

Electronic Supplementary Information

Easy access to the family of thiazole *N*-oxides using HOF·CH₃CN complex

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Experimental Section

¹H NMR and ¹³C NMR were obtained at 200 and 50.2 MHz, respectively, with CDCl₃ as a solvent and Me₄Si as an internal standard. In the case of water soluble by-products D₂O was used as a solvent. MS and HRMS spectra were measured under CI conditions. In cases where the CI method could not detect the molecular ion, we have successfully used Amirav's supersonic Cluster CI GC-MS method developed in our department. The main feature of this method is to provide electron ionization while the sample is cooled vibrationally in a supersonic molecular beam. This process enhances the relative abundance of the molecular ions considerably (see reference 14 in the main paper). The spectral properties of all products presented in this work are in excellent agreement with their structures.

General Procedure for Working with Fluorine: Fluorine is a strong oxidant and very corrosive material. It should be used only with an appropriate vacuum line such as the

one described in reference 8. For the occasional user, however, various premixed mixtures of F₂ in inert gases are commercially available, simplifying the process. If elementary precautions are taken, work with fluorine is relatively simple and we have had no bad experiences working with it.

General Procedure for Producing HOF•CH₃CN complex: Mixtures of 10-15% F₂ in nitrogen were used in this work. They were passed at a rate of about 400 mL per minute through a cold (-10 °C) mixture of CH₃CN (60 ml) and H₂O (6 ml). The development of the oxidizing power was monitored by reacting aliquots with an acidic aqueous solution of KI. The liberated iodine was then titrated with thiosulfate. Typical concentrations of the oxidizing reagent were around 0.4 - 0.6 mol/liter.

General Procedure for Oxidations: The thiazole (usually 3 – 8 mmols) was dissolved in CH₂Cl₂ at 0°C. The HOF•CH₃CN solution, kept at similar or lower temperature, was added in one portion to the reaction mixture and, after minutes (see main text), the reaction was stopped by adding NaHCO₃. The organic material was extracted with CH₂Cl₂, washed with water and dried over MgSO₄. The crude product was usually purified either by vacuum flash chromatography, using silica-gel 60-H (Merck), or by recrystallization.

2,4-Dimethylthiazole N-oxide (2a) was prepared from **1a** as described above in 91% yield. ¹H NMR 6.84 (s, 1H), 2.57 (s, 3H), 2.35 ppm (s, 3H); ¹³C NMR 145.1, 142.8, 108.6, 13.3, 13.2 ppm. HRMS (CI) (*m/z*): calcd for C₅H₈NOS 130.032661 (MH)⁺, found 130.032470. Anal. Calcd for C₅H₇NOS: N, 10.84; S, 24.82. Found: N, 10.53; S, 24.52.

2,4-Dimethylthiazole *N,S,S*-trioxide (3a) was obtained from **1a** as a by-product in 5% yield. ¹H NMR 7.37 (s, 1H), 2.68 (s, 3H), 2.37 ppm (s, 3H); ¹³C NMR 152.7, 143.7, 111.9, 12.9, 12.0 ppm. Cluster CI-GC-MS: 161, 193 (M)⁺ and (M + MeOH)⁺.

2-Isopropyl-4-methylthiazole *N*-oxide (2b) was prepared from **1b** as described above in 87% yield. ¹H NMR 6.98 (s, 1H), 3.56 (heptet, 1H, *J*=7 Hz), 2.28 (s, 3H), 1.28 ppm (d, 6H, *J*=7 Hz); ¹³C NMR 156.8, 145.3, 109.8, 28.2, 20.5, 12.9 ppm. CIMS: 158 (MH)⁺. Anal. Calcd for C₇H₁₁NOS·H₂O: C, 48.00; H, 7.42; N, 8.00; S, 18.28. Found: C, 48.18; H, 7.93; N, 7.94; S, 17.97.

