.04 (3H, t, J=7 Hz, Me), 1.30 (3H, t, J=7 Hz, Me), 3.71 (1H, d, J=11 Hz, SCH), 3.75–3.84 (1H, m, CH_2), 3.91–3.99 (1H, m, CH_2), 4.18–4.33 (2H, m, CH_2), 4.56 (1H, d, J=11 Hz, CHCO), 6.98–7.39 (10H, m, ArH), 8.28 (1H, s, 3-H). ^{13}C NMR ($CDCl_3$) δ: 13.85 (q), 14.22 (q), 41.64 (d), 53.26 (d), 62.06 (t), 62.13 (t), 127.73 (d), 128.24 (d×3), 128.57 (s), 128.71 (d×2), 129.77 (d×2), 130.38 (d×2), 132.32 (s), 138.07 (s), 138.19 (s), 156.78 (d), 166.60 (s), 167.03 (s); High resolution mass spectrum, *m/z*, 409.1344 (calcd for $C_{23}H_{23}NO_4S$, 409.1348).

2.1.8. With sodium salt of acetylacetone. $NaCH(COCH_3)_2$ [prepared from acetylacetone (75 mg, 0.75 mmol) and NaH (30 mg, 0.75 mmol) in dry THF (2 ml)] was added dropwise to a suspension of **1** (175 mg, 0.50 mmol) in dry THF (2 ml) at 0°C. The work-up as above afforded 3-(4,5-diphenyl-6*H*-1,2-thiazin-6-yl)pentane-2,4-dione **3j** (180 mg, quant.) as white needles, mp 96–100°C, IR (KBr, cm^{-1}): 1720 (CO), 1470 (N=CH). ^1H NMR ($CDCl_3$) δ: 1.76 (3H, s, Me), 2.25 (3H, s, Me), 4.24 (1H, d, J=11 Hz, 6-H), 4.62 (1H, d, J=11 Hz, CHCO), 7.08–7.39 (10H, m, ArH), 8.32 (1H, s, 3-H). ^{13}C NMR ($CDCl_3$) δ: 29.31 (q), 31.64 (q), 41.86 (d), 69.41 (d), 127.85 (d), 128.47 (d), 128.63 (d×2), 128.84 (d×2), 129.64 (d×2), 130.46 (d×2), 130.50 (s), 132.29 (s), 137.34 (s), 138.31 (s), 157.33 (d), 201.32 (s), 201.64 (s). MS *m/z*: 349 (M^+). Anal. calcd for $C_{21}H_{19}NO_2S$: C, 72.18; H, 5.48; N, 4.01. Found: C, 71.74; H, 5.73; N, 3.93.

2.1.9. Reaction of 6-methoxy-4,5-diphenyl-6*H*-1,2-thiazine 3a with 70% $HClO_4$. 70% $HClO_4$ was added dropwise to a solution of **3a** (0.11 g, 0.41 mmol) in dry ether (12 ml) at 0°C and the reaction mixture was stirred for 20 min. The precipitates were collected by filtration and washed with ether (5 ml×3) to give **1** (0.11 g, 88%).

2.1.10. Reaction of 4,5-diphenyl-6-(phenylsulfanyl)-6*H*-1,2-thiazine 3h with SO_2Cl_2/70% $HClO_4$. A solution of SO_2Cl_2 (83 mg, 0.61 mmol) in dry ether (5 ml) was added dropwise to a solution of **3h** (0.20 g, 0.56 mmol) in dry ether (10 ml) at 0°C. The reaction mixture was stirred for 10 min and then 70% $HClO_4$ was added dropwise to the mixture. The precipitates were collected by filtration and washed with dry ether (5 ml×3) to give **1** (0.15 g, 77%).