2-Isopropyl-4-methylthiazole *N,S,S*-trioxide (3b) was obtained from **1b** as a by-product in 6% yield. ¹H NMR (two conformers) 7.51 (s, 1H), 7.43 (s, 1H), 3.61 (heptet, 2H, *J*=7 Hz), 2.47 (s, 3H), 2.40 (s, 3H), 1.44 (d, 6H, *J*=7 Hz), 1.39 ppm (d, 6H, *J*=7 Hz); ¹³C NMR 182.6, 171.1, 144.3, 144.2, 116.2, 113.5, 30.7, 28.9, 21.3, 20.0, 12.4, 11.5 ppm. Cluster CI-GC-MS: 189, 221 (M)⁺ and (M + MeOH)⁺.

4,5-Dimethylthiazole *N*-oxide (2c) was prepared from **1c** as described above in 95% yield. ¹H NMR 8.06 (s, 1H), 2.35 (s, 3H), 2.25 ppm (s, 3H); ¹³C NMR 141.4, 127.0, 125.6, 13.3, 10.5 ppm. CIMS: 130 (MH)⁺. Anal. Calcd for C₅H₇NOS: C, 46.49; H, 5.46; N, 10.84. Found: C, 45.94; H, 5.60; N, 10.27.

4,5-Dimethylthiazole *N,S,S*-trioxide (3c) was obtained from **1c** as a by-product in 3% yield. ¹H NMR 8.50 (s, 1H), 2.33 (s, 3H), 2.17 ppm (s, 3H); ¹³C NMR 140.0, 133.4, 128.6, 12.1, 9.5 ppm. Cluster CI-GC-MS: 161, 193 (M)⁺ and (M + MeOH)⁺.

4-Methyl-5-thiazolyethyl acetate *N*-oxide (2d) was prepared from **1d** as described above in 91% yield. ¹H NMR 8.15 (s, 1H), 4.23 (t, 2H, *J*=6 Hz), 3.05 (t, 2H, *J*=6 Hz), 2.31 (s, 3H), 2.04 ppm (s, 3H); ¹³C NMR 170.4, 142.5, 128.1, 126.5, 62.7, 27.2, 20.6, 10.7 ppm. Cluster

CI-GC-MS: 202, 234 (MH)⁺ and (MH + MeOH)⁺. Anal. Calcd for C₈H₁₁NO₃S: C, 47.75; H, 5.51; N, 6.96; S, 15.93. Found: C, 47.87; H, 5.65; N, 6.55; S, 15.37.

4-Methyl-5-thiazolyethyl acetate N,S,S-trioxide (3d) was obtained from **1d** as a by-product in 5% yield. ¹H NMR 8.68 (s, 1H), 4.34 (t, 2H, *J*=6 Hz), 3.22 (t, 2H, *J*=6 Hz), 2.32 (s, 3H), 2.10 ppm (s, 3H); ¹³C NMR 173.8, 141.3, 134.9, 129.2, 63.6, 26.2, 20.1, 9.8 ppm.

Cluster CI-GC-MS: 234, 265 (MH)⁺ and (M + MeOH)⁺.

2,4,5-Trimethylthiazole N-oxide (2e) was prepared from **1e** as described above in 90% yield. ¹H NMR 2.49 (s, 3H), 2.29 (s, 3H), 2.23 ppm (s, 3H); ¹³C NMR 140.7, 139.8, 120.6, 12.8, 12.7, 11.1 ppm. CIMS: 144 (MH)⁺. Anal. Calcd for C₆H₉NOS·1/2H₂O: C, 47.37; H, 6.58; N, 9.21. Found: C, 47.80; H, 6.59; N, 9.41.

2,4,5-Trimethylthiazole N,S,S-trioxide (3e) was obtained from **1e** as a by-product in 5% yield. ¹H NMR 2.59 (s, 3H), 2.39 (s, 3H), 2.26 ppm (s, 3H); ¹³C NMR 147.0, 139.4, 123.7, 12.3, 11.5, 10.1 ppm. Cluster CI-GC-MS: 175, 207 (M)⁺ and (M + MeOH)⁺.

2-Ethyl-4,5-dimethylthiazole N-oxide (2f) was prepared from **1f** as described above in 87% yield. ¹H NMR 2.95 (q, 2H, *J*=7.5 Hz), 2.30 (s, 3H), 2.22 (s, 3H), 1.26 ppm (t, 3H, *J*=7.5 Hz); ¹³C NMR 147.7, 140.8, 121.3, 20.8, 12.7, 11.3, 10.8 ppm. CIMS: 158 (MH)⁺. Anal. Calcd for C₇H₁₁NOS·1/2H₂O: C, 50.60; H, 7.23; N, 8.43. Found: C, 50.66; H, 6.90; N, 8.40.

2-Ethyl-4,5-dimethylthiazole N,S,S-trioxide (3f) was obtained from **1f** as a by-product in 6% yield. ¹H NMR 2.97 (q, 2H, *J*=7.5 Hz), 2.39 (s, 3H), 2.24 (s, 3H), 1.32 ppm (t, 3H, *J*=7.5 Hz); ¹³C NMR 152.9, 139.7, 123.8, 20.7, 11.6, 10.8, 10.0 ppm. Cluster CI-GC-MS: 189, 221 (M)⁺ and (M + MeOH)⁺.

5-Acetyl-2,4-dimethylthiazole N-oxide (2g) was prepared from **1g** as described above in 85% yield; mp: 107-109 °C (n-Hexane/CH₂Cl₂). ¹H NMR 2.67 (s, 3H), 2.60 (s, 3H), 2.52 ppm (s, 3H); ¹³C NMR 188.6, 149.5, 147.0, 125.6, 29.1, 13.6, 13.3 ppm. CIMS: 172 (MH)⁺. Anal. Calcd for C₇H₉NO₂S: C, 49.10; H, 5.30; N, 8.18; S, 18.73. Found: C, 49.30; H, 5.28; N, 7.93; S, 18.31.

5-Acetyl-2,4-dimethylthiazole N,S,S-dioxide (3g) was obtained from **1g** as a by-product in 10% yield. ¹H NMR 2.74 (s, 3H), 2.65 (s, 3H), 2.60 ppm (s, 3H); ¹³C NMR 192.0, 161.5, 148.3, 128.5, 28.7, 13.6, 12.4 ppm. Cluster CI-GC-MS: 204, 235 (MH)⁺ and (M + MeOH)⁺.

2-Methylnaphtho[1,2-d]thiazole N-oxide (2h) was prepared from **1h** as described above in 78% yield; mp: 99-102 °C. ¹H NMR 10.18 (d, 1H, *J*=8 Hz), 7.95-7.83 (m, 2H), 7.75-7.59 (m, 3H), 2.78 ppm (s, 3H); ¹³C NMR 143.4, 136.2, 132.5, 128.4, 127.8, 127.4, 127.3, 124.9, 123.7, 122.4, 118.7, 13.6 ppm. HRMS (CI) (*m/z*): calcd for C₁₂H₁₀NOS 216.048311 (MH)⁺, found 216.047778.

2-Methylnaphtho[1,2-d]thiazole N,S,S-trioxide (3h) was obtained from **1h** as a by-product in 10% yield. ¹H NMR 7.97-7.88 (m, 4H), 7.63-7.60 (m, 2H), 2.41 ppm (s, 3H); ¹³C NMR (two conformers) 174.5, 174.3, 147.7, 136.7, 134.6, 134.4, 129.9, 129.8, 129.7, 129.4, 128.6, 128.4, 128.3, 128.1, 127.9, 127.6, 127.5, 127.4, 123.6, 123.0, 122.6, 117.9, 22.1, 21.6 ppm.

2-Bromo-4-methyl-5-thiazolyethyl acetate N-oxide (2d-Br) was prepared from **2d** in 91% yield. ¹H NMR 4.17 (t, 2H, *J*=6 Hz), 3.00 (t, 2H, *J*=6 Hz), 2.30 (s, 3H), 2.00 ppm (s, 3H); ¹³C NMR 170.4, 142.4, 126.2, 114.9, 62.6, 27.4, 20.7, 11.9 ppm. HRMS (CI) (*m/z*): calcd for C₈H₁₁BrNO₃S 279.964301 (MH)⁺, found 279.964073.