2.1.11. Reaction of 1 with 1,2,3-trimethoxybenzene. A solution of **1** (150 mg, 0.43 mmol) and 1,2,3-trimethoxybenzene (87.0 mg, 0.52 mmol) in 1,2-dichloroethane (1.5 ml) was refluxed with stirring for 0.5 h. The solvent

was evaporated and the residue was subjected to preparative TLC on silica gel with hexane–ethyl acetate (10:1) to afford 6-(2,3,4-trimethoxyphenyl)-4,5-diphenyl-6*H*-1,2-thiazine **6a** (56.0 mg, 31%) as pale yellow prisms, mp 137–141°C, (from ether–CH_2Cl_2). IR (KBr, cm^{-1}): 1470 (N=CH), 1100 (ether). ^1H NMR ($CDCl_3$) δ: 3.86 (3H, s, OMe), 3.92 (3H, s, OMe), 4.01 (3H, s, OMe), 4.98 (1H, s, 6-H), 6.61 (1H, d, J=9 Hz, ArH), 6.99 (1H, d, J=9 Hz, ArH), 7.02–7.14 (7H, m, ArH), 7.20–7.22 (1H, m, ArH), 7.23–7.29 (2H, m, ArH), 8.18 (1H, s, 3-H). ^{13}C NMR ($CDCl_3$) δ: 39.35 (q), 56.15 (q), 61.00 (q), 61.49 (d), 106.80 (d), 122.98 (d), 126.53 (s), 127.80 (d), 128.23 (d×3), 128.75 (d×2), 129.08 (s), 129.72 (d×2), 130.18 (d×2), 132.55 (s), 139.12 (s), 139.58 (s), 142.94 (s), 150.67 (s), 153.87 (s), 155.04 (d). MS *m/z*: 417 (M^+). Anal. calcd for $C_{25}H_{23}NO_3S$: C, 71.92; H, 5.55; N, 3.35. Found: C, 71.72; H, 5.68; N, 3.26.

2.1.12. Reaction of 1 with 1,2-dimethoxybenzene. A solution of **1** (150 mg, 0.43 mmol) and 1,2-dimethoxybenzene (118 mg, 0.88 mmol) in 1,2-dichloroethane (2 ml) was refluxed with stirring for 0.5 h. The work-up as above afforded 6-(3,4-dimethoxyphenyl)-4,5-diphenyl-6*H*-1,2-thiazine **6b** (65.0 mg, 39%) as pale yellow prisms, mp 139–143°C, (from ether–CH_2Cl_2). IR (KBr, cm^{-1}): 1520 (N=CH), 1030 (ether). ^1H NMR ($CDCl_3$) δ: 3.86 (3H, s, OMe), 3.88 (3H, s, OMe), 4.56 (1H, s, 6-H), 6.85 (1H, d, J=9 Hz, ArH), 6.96–6.98 (2H, m, ArH), 7.07–7.27 (10H, m, ArH), 8.19 (1H, s, 3-H). ^{13}C NMR ($CDCl_3$) δ: 45.72 (q), 56.09 (q), 56.17 (d), 110.76 (d), 111.41 (d), 120.02 (d), 127.88 (d), 128.33 (d×2), 128.40 (d), 128.84 (d×2), 129.90 (d×2), 130.18 (d×2), 133.64 (s), 139.07 (s), 139.48 (s), 149.20 (s), 149.57 (s), 155.39 (d). MS *m/z*: 387 (M^+). Anal. calcd for $C_{24}H_{21}NO_2S{\cdot}1/6H_2O$: C, 73.82; H, 5.51; N, 3.59. Found: C, 73.98; H, 5.65; N, 3.69. High resolution mass spectrum, *m/z*, 387.1302 (calcd for $C_{24}H_{21}NO_2S$, 387.1293).

2.1.13. Reaction of 1 with furan. A solution of **1** (150 mg, 0.43 mmol) and furan (58.0 mg, 0.86 mmol) in dry MeCN (1 ml) was stirred at room temperature for 3 h. Ether was added to the reaction mixture to afford 6-(2-furyl)-4,5-diphenyl-6*H*-1,2-thiazine **6c** (63.0 mg, 46%) as yellow powders, mp 88–90°C, IR (KBr, cm^{-1}): 1450 (N=CH), 1010 (ether). ^1H NMR ($CDCl_3$) δ: 4.74 (1H, s, 6-H), 6.28–6.30 (1H, m, ArH), 6.35 (1H, dd, J=1 and 2 Hz, ArH), 7.01–7.21 (7H, m, ArH) 7.23–7.34 (3H, m, ArH), 7.47 (1H, d, J=1 Hz, ArH), 8.23 (1H, s, 3-H). ^{13}C NMR ($CDCl_3$) δ: 40.30 (d), 109.70 (d), 111.05 (d), 127.32 (s), 127.94 (d), 128.40 (d×2), 128.57 (d), 128.81 (d×2), 129.92 (d×2), 130.20 (d×2), 131.47 (s), 138.73 (s), 138.82 (s), 143.60 (d), 151.83 (s), 156.05 (d). MS *m/z*: 317 (M^+). Anal. calcd for $C_{20}H_{15}NOS{\cdot}1/6H_2O$: C, 74.97; H, 4.82; N, 4.37. Found: C, 75.13; H, 4.82; N, 4.20. High resolution mass spectrum, *m/z*, 317.0876 (calcd for $C_{20}H_{15}NOS$, 317.0874).