UV/Vis spectroscopic data and the derived HOMO-LUMO energy gaps:

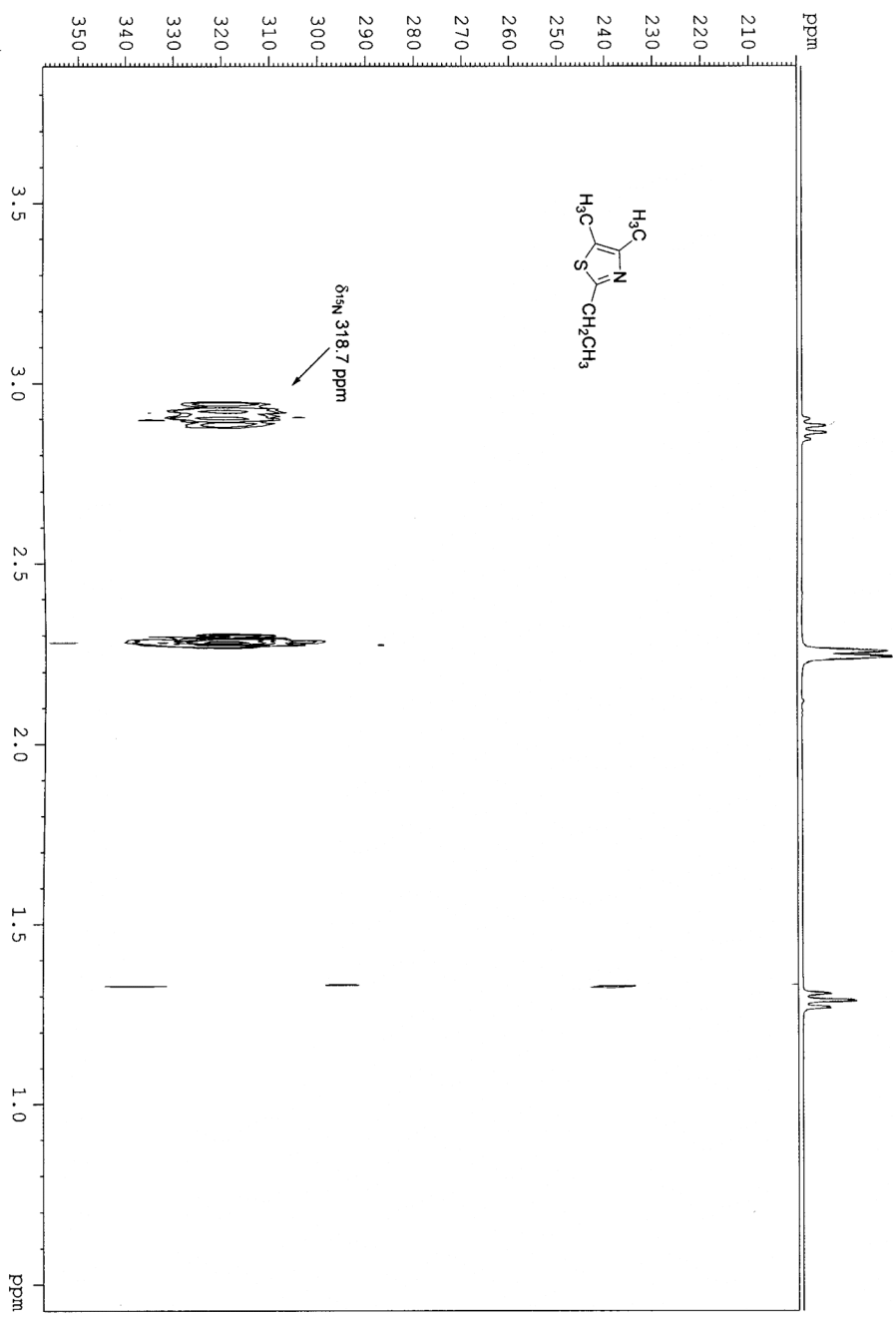
entry	compound	$\lambda_{1-2, \text{max}}$ [nm] ^[a]	ΔE_g ^[b]
1	1a	244	5.08
2	2a	238, 282	4.40
3	1b	244	5.08
4	2b	238, 282	4.40
5	1c	250	4.96
6	2c	238, 282	4.40
7	1d	246	5.04
8	2d	236, 288	4.31
9	1e	252	4.92
10	2e	242, 276	4.49
11	1f	252	4.92
12	2f	246, 278	4.46
13	1g	272	4.56
14	2g	240, 348	3.56
15	1h	242, 292	4.25
16	2h	238, 314	3.95

^a The spectra were measured in CHCl₃.

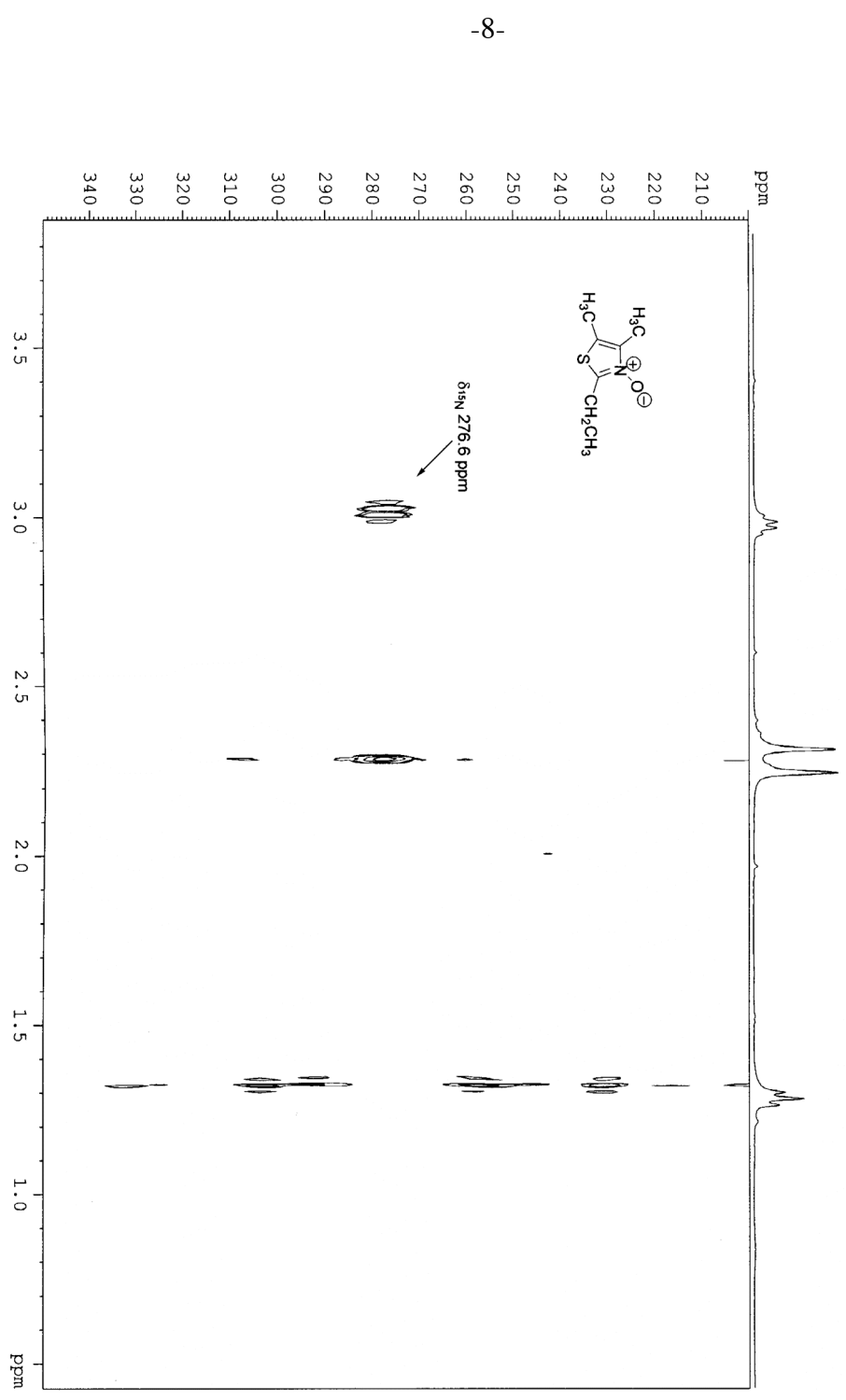
^b HOMO-LUMO gap was calculated from the low-energy band of the UV/Vis spectrum.