2.1.14. Treatment of 6-phenacyl-4,5-diphenyl-6*H*-1,2-thiazine 3e with SO_2Cl_2/70% $HClO_4$. A solution of SO_2Cl_2 (80 mg, 0.60 mmol) in dry ether (3 ml) was added dropwise to an ice-cooled solution of **3e** (200 mg, 0.54 mmol) in dry ether (8 ml) and the mixture was stirred for 0.5 h. 70% $HClO_4$ (85.0 mg, 0.60 mmol) was added to the mixture and the whole was stirred for 3 h. The reaction mixture was concentrated and the residue was purified by the preparative TLC on silica gel with hexane–ethyl acetate (5:1) to afford 6-(1-chlorophenacylidene)-6*H*-4,5-diphenyl-1,2-thiazine **7** (97.0 mg, 58%) as an inseparable mixture of two geometrical isomers (*E* and *Z* isomers). The two isomers were obtained in the ratio of 7:2, but each isomer could not be assigned, mp 33–37°C, red powders, IR (KBr, cm^{-1}): 1660 (CO). ^1H NMR ($CDCl_3$) δ: 6.65–6.72 (3H, m, ArH), 6.80–6.84 (1H, m, ArH), 6.87–6.92 (1H, m, ArH), 7.00–7.05 (1H, m, ArH), 7.07–7.17 (3H, m, ArH), 7.20–7.27 (2H, m, ArH), 7.34–7.47 (3H, m, ArH), 7.67–7.69 (1H, m, ArH), 8.19 (1H, s, 3-H of one isomer), 8.54 (1H, s, 3-H of the other isomer). FAB MS *m/z*: 402 (M^++1). Anal. calcd for $C_{24}H_{16}ClNOS$: C, 71.72; H, 4.01; N, 3.49. Found: C, 71.94; H, 4.22; N, 3.40.

2.1.15. 6-(3,4-Dimethoxyphenyl)-4,5-diphenyl-1,2-thiazinylium perchlorate 11. A solution of SO_2Cl_2 (67.0 ml, 0.50 mmol) in dry ether (10 ml) was added dropwise to an ice-cooled solution of **6b** (175 mg, 0.45 mmol) in dry ether (12 ml) at 0°C and the mixture was stirred for 0.5 h. 70% $HClO_4$ (71.0 mg, 0.50 mmol) was added dropwise to the mixture, which was stirred for 3 h. The precipitated red powders were filtrated and washed with dry ether (10 ml×3) to give 6-(3,4-dimethoxyphenyl)-4,5-diphenyl-1,2-thiazinylium perchlorate **11** (222 mg, quant.) as red powders, mp 208–210°C, IR (KBr, cm^{-1}): 1100 (ClO_4^-). ^1H NMR ($CDCl_3$) δ: 3.43 (3H, s, OMe), 3.89 (3H, s, OMe), 6.61 (1H, d, J=2 Hz, ArH), 6.89 (1H, d, J=8 Hz, ArH), 7.13–7.39 (11H, m, ArH), 9.78 (1H, s, 3-H). ^{13}C NMR ($CDCl_3$) δ: 56.14 (q), 56.45 (q), 111.80 (d), 112.44 (d), 122.63 (s), 125.08 (d), 129.01 (d×2), 129.08 (d×2), 129.71 (d), 130.26 (d×2), 130.62 (d×2), 130.87 (d), 132.11 (s), 135.25 (s), 149.75 (s), 150.61 (s), 151.58 (s), 153.96 (s), 163.77 (d), 189.59 (s). MS *m/z*: 386 ($M^+-ClO_4^-$). Anal. calcd for $C_{24}H_{20}ClNO_6S$: C, 59.32; H, 4.15; N, 2.88. Found: C, 58.76; H, 4.20; N, 2.86.

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