The following pages contain ¹H-¹⁵N HMBC data for the compounds **1f**, **2f**, **1g** and **2g**.

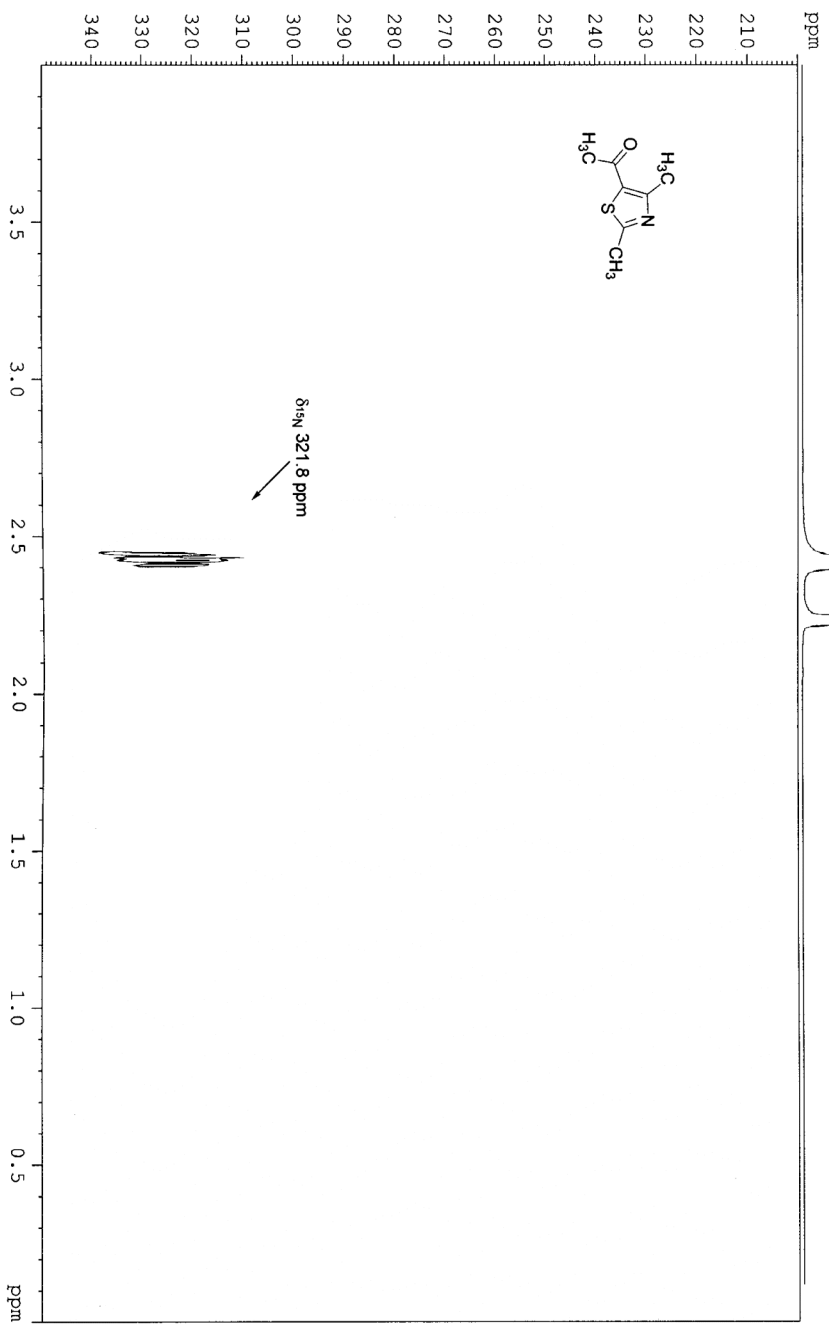
^1H - ^{15}N HMBC spectra of compound 1f (40 MHz, CDCl_3).



^1H - ^{15}N HMBC spectra of compound 2f (40 MHz, CDCl_3).



^1H - ^{15}N HMBC spectra of compound 1g (40 MHz, CDCl_3).



^1H - ^{15}N HMBC spectra of compound 2g (40 MHz, CDCl_3).

